WEST COUNTY WASTEWATER

WQRRP ELECTRICAL IMPROVEMENTS PROJECT

PROJECT NO. 20PP501

September 24**, 2021**

Angela Andrews, Capital Portfolio Manager

WEST COUNTY WASTEWATER

WEST COUNTY WASTEWATER
RICHMOND, CALIFORNIA

WQRRP ELECTRICAL IMPROVEMENTS PROJECT

CLIENT PROJECT NO. 20PP501

TECHNICAL SPECIFICATIONS

VOLUME 1 OF 2

SEPTEMBER 2021

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2021.09.20 15:27:26 -07'00'

REGISTERED PROFESSIONAL ENGINEER
ERIK M. BAHNEMAN
No. E19683
ELECTRICAL
STATE OF CALIFORNIA

Digitally signed by Jonathan M Boitano
Contact Info: Carollo Engineers, Inc.
Date: 2021.09.20 15:28:44 -07'00'

REGISTERED PROFESSIONAL ENGINEER
JONATHAN M. BOITANO
No. 80753
CIVIL
STATE OF CALIFORNIA

carollo®

2795 MITCHELL DRIVE • WALNUT CREEK, CALIFORNIA 94598-1601 • P. 925.932.1710

WEST COUNTY WASTEWATER

WQRRP ELECTRICAL IMPROVEMENTS PROJECT

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NOTICE TO CONTRACTORS
INVITING SEALED BIDS
WEST COUNTY WASTEWATER
WQRRP ELECTRICAL IMPROVEMENTS PROJECT
DISTRICT PROJECT NO. 20PP501

ENGINEER'S ESTIMATE = $1,995,000

PLEASE TAKE NOTICE THAT the Board of West County Wastewater (the "District"), Richmond, California, invites and will receive sealed bids for furnishing all labor, equipment, materials and services specified for the construction of West County Wastewater Project No. 20PP501, WQRRP Electrical Improvements Project, in conformance with the approved Contract Documents (the "Project").

The work covered by this contract will be performed at the West County Wastewater Water Quality and Resource Recovery Plant at 2377 Garden Tract Road, Richmond, CA 94801. The work includes, but is not limited to, the following:

1. Obtaining all necessary permits prior to starting the work, unless otherwise instructed by District staff.

2. Providing all necessary materials, supplies, equipment, services and personnel, to adequately carry out or complete the project.

3. Replacement of the MCC and associated VFDs in the effluent pump station building and construction of new electrical building to house new MCC and associated equipment, replacement of the VFDs in the south headworks building's raw sewage pump station, and replacement of the transformer in the maintenance building.

4. Performing work site cleanup duties, including, but not limited to removing all debris and placing materials, supplies and equipment in an organized manner, prior to leaving the site, each day.

5. All other work as shown and specified in the Contract Documents.

The Engineer's estimate is $ 1,995,000.

A pre-bid conference to discuss the Project will be held at **10:00 A.M., local time on October 4, 2021** at 2377 Garden Tract Road Richmond, CA 94801. A MANDATORY site visit immediately after the pre-bid conference shall be attended by all prime contractors interested in bidding the project. The alternate time for the MANDATORY site visit is at **October 6** at 2377 Garden Tract Road Richmond, CA 94801.

Bid opening date: The District will receive sealed bids at the reception area prior to **2:00 P.M., local time, October 25, 2021** at 2910 Hilltop Drive, Richmond, CA 94806. At the deadline, accepted bids will be publicly opened.

Contract Documents are on file and may be examined without charge at the District's Administrative Offices, 2910 Hilltop Drive, Richmond, CA 94806.

Inquiries regarding further information about the project may be directed to Keith G. Reynolds at (510) 222-6700 (ext. 3628) or kreynolds@wcwd.org.

Copies of the Contract Documents may be obtained at the District's Administrative Offices. The Contract Documents may be obtained for a nonrefundable fee of $50.00 if picked up, or $60.00 if requested by mail. Payment must be made at the time that the documents are obtained. Make check and/or money order payable to "West County Wastewater District". Credit cards are also accepted.

In accordance with Labor Code section 1725.5, all participating contractors and subcontractors must be registered with the Public Works Contractor Registration program established by the Department of Industrial Relations.

Prospective bidders are directed to the Disadvantaged Business Enterprise (DBE) requirements for bidders as detailed in Section 00 45 27. “Contractors are required to post subcontractor solicitations for a minimum of thirty (30) calendar days before the bid opening date.”

Please take notice that, pursuant to Part 7, Chapter 1, Article 2, and Section 1770 et seq. of the Labor Code of the State of California, the successful bidding contractor and its subcontractors shall pay their labor forces not less than the general prevailing rate of per diem wages as determined by the Director of Industrial Relations, and travel and subsistence pay as such are defined in applicable collective bargaining agreements filed in accordance with Sections 1773.1 and 1773.8 of the Labor Code, for work needed and performed on this Project. Those determinations in effect at the time of publishing this notice are on file at the District's Administrative Offices and may be examined there, and copies of the determinations are available to any interested party on request. The successful bidding contractor shall, pursuant to Section 1773.2 of the Labor Code, post and maintain a copy of the wages' determinations at the project site throughout the duration of the work.

Please take notice that, if the higher of (a) the Engineer’s Estimate for the Project or (b) the actual awarded bid amount (not including budget contingencies) exceeds $1 million, the Project will be subject to the Project Stabilization Labor Agreement for the West County Wastewater District, effective January 1, 2021 ("PSLA"). If the Project is subject to the PSLA, Contractor and all of its subcontractors of all tiers shall be bound by the PSLA by signing the Agreement to be Bound that is attached as Attachment A to the PSLA and must return all signed copies to the District.

The only bids that will be considered must be signed by the prime contractor who proposes to undertake the work and who is properly licensed in accordance with the Contractor's License Law as provided beginning at Section 7000 of the Business and Professions Code of the State of California. The valid license(s) required for the work as follows: **Class A (General Engineering Contractor), and Class C-42 (Sanitation System Contractor).** Each bid must be submitted on the forms furnished within the Contract

Documents and must be accompanied by a certified or cashier's check or bidder's bond for an amount not less than ten percent of the aggregate total bid.

The Contractor may substitute securities for any funds withheld to ensure performance under this Contract pursuant to Section 22300 of the California Public Contract Code.

The District's Board of Directors reserves the right to reject any or all bids for the work and waive any non-material irregularity in bids received. Dated October, 2021 at Richmond, California.

SECTION 00 21 13

INSTRUCTIONS TO BIDDERS

Subsection

1. Preparation and Submission of Proposals
2. Examination of Documents and Explanation to Bidders
3. Site Inspection and Conditions
4. West County Wastewater's Modification of the Documents
5. Registration of Contractors
6. Schedule of Bid
7. Comparison of Proposals
8. Bidder's Statement of Equipment/Material Manufacturers and Suppliers and Statement of Subcontractors
9. Qualification of Bidders
l0. Certification of Completion Requirements
11. Proposal Security
l2. Bidder's Modification and Withdrawal of Proposals
l3. Substitutions
l4. Proposal Opening and Award of Contract
l5. Relief of Bidders
l6. Bonds and Insurance Policies
l7. Nondiscrimination in Employment
18. Agreement to Assign (Bidders)
19. Plans and Specifications to Successful Bidders
20. Local Employment Good Faith Outreach Efforts
21. Bid Protests

Subsection 1. PREPARATION AND SUBMISSION OF PROPOSALS

Proposals shall be submitted on the forms provided. All proposal forms shall be properly executed and all blank spaces shall be filled in. Failure to comply with this requirement may be cause for rejection of the proposal.

The quantities included in the bid proposal are estimates of the work to be completed. West County Wastewater may add work of the same nature to this Contract if the addition is in the best interests of West County Wastewater.

Partial or incomplete proposals will not be considered. Proposals shall be in strict conformity with the approved Contract Documents for Project No. 20PP501, WQRRP Electrical Improvements Project and any Addenda thereto.

The bidder shall submit its proposal prior to the stated closing time. Any proposal received after the stated closing time for receipt of proposals will be marked as to date and time received and returned unopened.

Each proposal shall show the full legal name and business address of the bidder, including street address if it differs from its mailing address, and shall be signed with the usual signature of the person or persons authorized to bind the bidder and shall be dated. Proposals by a partnership or joint venture shall list the full names and addresses of all partners or joint venturers. The state of incorporation shall be stated in and the corporate seal shall be affixed to the proposal to which a corporation is a party as a bidder. The name of each signatory shall be typed or otherwise clearly imprinted below each signature. When requested by West County Wastewater, satisfactory evidence of the authority of any signatory on behalf of the bidder shall be furnished.

The preparation of a proposal shall be by and at the expense of the bidder. The bid submitted must not contain any erasure, interlineation or other corrections unless each correction is suitably authenticated by affixing in the margin immediately opposite the correction the signature or signatures of the person or persons submitting the bid.

Changes in or additions to the bid form, recapitulation of the work bid upon, alternative bids or any other modifications of the bid form which are not specifically called for in the Contract Documents may result in rejection of the bid by West County Wastewater, as not being responsive to the Invitation to Bid. No oral or telephonic modification of any bid submitted will be considered.

Each proposal shall be enclosed in a sealed envelope distinctly marked "Proposal" and bearing West County Wastewater's project number, title as given, and the name and address of the bidder. Proposals shall either be delivered in accordance with Section 00 11 16 Invitation to Bid, or mailed addressed to West County Wastewater, 2910 Hilltop Drive, Richmond, California 94806, Attention: Secretary. Proposals may be delivered in person to: West County Wastewater, 2910 Hilltop Drive, Richmond, California, during normal business hours, being 08:00 a.m. to 12:00 p.m. and from 01:00 p.m. to 05:00 p.m., Monday through Friday.

Proposals shall be firm for sixty calendar days from and after the stated closing time, or until a Contract is fully executed by West County Wastewater and a bidder, whichever is earlier.

In response to the Invitation to Bid, Section 00 01 16, dated and in accordance with the accompanying Instructions to Bidders, Section 00 21 13, the undersigned hereby proposes to West County Wastewater, to furnish all labor, technical and professional services, supervision, materials, and equipment (other than materials and equipment specified as furnished by West County Wastewater), and to perform all operations necessary and required for construction of West County Wastewater Project No. 20PP501, WQRRP Electrical Improvements Project, in accordance with the provisions of Sections 00 01 10 through 17950, Technical Specifications and Contract Drawings inclusive of West County Wastewater's Contract Documents for West County Wastewater Project No. 20PP501 and any Addenda thereto, and at the prices stated opposite the respective items set forth in Section 00 41 43, Schedule of Bid, attached hereto.

This Proposal constitutes a firm offer to West County Wastewater which cannot be withdrawn for sixty (60) calendar days from and after the date set for opening of proposals, or until a contract is fully executed by West County Wastewater, whichever is earlier.

It is the intent of West County Wastewater to provide a safe working environment under normal conditions. BECAUSE OF POTENTIALLY HAZARDOUS CONDITIONS SUCH AS POTENTIALLY EXPLOSIVE ATMOSPHERES AND POSSIBLE EXPOSURE TO PATHOGENS, SPECIALIZED EQUIPMENT MAY BE NECESSARY AND STRICT CONFORMANCE WITH SAFETY REGULATIONS WILL BE REQUIRED. Attention is further directed to Section 00 72 20, Laws and Regulations.

The undersigned Bidder hereby certifies that it has examined and is fully familiar with all of the provisions of the Contract Documents and any Addenda thereto, has carefully checked all of the words and figures shown on its Schedule of Bid, Section 00 41 13; has carefully reviewed the accuracy of all statements in this Proposal and attachments hereto; and understands and agrees that West County Wastewater will not be responsible for any errors or omissions on the part of the undersigned in preparing this Proposal.

The undersigned Bidder has, by careful examination of the Contract Documents and any Addenda thereto, where applicable, and by examination of the actual site conditions, satisfied itself as to the nature and location of all work, the general and local conditions to be encountered in the performance of any work, the requirements of the Contract, and all other matters which can in any way affect the work or the cost thereof.

If awarded the Contract, the undersigned agrees to execute and deliver to West County Wastewater within ten (10) calendar days after receipt of West County Wastewater's Notice of Award, the Contract and the necessary Performance Bond, Payment Bond, Construction Schedule and policies of insurance in accordance with the Contract Documents.

Attached hereto and by this reference incorporated herein and made a part of this Proposal are the following forms from the Contract Documents, which have been completed and executed by the undersigned Bidder:

Section 00 21 13	Instructions to Bidders
Section 00 41 13	Schedule of Bid

Section 00 43 13	Bid Security Form (Bidder's Bond)
Section 00 43 33	Bidder's Statement of Equipment/Materials Suppliers
Section 00 43 34	Major Equipment Manufacturer Substitutions
Section 00 43 36	Bidder's Statement of Subcontractors
Section 00 45 13	Bidder's Statement of Qualifications
Section 00 45 16	Certificate Regarding Completion Time
Section 00 45 17	Contractor Safety Acknowledgement
Section 00 45 18	Certificate Regarding Inspection of Contract Documents and Site
Section 00 45 19	Non-Collusion Declaration
Section 00 45 26	Workers' Compensation Certification

The undersigned Bidder also acknowledges receipt, understanding and full consideration of the following Addenda to the Contract Documents: Addenda No(s). _____.

There is enclosed herewith a proposal security in the form of a Bidder's Bond in favor of, or a certified check, or a cashier's check payable to West County Wastewater in an amount not less than ten (10) percent of the amount of the Proposal total as set forth in the Schedule of Bid, Section 00 41 13, which shall be and remain the property of West County Wastewater in the event of failure of the undersigned to execute and deliver the Contract and to furnish the necessary bonds and certificates and endorsements of insurance in accordance with the Procurement Form Supplements, Section 00 43 00, Representations and Certifications, Section 00 45 00, Contract Forms, Section 00 52 00 and Bond Forms, Section 00 61 00 of the Contract Documents. It is further understood by the undersigned that such failure will cause substantial injury to West County Wastewater, including delay in its construction program, which is not easily reduced to monetary terms; and it is, therefore, agreed that the amount of the Bidder's Proposal security is to be considered as liquidated damages for such injury and will be retained by West County Wastewater in the event of such a failure.

The undersigned Bidder certifies that it is now licensed in accordance with the provisions of the Contractor's License Law of the State of California, and the number of said license is _____, and the classification of said license is _____, and the said license expires_____. The undersigned Bidder certifies that it is now registered with the Public Works Contractor Registration program established by the Department of Industrial Relations, in accordance with SB 854, and the number of said registration is _____, and the said registration expires_____. The undersigned Bidder certifies that its subcontractor(s) is/are now licensed in accordance with the provisions of the Contractor's License Law of the State of California, and the number of said license is _____, and the classification of said license is _____, and the said license(s) expire(s)_____. The undersigned Bidder certifies that its subcontractor(s) is/are now registered with the Public Works Contractor Registration program established by the Department of Industrial Relations, in accordance with SB 854, and the number of said registration(s) is/are _____, _____, and the said registration(s) expire(s)_____, _____.

BIDDER:

_____
Company Name

_____
Business Address

By _____
Authorized Signature

_____
Type or Print Name

_____
Title

Dated _____

Corporate Seal
(if Bidder is a Corporation)

State of Incorporation:

_____

Subsection 2. EXAMINATION OF DOCUMENTS AND EXPLANATION TO BIDDERS

Any bidder planning to submit a proposal is responsible for examining with appropriate care the complete Contract Documents, including all Addenda, and is also responsible for being informed with respect to all conditions which might in any way affect the cost or the performance of any work. Failure to do so will be at the sole risk of the bidder, and no relief can be given for errors or omissions by the bidder.

All questions relative to the Contract Documents shall be in writing and shall be directed to Keith G. Reynolds, West County Wastewater, 2910 Hilltop Drive, Richmond, California 94806. Questions may also be sent via. e-mail to kreynolds@wcwd.org.

Should the bidder find discrepancies in or omissions from the Contract Documents, or should the intent or meaning of the documents appear unclear or contain patent ambiguities, the bidder shall at once notify West County Wastewater of such findings. Questions received less than five calendar days prior to the date for opening of the bids may not be answered. The bidder making such request shall be solely responsible for its timely receipt by West County Wastewater. Replies to such findings may be made in the form of addenda which will be issued simultaneously to all persons who have obtained a copy of the Contract Documents from West County Wastewater. Only questions answered by formal written addenda will be binding.

The bidder confirms it has familiarized itself with the Contract Documents and has found them fit and sufficient for the purpose of preparing its bid. By submission of its bid, the successful bidder agrees that it has familiarized itself with the provisions of Section 00 72 03, Discovery of Errors, Omissions, or Discrepancies in the Contract.

Copies of the Contract Documents, where applicable, are available for examination without charge during normal business hours (08:00 a.m. to 12:00 p.m. and 01:00 p.m. to 05:00 p.m., Monday through Friday) at:

West County Wastewater
2910 Hilltop Drive
Richmond, California 94806

Copies of the Contract Documents may be obtained at West County Wastewater's Administrative Offices for a non-refundable fee of $50.00 per set if picked up at West County Wastewater's Administrative Offices, and/or $60.00 if requested by mail. Payment must be made at the time that the documents are obtained. Make check and/or money order payable to West County Wastewater.

At the time each bidder obtains a copy of the documents, it shall designate the email address to which written addenda are to be sent, the facsimile number to which faxed addenda are to be sent and the telephone number to which telephonic notices are to be made.

Subsection 3. SITE INSPECTION AND CONDITIONS

It is the intent of West County Wastewater to provide a safe working environment under normal conditions. BECAUSE OF POTENTIALLY HAZARDOUS CONDITIONS SUCH AS CONFINED SPACES, POTENTIALLY EXPLOSIVE ATMOSPHERES, AND POSSIBLE EXPOSURE TO PATHOGENS, SPECIALIZED EQUIPMENT MAY BE NECESSARY AND STRICT CONFORMANCE WITH SAFETY REGULATIONS WILL BE REQUIRED. Attention is further directed to Section 00 72 20, Laws and Regulations.

In addition to examination of the Contract Documents, each prospective bidder shall become fully informed regarding all existing and expected conditions and matters which could affect any work or performance of any work in any way, and especially the cost of performing any work. The project may be visited and conditions discussed at the pre-bid conference set forth in Section 00 11 16, Invitation to Bid.

The records of this effort are not part of the Contract, and are made available for inspection solely for the convenience of the prospective bidders. Neither West County Wastewater nor Engineer assumes any responsibility for the sufficiency or accuracy of the investigations made and there is no representation, warranty, or guarantee that the conditions indicated in the report are correct or representative. The prospective bidder may, upon written request, inspect this report at West County Wastewater's Administrative Offices.

Any failure to fully investigate the sites or the foregoing conditions shall not relieve the bidder from responsibility for estimating properly the difficulty or cost of successfully performing any work. Neither West County Wastewater nor any of its representatives or agents assumes any responsibility for any understanding or representation made by West County Wastewater or any of its representatives or agents prior to the execution of a Contract pursuant to the Contract Documents.

Subsection 4. WEST COUNTY WASTEWATER'S MODIFICATION OF THE DOCUMENTS

West County Wastewater may modify any provision or part of the document at any time prior to three calendar days before closing time, provided that the closing time set forth in Section 00 11 16, Invitation to Bid, may be extended by West County Wastewater at any time prior to said closing time. Such revisions, if any, will be in the form of addenda which will be issued as set forth in Section 00 21 13, Subsection 2, Examination of Documents and Explanation to Bidders.

Addenda issued during the time of bidding shall become a part of the documents furnished bidders for the preparation of bids, shall be covered in the bids and shall be made a part of the Contract. Each bid shall include a specific acknowledgment in the space provided for receipt of all Addenda issued during the bidding period. Failure to so acknowledge may result in the bid being rejected as non-responsive. Failure of any bidder to receive such addenda shall not be grounds for non-compliance with the terms of the instructions.

Subsection 5. REGISTRATION OF CONTRACTORS

All bidders shall be licensed under the provisions of Chapter 9, Division 3, or the Business and Professions Code of the State of California to do the type of work contemplated in the project and shall be skilled and regularly engaged in the general class or type of work called for under the Contract.

In accordance with SB 854, all participating contractors and subcontractors must be registered with the Public Works Contractor Registration program established by the Department of Industrial Relations. Each bidder shall set forth in its proposal the number, and date of expiration.

Subsection 6. SCHEDULE OF BID

Bids shall be prepared on the forms contained in Section 00 41 43, Schedule of Bid. The Total Base Bid shall constitute full compensation for furnishing all materials and doing all work indicated on the drawings or herein specified.

Bidders are advised that a potential exists for the performance of extra work and furnishing of materials by the Contractor which is required for the proper completion of the work or construction of the whole of the project as originally contemplated.

Subsection 7. COMPARISON OF PROPOSALS

Proposals will be compared on the basis of the Total Base Bid stated in Section 00 41 43, Schedule of Bid.

For the purpose of initial evaluation of bids, the following will be utilized in resolving arithmetic discrepancies found on the face of the bidding schedule as submitted by bidders:

a. In case of discrepancy between unit price and extended price, the unit price will govern and will be used to correct the extension of unit prices.

b. Apparent errors in addition of lump-sum and extended prices will be corrected.

c. If no monetary symbol ($ or ¢) is entered with a unit price, lump sum, or extension, a dollar sign ($) will be assumed to be the bidder's intent.

Unless the bid is corrected for arithmetic errors as discussed above, then in the event that there is a discrepancy in the proposal between the lump-sum price or extended unit price written in words and indicated in figures, the price written in words shall govern.

West County Wastewater agrees to examine and consider each bid submitted in consideration of the bidder's agreements, as herein above set forth and as set forth in the proposal forms.

Any proposal which, in the opinion of West County Wastewater, is so unbalanced between the various Contract items as to be detrimental to the best interests of West County Wastewater, will be rejected.

Subsection 8. BIDDER'S STATEMENT OF EQUIPMENT/MATERIAL MANUFACTURERS AND SUPPLIERS AND STATEMENT OF SUBCONTRACTORS

In the form entitled Bidder's Statement of Equipment/Material Manufacturers and Suppliers, provided within Section 00 43 33, each bidder must submit the name of each person, company, or firm who will, off the job site, specially fabricate and/or provide materials or equipment proposed to be furnished under the bid.

In the form entitled Bidder's Statement of Subcontractors, provided within Section 00 43 36, the bidder shall submit the name and location of the place of business of each subcontractor who will perform work or labor or render service to the prime contractor in or about the construction of the work or improvement, or a subcontractor licensed by the State of California who under subcontract to the prime contractor specially fabricates and installs a portion of the work or improvement according to detailed drawings contained in the Plans Specifications, in an amount in excess of one-half of one percent of the proposal total or five thousand dollars, whichever is greater, as set forth in the Schedule of Bid, Section 00 41 43. The prime contractor shall indicate the portion which will be done by each such contractor for each such portion as its defined by the subcontractor in its bid.

Failure to list subcontractors in the Bidder's Statement of Subcontractors Section 00 43 36 is an express statement by the bidder that it will perform that portion of the work with its own forces. Any request for substitution of a listed subcontractor must be made as provided in the Public Contract Code Section 4107. The prime contractor may not substitute any person or subcontractor for a listed subcontractor without first obtaining written permission of the West County Wastewater's Board of Directors.

Subsection 9. QUALIFICATION OF BIDDERS

Each bidder shall examine the site and submit with its proposal a financial responsibility, technical ability, and experience statement, substantially in the form included as Section 00 45 13, Bidder's Statement of Financial Responsibility, Technical Ability, and Experience.

If bidder is a corporation, it shall submit its state of incorporation in addition to its business address; if a partnership or joint venture, full names of all partners or joint venturers shall be given in the form included in the Proposal, Section 00 52 00.

West County Wastewater expressly reserves the right to reject any proposal if it determines that the bidder's business and technical organization, financial resources, plant and equipment to be used in performing work, or lack of successful experience in performing work, or lack of successful experience in performing work of similar type and magnitude, is such that it is not in the West County Wastewater's best interest to accept the bidder's proposal.

Contractors or subcontractors who have been determined to have violated any public work laws as set forth in Labor Code Section 1777.7 shall be denied the privilege to bid the work as provided therein.

Subsection 10. CERTIFICATION OF COMPLETION REQUIREMENTS

Each bidder shall submit, as part of its proposal, a completed and executed certificate pertaining to the acceptability of the construction time frame as set forth in Section 00 45 16, Certificate Regarding Completion Time.

The Contract time for this work shall be deemed to start five (5) calendar days from the date of the Notice to Proceed. **At the time of Bid, the Contractor must submit a detailed construction phasing schedule in accordance with Section 00 45 16, CERTIFICATE REGARDING COMPLETION TIME. Notice to Proceed will not be issued until a reasonable construction schedule is submitted to West County Wastewater.**

Subsection 11. PROPOSAL SECURITY

No proposal will be considered unless it is accompanied by proposal security in the form of a certified check or a cashier's check, payable to the order of West County Wastewater, for a sum not less than ten percent of the proposal total as set forth in the Schedule of Bid, Section 00 41 43, or a bidder's bond in the same amount executed as surety by a corporation acceptable to West County Wastewater and authorized to issue such surety bond in the State of California. Such bond shall be in substantial conformity with the form included as Section 00 43 13, Bidder's Bond. Payment of the proposal security in cash is not acceptable.

Within fifteen calendar days after execution of the Contract pursuant to the Contract Documents, and in any event not later than seventy calendar days after the proposal opening, West County Wastewater will return to each bidder the proposal security which accompanied its proposal, except such security which may have been forfeited in accordance with the provisions of the Contract Documents.

Subsection 12. BIDDER'S MODIFICATION AND WITHDRAWAL OF PROPOSALS

A bidder may, without prejudice to itself, modify or withdraw its proposal by written request, provided that the request is received by West County Wastewater prior to the closing time, at the place where the proposals are to be opened. Following withdrawal of its proposal, the bidder may submit a new proposal, provided that such new proposal is received prior to the stated bid opening date as provided in Section 00 11 16, Invitation to Bid.

Subsection 13. SUBSTITUTIONS

Proposals for substitution of materials, methods, and alternatives thereto not specified in the Specifications shall be submitted in writing to West County Wastewater. Failure to submit requests for substitutions will be considered as evidence that the work will be accomplished with materials and by methods specified and in a manner, approved by West County Wastewater.

Subsection 14. PROPOSAL OPENING AND AWARD OF CONTRACT

Proposals will be kept unopened until the time stated for opening of proposals. At such time, the contents of the proposal will be made public. No responsibility shall attach to West County Wastewater or any of its officers, employees, or representatives for the premature opening of a

proposal. All bidders or their authorized representatives are invited to be present at the proposal opening.

If award is made, it will be based on the lowest responsive, responsible bid whose base bid is the lowest.

The right is reserved, as the interest of West County Wastewater may require, to reject any or all proposals and to waive any informality in proposals received.

Within sixty days after the time of opening of the bids, West County Wastewater will act either to accept a bid, to reject all bids or with the consent of the bidders and their sureties to extend the time in which West County Wastewater may act. The acceptance of a bid will be evidenced by a Notice of Award of Contract in writing, delivered in person or by certified mail to the bidder whose bid is accepted. No other act of West County Wastewater will constitute acceptance of a bid. The Award of Contract shall obligate the bidder whose bid is accepted to furnish performance and payment bonds and evidences of insurance, and to execute the Agreement in the form set forth in the Contract Documents. The Contract will require the completion of the Work according to the Contract Documents.

The Agreement shall be executed by the successful bidder and returned, together with the Contract bonds and evidences of insurance, within the specified time period after receiving written Notice of Award of the Contract. Time is of the essence in this regard. After execution by the owner, one copy of the Agreement shall be returned to Contractor.

The failure of any bidder to whom West County Wastewater may award the Contract, as aforesaid to sign and return to West County Wastewater, the Contract together with the required Performance Bond, Payment Bond, and insurance certificates and endorsements the specified time period, shall entitle West County Wastewater to declare a breach of Contract by such bidder, to award the Contract to another bidder in accordance with the provisions of the Contract Documents, and to declare a forfeiture of the bidder's proposal security accompanying its proposal.

In the event of such failure, West County Wastewater will suffer damage, the amount of which is difficult, if not impossible, to ascertain, and West County Wastewater shall therefore be entitled to retain the amount of such cashier or certified check, submitted by the bidder as proposal security, or to enforce the provisions of the Bidder's Bond in the amount thereof, as liquidated damages for such breach of Contract, as provided by applicable law.

Subsection 15. RELIEF OF BIDDERS

Should a bidder claim a mistake was made in its bid, the bidder shall give West County Wastewater written notice within five calendar days after proposal opening of the alleged mistake, and detail in said notice the circumstances under which the mistake occurred all in accordance with Public Contract Code, Section 5103. Final determination of relief of bidders shall be made by West County Wastewater's Board. Should West County Wastewater's Board accept the bidder's claim for relief, the bidder will be released from all obligations and further requirements and its proposal security will be returned as applicable.

Subsection 16. BONDS AND INSURANCE POLICIES

The bidder to whom the contract award is made shall, at the time of execution of the Contract, furnish to West County Wastewater a Performance Bond and a Payment Bond, executed as surety by a corporation acceptable to West County Wastewater and authorized to issue such surety bonds in the State of California. Such bonds shall be substantially in the form included in Section 00 61 13, Performance Bond and Section 00 61 14, Payment Bond. Such Performance Bond and Payment Bond shall be for one hundred percent of the proposal total as set forth in the Schedule of Bid, Section 00 41 43. The entire cost of these bonds shall be borne by the successful bidder.

If the surety on any bond furnished by the Contractor is declared bankrupt, or becomes insolvent, or its right to do business is terminated, or it ceases to meet the requirements of the above paragraph, the Contractor shall, within five calendar days thereafter, notify West County Wastewater and substitute another bond and surety, both of which must be acceptable to West County Wastewater.

Subsection 17. NONDISCRIMINATION IN EMPLOYMENT

Contracts for work under this Proposal will obligate the Contractor and subcontractors not to discriminate in employment practices.

Subsection 18. AGREEMENT TO ASSIGN (BIDDERS)

The bidder's attention is directed to the provisions of Government Code, Section 4552, which requires that in submitting a bid to a public purchasing body, bidders offer to assign all rights arising from violations of antitrust regulations to the public entity if the bid is accepted. In pertinent part, Government Code, Section 4552, reads as follows:

In submitting a bid to a public purchasing body, the bidder offers and agrees that if the bid is accepted, it will assign to the purchasing body all rights, title, and interest in and to causes of action it may have under Section 4 of the Clayton Act (15 U.S.C. Sec 15) or under the Cartwright Act (Chapter 2 [commencing with Section 16700] of Part 2 of Division 7 of the Business and Professions Code), arising from the purchase of goods, materials, or services by the bidder for sale to the purchasing body pursuant to the bid. Such assignment shall be made and become effective at the time the purchasing body tenders final payment to the bidder.

Subsection 19. PLANS AND SPECIFICATIONS TO SUCCESSFUL BIDDERS

The bidder to whom award is made may obtain four (4) sets of Plans and Specifications for the work at no extra costs. Additional sets may be purchased at $50.00 per set. It is the Contractor's responsibility to provide its own set(s) of conformed Plans and Specifications.

Subsection 20. LOCAL EMPLOYMENT GOOD FAITH OUTREACH EFFORTS

West County Wastewater has adopted a Local Employment Policy (the “Policy”). The following provisions describe how compliance with the Policy can be achieved. A copy of the adopted Policy can be obtained from West County Wastewater upon request.

Employment Goals

For each West County Wastewater Project, West County Wastewater has established the following goals for employment of West County Wastewater Residents:

1. At least 50% of the total work hours for the West County Wastewater Project shall be performed by West County Residents.
2. At least 50% of New Hires for the West County Wastewater Project shall be West County Residents for the duration of the West County Project.

Submittal Requirements

All Contractors, or Contractors and listed Subcontractors must either achieve the Employment Goals or document Good Faith Outreach Efforts to achieve the Employment Goals. The documented achievement of the Employment Goals or the Good Faith Outreach Efforts may be submitted after the bid opening date, but must be submitted prior to the award of the contract. Prior to the award, West County Wastewater will evaluate the documentation provided by the apparent low bidder. Failure of the apparent low bidder to adequately document either compliance with the Policy or Good Faith Outreach Efforts may cause that low bidder to be deemed a nonresponsive bidder.

Good Faith Outreach Efforts

West County Wastewater has not attempted to set forth every voluntary step that Contractors and Subcontractors must take to address their obligations under the Policy. Contractors and Subcontractors who do business with West County Wastewater have flexibility to make those efforts that are best suited to their particular situation as long as those efforts are legal, in good faith and will serve the purposes of the Policy.

Good Faith Outreach Efforts may include, but are not limited to:

1. Seeking referral assistance from organizations that provide community job training and employment services to individuals and businesses such as Richmond BUILD, the City of Richmond Employment Training Department, Richmond WORKS Career Center, the San Pablo Economic Development Corporation, the Contra Costa Building Construction and Trades Council, and local apprenticeship programs,
2. Having a recruitment program designed to attract West County Wastewater Residents of all ethnic and gender backgrounds.
3. Requesting local referrals from a union hall.
4. Requesting local referrals from Contra Costa Community College and other educational or trade institutions.

The Contractor or its Subcontractors shall make all final hiring and retention decisions and are not limited in their ability to assess qualifications of prospective workers. No provision shall be interpreted to require a Contractor or Subcontractor to employ a worker not qualified for the position in question.

Records
All Contractors and Subcontractors performing work on West County wastewater Projects shall keep payroll and other records, including timecards, tax forms, daily logs, and evidence of Good Faith Outreach Efforts for all workers within each trade performing work on the West County Wastewater Project. These records shall be kept for four years from the date of filing a notice of completion on that West County Wastewater Project. The records for each worker shall include:

1. Name
2. Address
3. Social Security number
4. Trade classification (if any)
5. Apprentice or Journey – level status
6. Daily and weekly number of hours worked
7. Gross compensation
8. The self – identified race, gender and ethnicity.

Access to Records
Authorized West County Wastewater staff shall be permitted to review such records as may be required to assure the accuracy of the submitted information and compliance with the Policy. Failure to submit the required information in a timely manner, or failure to allow West County Wastewater staff to review such records in a timely manner may cause West County Wastewater to hire an auditor, at the Contractor's expense, to audit the records and may result in the withholding of payments and/or termination of the contract.

Noncompliance
In the event of a Contractor's noncompliance with the Policy during the bidding process, the Contractor's bid may be deemed nonresponsive and ineligible for contract award.

After the contract on a West County Wastewater Project is awarded, Contractors who fail to submit any documentation demonstrating compliance with the Policy in a timely manner, or who fail to otherwise comply with the Policy, may be denied future contracts with West County Wastewater or have their contract terminated. In the event of a Contractor's or Subcontractor's noncompliance with the Policy during the performance of the contract, the Contractor may be considered in material breach of contract. In addition to any other remedy which West County Wastewater may have under the Policy or by operation of law, West County Wastewater in its sole discretion may:

1. Withhold progress payments to the Contractor starting from the date of West County Wastewater's written notification of noncompliance to the Contractor and continuing for up to sixty (60) working days after the notification date or until compliance is verified by West County Wastewater, or the Contractor demonstrates to the satisfaction of West County Wastewater that Good Faith Outreach Efforts have been implemented to correct the noncompliance, whichever occurs first.
2. Cancel or suspend the contract in whole or in part.

West County Wastewater Resident
"West County Wastewater Resident" is a person whose primary residence is within West County Wastewater's boundaries. West County Wastewater may allow individuals whose primary residence is not within West County Wastewater's boundaries to count as West County Wastewater Residents under certain conditions. If the Contractor or Subcontractor can demonstrate that there are not enough

qualified West County Wastewater Residents, the definition shall be expanded to include the following regions listed in their order of priority.

1. Individuals who reside within a five mile radius of the Water Quality and Resource Recovery Plant (WQRRP).
2. Individuals who reside within West Contra Costa County.
3. Individuals who reside within Contra Costa County.

New Hire
"New Hire" shall mean any employee of a Contractor or Subcontractor who is not listed on the Contractor's or Subcontractor's quarterly tax statement most recently filed prior to the commencement of work on a West County Wastewater Project.

Compliance With State And Federal Law
The Policy shall be enforced only to the extent that it is consistent with the laws of the State of California and the United States of America. No Contractor shall be required by the Policy to violate its obligations under an Agreement governed by the National Labor Relations Act and the Labor – Management Relations Act.

Severability
The provisions of the Policy are declared to be separate and severable. The invalidity of any clause, sentence, paragraph, subdivision, section, or portion of the Policy, or the invalidity of the application thereof to any person or circumstance shall not affect the validity of the remainder of the Policy, or the validity of its application to other persons or circumstances.

Equal Employment Opportunity
All Contractors and their Subcontractors shall assure that there is no discrimination, harassment or retaliation against any person based on sex, race, color, ancestry, religious creed, national origin, physical disability (including HIV and AIDS), mental disability, medical condition, age, marital status, genetic information, gender, gender identity, gender expression, sexual orientation or military and veteran status within the meaning of California Government Code §12940 and shall be bound by all laws prohibiting discrimination, harassment or retaliation.

Subsection 21. BID PROTESTS

Any Bid Protest of the proposed award of Contract to the Bidder with the lowest responsive bid must be submitted in writing to West County Wastewater, no later than 5:00 pm on the fifth business day following the date of the bid opening. All Bid Protests shall comply with the following procedures:

1. The initial Bid Protest must contain a complete statement of the basis for the Protest.

2. The Bid Protest must state the facts and refer to the specific portions of the document or the specific statutes that form the basis for the Bid Protest. The Bid Protest must include the name, address and telephone number of the person representing the protesting party.

3. The party filing the Bid Protest must concurrently transmit a copy of the initial protest to the bidder deemed the lowest bidder.

4. The party filing the protest must have submitted a Bid on the project. A subcontractor of a party filing a bid on the project may not submit a Bid Protest.

5. The procedure and time limits set forth in this Subsection are mandatory and are the Bidder's sole and exclusive remedy in the event of a Bid Protest. The bidder's failure to fully comply with these procedures shall constitute a waiver of any right to further pursue the Bid Protest, including the filing of a challenge of the award pursuant to the California Public Contracts Code, the filing of a claim pursuant to the California Government Code, or filing of any other legal proceedings.

6. West County Wastewater shall review all timely Bid Protests prior to formal award of the Contract. West County Wastewater shall not be required hold an administrative hearing to consider a timely Bid Protest, but may do so at the discretion of the General Manager.

7. These Bid Protest procedures shall not limit West County Wastewater's Board of Directors' ability to reject all bids.

END OF SECTION 00 21 13

SECTION 00 41 43
SCHEDULE OF BID

Schedule of Prices for Construction of WCW Project No. 20PP501 WQRRP Electrical Improvements Project

Item No.	Description	Quantity	Unit	Unit/LS Price	Amount
1.	Mobilization as described and specified for the lump sum (LS) price of _____	LS	LS	____NA____	_____
2.	Demobilization as described and specified for the lump sum (LS) price of _____	LS	LS	____NA____	_____
3.	Effluent pump station as described and specified for the lump sum (LS) price of _____	LS	LS	____NA____	_____
4.	Effluent pump station electrical building as described and specified for the lump sum (LS) price of _____	LS	LS	____NA____	_____
5.	Effluent pump station electrical building MCC as described and specified for the lump sum (LS) price of _____	LS	LS	____NA____	_____
6.	Effluent pump station electrical building VFDs as described and specified for the lump sum (LS) price of _____	LS	LS	____NA____	_____
7.	Headworks building raw sewage pump station as described and specified for the lump sum (LS) price of _____	LS	LS	____NA____	_____
8.	Headworks building VFDs as described and specified for the lump sum (LS) price of _____	LS	LS	____NA____	_____

9.	Maintenance building as described and specified for the lump sum (LS) price of _____	LS	LS	____NA____	_____
10.	New PLC-5, PLC-1 & PLC-3 panel mod. & instruments as described and specified for the lump sum (LS) price of _____	LS	LS	____NA____	_____
11.	All work required by the plans and specifications not included in Bid Items No. 1 through No. 2 for the lump sum (LS) price of _____	LS	LS	____NA____	_____

Total **Base** Bid (**Items 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 ONLY**) all work incidental thereto and connected therewith):

(Enter Bid Numerically) $ _____

Total **Base** Bid in Words: _____ dollars and

_____ cents

In case of discrepancy between words and figures, the words shall prevail.

Signed: _____
Bidder

Total Bid (**including Additive Items**) all work incidental thereto and connected therewith):

(Enter Bid Numerically) $ _____

Total Bid (**including Additive Items**) Words: _____ dollars and

_____ cents

In case of discrepancy between words and figures, the words shall prevail.

Signed: _____
Bidder

GROUP 00 43 00
PROCUREMENT FORM SUPPLEMENTS

Section

00 43 13 Bid Security Form (Bidder's Bond)

00 43 33 Bidder's Statement of Equipment/Material Suppliers

00 43 34 Major Equipment Manufacturer Substitutions

00 43 36 Bidder's Statement of Subcontractors

00 43 93 Bid Submittal Checklist

SECTION 00 43 13
BID SECURITY FORM
(Bidder's Bond)

We, _____ as Principal, _____ _____ and as Surety, are firmly held and bound unto the West County Wastewater, a municipal district organized and existing under the laws of the state of California, sometimes referred to as WCW, in the sum of $_____ (which is a sum not less than ten percent of the amount of the accompanying Proposal total) for the payment of which we bind ourselves, our heirs, executors, administrators, successors, and assigns jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION IS SUCH THAT, WHEREAS, the Principal has submitted to West County Wastewater the accompanying proposal under a public Notice to Contractors inviting sealed bids for West County Wastewater Project No. 11862A10, Electrical Improvements Project, in Richmond, Contra Costa County, California.

NOW, THEREFORE, if the accompanying Proposal of the Principal is accepted and award be made by West County Wastewater to the Principal; and if the Principal withdraws said Proposal within the period specified in said Proposal during which period said Proposal cannot be withdrawn, or if the Principal shall fail, refuse, or neglect for any reason whatsoever within ten calendar days after receipt from West County Wastewater's of Notice of Award of the Contract to enter into the Contract with West County Wastewater in accordance with the Principal's proposal and the Instructions to Bidders, Section 00 21 13, for said Project, and to give bonds with good and sufficient surety, and to furnish the policies of insurance as stated in said proposal and the Instructions to Bidders for said Project, then the sum guaranteed by this Bond is forfeited to the West County Wastewater.

It is agreed between Principal and Surety that such failure or neglect would result in substantial injury to West County Wastewater which is not easily reduced to monetary terms; and it is, therefore, agreed that the amount of the Bidder's Proposal security is to be considered by Principal and Surety as liquidated damages for such injury. In the event suit is brought upon this Bond by West County Wastewater and judgment is recovered, the Surety or Sureties shall pay all costs incurred by west County Wastewater in such suit, including attorneys' fees to be fixed by the court.

Dated _____,

_____

_____
Principal (Authorized Signature)

_____
Business Address

In the presence of:

_____

_____

_____
Business Address

SEAL

_____

_____
Surety (Authorized Signature)

_____
Business Address
of Local Representative

In the presence of:

_____

_____

_____
Business Address of Home Office
of Surety Company

SEAL

SECTION 00 43 33
BIDDER'S STATEMENT OF EQUIPMENT/MATERIAL SUPPLIERS

The Contractor shall indicate opposite each item of equipment or material listed below, the name of the manufacturer or supplier of the equipment or material proposed to be furnished under the Bid as listed below or for any items exceeding five thousand dollars in value. Failure to comply with this requirement may render the proposal non-responsive and cause its rejection. Awarding of a contract under this Bid Proposal will not imply approval by West County Wastewater of the manufacturers or suppliers listed by the Contractor. West County Wastewater retains the right to reject the equipment or material listed by the Contractor if, in its discretion, the equipment or material does not comply with the Specifications.

The Contractor will not be allowed to propose changes or substitutions in the equipment and materials to be supplied or the manufacturer or supplier of said materials after the opening of the Bid Proposal without first having received written approval of West County Wastewater.

Equipment and/or Material Description	Name of Supplier, Fabricator, or Manufacturer, Location of Corporate Headquarters

Signed _____
Bidder

SECTION 00 43 34
MAJOR EQUIPMENT MANUFACTURER SUBSTITUTIONS

Any Manufacturer, including those not listed as an acceptable manufacturer, may be listed as a substitution.

The Bidder understands that after a contract is awarded, the Owner may, at his sole discretion, select items of any Manufacturer listed in the following substitute tabulation. If awarded the contract, the Bidder agrees to furnish and install any substitutions listed for the price indicated. The BASE BID will then be adjusted accordingly.

The Engineer may require detailed information to be submitted for preliminary evaluation of a substitute Manufacturer. This information could include equipment technical and performance details and other information deemed necessary by the Engineer and/or as described in the contract specification.

If a contract includes items of equipment of any Manufacturer which may require any modification or deviation from the plans, the undersigned agrees to prepare and submit detailed drawings to the Engineer showing all modifications in structures, piping, electrical and mechanical work, required to adapt the plans to the equipment selected. The Bidder further understands that the Engineer will review said detailed drawings of modifications and either approve them or indicate thereon changes necessary to comply with the project requirements. Detailed drawings which are not approved will be revised, then resubmitted to the Engineer for approval. If it is determined by the Engineer that the substitute equipment is not approved, then the original base bid equipment must be provided. The prices listed in the following tabulation are "installed" prices and take into consideration any changes that may be required.

SUBSTITUTION

Equipment Item	Manufacturer	Add (Deduct) From Base Bid

SECTION 00 43 36
BIDDER'S STATEMENT OF SUBCONTRACTORS

In accordance with the requirements of Section 00 21 13, Subsection 8, Instructions to Bidders, the undersigned Bidder submits herewith a list of subcontractors whom it proposes to employ on the work, with the proper firm name and business address of each, and the portion of the work to be done by each with the understanding that failure to name such subcontractors shall be witness that it shall have agreed to perform such portion of the work itself and that it shall not subcontract said portion of the work, and that such subcontracted work listed herein will not be performed by others, without first obtaining written permission of West County Wastewater's Board of Directors pursuant to provisions of Section 4107 of the Public Contract Code.

Subcontractor Name	CSLB Lic. No. & DIR Reg. No.	Business Address	Description of Work to be Done	% of Project

Signed:_____
Bidder

SECTION 00 43 93
BID SUBMITTAL CHECKLIST

Item #	Description	Item Completed
1	Complete the Addenda Acknowledgement section listed on page 4 of the Instructions to Bidders Section, Section 00 21 13 (*leave the line blank if no addendum has been issued*)	☐
2	Complete the CSLB, DIR and Bidder's information sections listed on page 5 of the Instructions to Bidders Section, Section 00 21 13	☐
3	Complete the schedule of prices section listed in the Schedule of Bid Section, Section 00 41 43	☐
4	Complete the sections shown in the Bid Security Form (Bidder's Bond) Section, Section 00 43 13 and provide the bid bond	☐
5	Complete the section shown in the Bidder's Statement of Equipment / Materials Suppliers Section, Section 00 43 33	☐
6	Complete the section shown in the Major Equipment Manufacturer Substitutions Section, Section 00 43 34 (*leave the lines blank if no substitutions are being proposed*)	☐
7	Complete the section shown in the Bidder's Statement of Subcontractors Section, Section 00 43 36 (*leave the lines blank if no subcontractors will be utilized*)	☐
8	Complete the section shown in the Bidder's Statement of Qualifications Section, Section 00 45 13	☐
9	Complete the section shown in the Certificate Regarding Completion Time Section, Section 00 45 16	☐
10	Complete the section shown in the Contractor Safety Acknowledgment Section, Section 00 45 17	☐
11	Complete the section shown in the Certificate Regarding Inspection of Contract Documents and Site Section, Section 00 45 18	☐
12	Complete the section shown in the Noncollusion Declaration Section, Section 00 45 19	☐
13	Complete the section shown in the Workers' Compensation Certification Section, Section 00 45 26	☐
14	Provide proof of the **posted** 30-day (minimum) DBE solicitation **required** in the Disadvantaged Business Enterprise (DBE) Requirements Section, Section 00 45 27 [SRF PROJECTS ONLY] (not applicable)	☐

GROUP 00 45 00
REPRESENTATIONS AND CERTIFICATIONS

Section

00 45 10 Instructions to Awardees

00 45 13 Bidder's Statement of Qualifications

00 45 15 Escrow Agreement for Security Deposits in Lieu of Retention

00 45 16 Certificate Regarding Completion Time

00 45 17 Contractor Safety Acknowledgement

00 45 18 Certificate regarding inspection of Contract Documents and Site

00 45 19 Non-Collusion Declaration

00 45 26 Workers' Compensation Certification

00 45 27 Disadvantaged Business Enterprise (DBE) certification form [SRF only] (not used)

SECTION 00 45 10
INSTRUCTIONS TO THE AWARDEE

A. Award and Execution of Contract

The successful bidder will be notified in writing by West County Wastewater's of Award of Contract within Sixty (60) calendar days after opening of proposals. Accompanying West County Wastewater's Notice of Award will be the Contract, in duplicate, which the successful bidder will be required to sign and return together with the Performance Bond, Payment Bond, and the required number of copies of insurance certificates and endorsements to West County Wastewater within fourteen (14) calendar days following receipt of such Notice of Award. West County Wastewater will promptly determine whether such Contract, bonds, and insurance certificates and endorsements are as required by the Contract Documents, and upon such determination will forward a fully signed copy of the Contract to the successful bidder. West County Wastewater may issue a Notice to Proceed at any time prior to forwarding the Contract. No work shall be performed at the site prior to the date set forth in the Notice to Proceed. The failure of any bidder to whom West County Wastewater may award the Contract, as aforesaid to sign and return to West County Wastewater, the Contract together with the required Performance Bond, Payment Bond, and insurance certificates and endorsements within the specified time period, shall entitle West County Wastewater to declare a breach of Contract by such bidder, to award the Contract to another bidder in accordance with the provisions of the Contract Documents, and to declare a forfeiture of the bidder's proposal security accompanying its proposal.

B. Bonds and Insurance Policies

The Bidder to whom the contract award is made shall, at the time of execution of the Contract, furnish to West County Wastewater a Performance Bond and a Payment Bond, executed as surety by a corporation acceptable to West County Wastewater and authorized to issue such Surety Bonds in the state of California. Such bonds shall be substantially in the form included in Sections 00 61 13 and 00 61 14 respectively, of the Contract Documents. Such Performance Bond and Payment Bond shall be for one hundred percent of the Proposal total as set forth in the Schedule of Bid, Section 00 41 43. The entire cost of these bonds shall be borne by the successful Bidder.

If the Surety on any bond furnished by the Contractor is declared bankrupt, or becomes insolvent, or its right to do business is terminated, or it ceases to meet the requirements of the above paragraph, the Contractor shall, within five calendar days thereafter, notify West County Wastewater and substitute another bond and surety, both of which must be acceptable to West County Wastewater.

The successful Bidder shall at the time of execution of the Contract deliver to West County Wastewater one copy of policies of insurance obtained in accordance with the requirements of the Contract Documents.

C. Workers' Compensation Statement

The Bidder to whom the Contract Award is made shall, at the time of execution of the Contract, furnish to West County Wastewater a statement certifying compliance with the workers' compensation provision of the California Labor Code. Such certification shall be substantially in the form included in Section 00 45 26 of the Contract Documents.

SECTION 00 45 13
BIDDER'S STATEMENT OF QUALIFICATIONS

The undersigned Bidder submits, as a part of its Proposal, the following statements as to its experience qualifications. The Bidder certifies that all statements and information set forth below are true and accurate.

A. The Bidder has been engaged in the contracting business under its present business name for _____ years.

B. Experience in work of a nature similar in type and magnitude to that set forth in the Contract Documents extends over a period of _____ years.

C. The Bidder, as prime contractor, has satisfactorily completed all contracts awarded to it, except as follows: (Name any and all exceptions and reasons therefore. Bidder shall attach and designate additional pages if necessary.)

_____

D. The undersigned Bidder submits herewith a statement of its financial responsibility and hereby authorizes the below named banks, companies, and institutions to release financial status information to West County Wastewater for the sole purpose of evaluating financial responsibility in conjunction with the proposal submitted for this Project.

Bank, Surety Company, or Other Institution	Branch of Office Address

_____

_____

E. The undersigned Bidder submits below a statement describing work similar in character to that anticipated in the proposed contract, which it has previously completed. Work described will be for jobs involving similar electrical improvements with contract amounts over $1,000,000. All experience listed shall have occurred in the last five years. Failure to complete this section, as required, may result in the bid being rejected as non-responsive. It is the intent of West County Wastewater to evaluate the responsiveness of the Contractor's bid in part based on whether the proposal and information set forth below reflect substantial experience in successful completion of work of the nature and magnitude of this project.

BIDDERS AND SUBCONTRACTOR'S QUALIFYING EXPERIENCE

Project Name	Contract Amount	Performed For			Year Performed
		Organization	Contact Name	Telephone and E-mail Address	

Signed:_____

Bidder

SECTION 00 45 15
ESCROW AGREEMENT FOR SECURITY DEPOSITS IN LIEU OF RETENTION

This Escrow Agreement is made and entered into by and between West County Wastewater whose address is 2910 Hilltop Drive, Richmond, California, and

_____

whose address is _____,

hereinafter called "Contractor," and _____

whose address is _____,

hereinafter called "Escrow Agent." For the consideration hereinafter set forth, West County Wastewater, Contractor, and Escrow Agent agree as follows:

1. Pursuant to Section 22300 of the Public Contract Code of the State of California, the Contractor has the option to deposit securities with the Escrow Agent as a substitute for retention earnings required to be withheld by West County Wastewater pursuant to the Construction Contract entered into between West County Wastewater and the Contractor for Project No. 20PP501, WQRRP Electrical Improvements Project, in the amount of ($_____) dated _____ (hereinafter referred to as the "Contract"). When the Contractor deposits the securities as a substitute for the Contract earnings, the Escrow Agent shall notify West County Wastewater within ten days of the deposit. The market value of the securities at the time of the substitution shall be at least equal to the cash amount then required to be withheld as retention under the terms of the Contract between West County Wastewater and the Contractor. Securities shall be held in the name of _____ and shall designate the Contractor as the beneficial owner.

2. West County Wastewater shall make progress payments to the Contractor for such funds which otherwise would be withheld from progress payments pursuant to the Contract provisions, provided that the Escrow Agent hold securities in the form and amount specified above.

3. Alternatively, West County Wastewater may make payments directly to the Escrow Agent in the amount of retention for the benefit of West County Wastewater until such time as the escrow created hereunder is terminated.

4. The Contractor shall be responsible for paying all fees for the expenses incurred by the Escrow Agent in administering the escrow account. These expenses and payment terms shall be determined by the Contractor and the Escrow Agent.

5. The interest earned on the securities or the money market accounts held in escrow and all interest earned on that interest shall be for the sole account of the Contractor and shall be subject to withdrawal by the Contractor at any time and from time to time without notice to West County Wastewater.

6. The Contractor shall have the right to withdraw all or any part of the principal in the Escrow Account only by written notice to the Escrow Agent accompanied by written authorization from West County Wastewater to the Escrow Agent that West County Wastewater consents to the withdrawal of the amount sought to be withdrawn by the Contractor.

7. West County Wastewater shall have a right to draw upon the securities in the event of default by the Contractor. Upon seven days written notice to the Escrow Agent from West County Wastewater of the default,

   the Escrow Agent shall immediately convert the securities to cash and shall distribute the cash as instructed by West County Wastewater.

8. Upon receipt of written notification from West County Wastewater certifying that the Contract is final and complete, and that the Contractor has complied with all requirements and procedures applicable to the Contract, the Escrow Agent shall release to the Contractor all securities and interest on deposit less escrow fees and charges of the Escrow Account. The escrow shall be closed immediately upon disbursement of all monies and securities on deposit and payments of fees and charges.

9. The Escrow Agent shall rely on the written notifications from West County Wastewater and the Contractor pursuant to Sections 4 and 6, inclusive, of this Agreement and West County Wastewater and the Contractor shall hold the Escrow Agent harmless from the Escrow Agent's release and disbursement of the securities and interest as set forth above.

10. The names of the persons who are authorized to give written notice or to receive written notice on behalf of West County Wastewater and on behalf of the Contractor in connection with the foregoing, and exemplars of their respective signatures are as follows:

On behalf of West County Wastewater:

_____
Title

_____
Name

_____
Signature

_____
Address

On behalf of the Contractor:

_____
Title

_____
Name

_____
Signature

_____
Address

On behalf of the Escrow Agent:

_____
Title

_____
Name

_____
Signature

_____
Address

At the time the Escrow Agent Account is opened, West County Wastewater and the Contractor shall deliver to the Escrow Agent a fully executed counterpart of this Agreement.

IN WITNESS WHEREOF, the parties have executed this Agreement by their proper officers on the date first set forth above.

West County Wastewater:

_____
Title

_____
Name

_____
Signature

Contractor:

_____
Title

_____
Name

_____
Signature

SECTION 00 45 16

CERTIFICATE REGARDING COMPLETION TIME

I, _____, am the duly authorized representative of _____ ,Contractor, which is submitting a Proposal to which this Certificate is attached for Project No. 20PP501, WQRRP Electrical Improvements Project.

I have the authority to bind _____. Contractor, as to all matters regarding the proposal to which this Certificate is attached.

I hereby certify that I, or Contractor's duly authorized representative have evaluated the required construction completion within One Hundred and Eighty (180) calendar days from the start date listed on the Notice to Proceed, and that the Contractor's bid contained in this proposal document reflects completing the work within this time frame. The Contract time for this work shall be deemed to start five (5) calendar days from the date of the Notice to Proceed.

I am also aware that in order for my bid to be considered responsive, West County Wastewater requires a detailed construction phasing schedule at the time of Bid. Notice to Proceed will not be issued until a reasonable construction schedule is submitted to West County Wastewater.

By: _____
Contractor

Dated: _____

SECTION 00 45 17

CONTRACTOR SAFETY ACKNOWLEDGMENT

PROJECT NO. 20PP501

PROJECT NAME: Electrical Improvements Project

The Contractor shall be fully responsible for all safety requirements in accordance with State of California Construction Safety Orders (CAL OSHA), and all other safety laws, regulations, specifications, and guidelines required by any other local or federal District.

I have read the above and the CAL OSHA's Construction Safety Orders and understand the safety considerations applicable to this project.

ACKNOWLEDGED BY: Contractor's Name _____

Date: _____ Signature: _____

SECTION 00 45 18

CERTIFICATE REGARDING INSPECTION OF CONTRACT DOCUMENTS AND SITE

I, _____, am the duly authorized representative of _____, Contractor, which is submitting a Proposal to which this Certificate is attached for Project No. 20PP501, WQRRP Electrical Improvements Project.

I have the authority to bind _____, Contractor, as to all matters regarding the Proposal to which this Certificate is attached.

1. I hereby certify that I, or Contractor's duly authorized representative, have examined the Contract Documents pertinent to Project No. 20PP501, including the Instructions to Bidders, General Conditions, Supplementary Conditions, and Technical Specifications.

2. I further certify that I, or Contractor's authorized representative, have examined the site pertinent to Project No. 20PP501, and have examined existing and expected conditions and matters which could affect any work or performance of any work in any way, especially the cost of performing any work.

_____ By: _____
Contractor

Dated: _____

SECTION 00 45 19
NONCOLLUSION DECLARATION

State of California)
) ss.
County of _____)

_____, being first duly sworn, deposes and says that he or she is _____ of _____, the party making the foregoing bid that the bid is not made in the interest of, or on behalf of, any undisclosed person, partnership, company, association, organization, or corporation; that the bid is genuine and not collusive or sham; that the bidder has not directly or indirectly induced or solicited any other bidder to put in a false or sham bid, and has not directly or indirectly colluded, conspired, connived, or agreed with any bidder or anyone else to put in a sham bid, or that anyone shall refrain from bidding; that the bidder has not in any manner, directly or indirectly, sought by agreement, communication, or conference with anyone to fix the bid price of the bidder or any other bidder, or to fix any overhead, profit, or cost element of the bid price, or of that of any other bidder, or to secure any advantage against the public body awarding the contract of anyone interested in the proposed contract; that all statements contained in the bid are true; and, further, that the bidder has not, directly or indirectly, submitted his or her bid price or any breakdown thereof, or the contents thereof, or divulged information or data relative thereto, or paid, and will not pay, any fee to any corporation, partnership, company association, organization, bid depository, or to any member or agent thereof to effectuate a collusive or sham bid.

Acknowledged By:

_____
Company Name

_____
Signature

_____
Title

_____
Date

SECTION 00 45 26
WORKERS' COMPENSATION CERTIFICATION

(AS REQUIRED BY SECTION 1861 OF THE CALIFORNIA LABOR CODE)

I am aware of the provisions of Section 3700 of the Labor Code which require every employer to be insured against liability for workers' compensation or to undertake self-insurance in accordance with the provisions of the Labor Code, and I will comply with such provisions before commencing the performance of the work of this Contract.

Contractor: _____

By: _____

Title: _____

Date: _____

GROUP 00 52 00
CONTRACT FORMS

Section

00 52 10 Instructions to Awardees

00 52 13 Contract

SECTION 00 52 10
INSTRUCTIONS TO THE AWARDEE

Award and Execution of Contract

The successful bidder will be notified in writing by West County Wastewater's of Award of Contract within Sixty (60) calendar days after opening of proposals. Accompanying West County Wastewater's Notice of Award will be the Contract, in duplicate, which the successful bidder will be required to sign and return together with the Performance Bond, Payment Bond, and the required number of copies of insurance certificates and endorsements to West County Wastewater within fourteen (14) calendar days following receipt of such Notice of Award. West County Wastewater will promptly determine whether such Contract, bonds, and insurance certificates and endorsements are as required by the Contract Documents, and upon such determination will forward a fully signed copy of the Contract to the successful bidder. West County Wastewater may issue a Notice to Proceed at any time prior to forwarding the Contract. No work shall be performed at the site prior to the date set forth in the Notice to Proceed. The failure of any bidder to whom West County Wastewater may award the Contract, as aforesaid to sign and return to West County Wastewater, the Contract together with the required Performance Bond, Payment Bond, and insurance certificates and endorsements within the specified time period, shall entitle West County Wastewater to declare a breach of Contract by such bidder, to award the Contract to another bidder in accordance with the provisions of the Contract Documents, and to declare a forfeiture of the bidder's proposal security accompanying its proposal.

Bonds and Insurance Policies

The Bidder to whom the contract award is made shall, at the time of execution of the Contract, furnish to West County Wastewater a Performance Bond and a Payment Bond, executed as surety by a corporation acceptable to West County Wastewater and authorized to issue such Surety Bonds in the state of California. Such bonds shall be substantially in the form included in Sections 00 61 13 and 00 61 14 respectively, of the Contract Documents. Such Performance Bond and Payment Bond shall be for one hundred percent of the Proposal total as set forth in the Schedule of Bid, Section 00 41 43. The entire cost of these bonds shall be borne by the successful Bidder.

If the Surety on any bond furnished by the Contractor is declared bankrupt, or becomes insolvent, or its right to do business is terminated, or it ceases to meet the requirements of the above paragraph, the Contractor shall, within five calendar days thereafter, notify West County Wastewater and substitute another bond and surety, both of which must be acceptable to West County Wastewater.

The successful Bidder shall at the time of execution of the Contract deliver to West County Wastewater one copy of policies of insurance obtained in accordance with the requirements of the Contract Documents.

Workers' Compensation Statement

The Bidder to whom the Contract Award is made shall, at the time of execution of the Contract, furnish to West County Wastewater a statement certifying compliance with the workers' compensation provision of the California Labor Code. Such certification shall be substantially in the form included in Section 00 45 26 of the Contract Documents.

[THE REMAINDER OF THIS PAGE IS LEFT INTENTIONALLY BLANK]

SECTION 00 52 13
CONTRACT

This Contract is entered into as of this (_) day of (_), 20__, by and between West County Wastewater, a public entity, organized, and existing under the laws of the state of California, and _____, sometimes referred to as the Contractor.

The parties agree as follows:

A. The Contractor, for and in consideration of the payment to be made to the Contractor as hereinafter provided, shall furnish all plant labor, technical and professional services, supervision, materials, and equipment other than such materials and equipment as may be specified to be furnished by West County Wastewater, and perform all operations necessary and required to construct Project No. 20PP501, Electrical Improvements Project, in Richmond, California, in strict conformity with the terms and conditions of this Contract, which includes the following:

1. The Contractor's proposal dated _____, in response to West County Wastewater's Notice to Contractors advertised on _____ and _____, relating to West County Wastewater's Contract Documents for Project No. 20PP501, as such Proposal is on file at the office of the West County Wastewater, 2910 Hilltop Drive, Richmond, California.

2. Sections 00 01 0 through 17950 of the Specifications, the Technical Specifications and the Contract Drawings, inclusive of West County Wastewater's Contract Documents for Project No. 20PP501 and Addenda No(s)._____, thereto, and the Notice of Award from West County Wastewater to the Contractor dated_____ all as filed in said office of the West County Wastewater.

   Such Proposal, Contract Documents: Sections 00 01 0 through 17950, the Technical Specifications, the Contract Drawings, and all Addenda, and said Notice of Award are by this reference incorporated herein and made a part of the Contract, provided, that if any conflict exists between such Proposal and the other provisions of the Contract, the other provisions of the Contract shall govern unless otherwise mutually agreed in writing by the parties hereto. All Contract Documents shall be construed in accordance with the laws of the State of California.

B. Time of Performance: Time is of the essence in the performance of this Contract. The Contractor shall begin work as provided in the General and Special Conditions of the Project Manual and once work is started, it shall be diligently prosecuted to completion on or before the expiration of the time hereinafter stated:

Bid Item Completion Required Within:

ALL : The Contract time for this work shall be deemed to start five (5) calendar days from the date of the Notice to Proceed. The Contractor shall complete the work in One Hundred and Eighty (180) Calendar Days.

It is further agreed by the parties to the Contract that in case all work called for under the Contract, in all parts and requirements, is not finished or completed on or before the expiration dates or intermediate milestones herein set forth, the Contractor may be assessed liquidated damages specified under Section 00 72 42, Liquidated Damages of the Contract Documents.

C. West County Wastewater, in consideration of the Contractor's performance in accordance with the Contract, will pay to Contractor compensation based upon the prices set forth in the Contractor's Proposal and computed and paid for in accordance with the measurement and payment provisions of Section 00 72 39, Measurement and Payment of the Contract Documents.

D. No oral agreement or conversation with any representative or employee of West County Wastewater either before or after the execution of the Contract, shall affect or modify any of the terms or obligations herein contained. This Contract constitutes the entire agreement between the parties hereto and no changes, alterations, or modifications hereof shall be effective unless in writing and signed by the parties hereto.

E. Contractors are required by law to be licensed and regulated by the Contractor's State License Board. Any questions concerning a contractor may be referred to the Registrar, Contractor's State License Board, 9835 Goethe Road, PO Box 26000 Sacramento, CA 95826.

F. West County Wastewater shall pay the Contractor for completion of the work in accordance with the Contract Documents, the not-to-exceed Contract price of _____ _____ Dollars ($) in accordance with the amounts set forth in Section 00 41 43, Schedule of Bid, and based on the total base and any additive bid prices named in the aforementioned Schedule of Bid, in addition to the contingency amount approved by the Board of Directors.

G. Reference is hereby made to the provisions for payment of minimum per diem wages contained in Section 00 11 16, Invitation to Bid. In accordance with said provisions, the Contractor and each subcontractor engaged in the work shall pay each respective employee thereof an amount not less than the per diem wages established by the Department of Industrial Relations. Copies of the prevailing rate of per diem wages are on file at the West County Wastewater Administrative Offices and shall be made available to any interested party on request.

H. Bidders shall promptly notify West County Wastewater, in writing, of all the classifications of labor not listed in the prevailing wage determinations but necessary for the performance of the Work, before bids are submitted.

Dated:_____

CONTRACTOR: _____

Company Name

By: _____

Title: _____

WEST COUNTY

WASTEWATER: By: _____

Title: General Manager

ATTEST: _____

Vice-President of the Board

I hereby approve the form of the foregoing Contract this _____ day of _____ , 20___.

_____

Board Attorney

GROUP 00 61 00
BOND FORMS

Section

00 61 13 Performance Bond

00 61 14 Payment Bond

SECTION 00 61 13
PERFORMANCE BOND

We,_____, as Principal, and, _____, as Surety, are jointly and severally held and bound unto the West County Wastewater, organized and existing under the laws of the state of California, in the sum of _____dollars ($_____) for the payment of which we jointly and severally bind ourselves, our heirs, executors, administrators and assigns, and successors and assigns, firmly by these presents.

THE CONDITIONS OF THIS BOND ARE SUCH THAT, WHEREAS, on the _____day of _____, the said _____ _____, Principal herein, executed a certain Contract with West County Wastewater, by the terms, conditions, and provisions of which Contract the said _____, Principal herein agrees to construct the WQRRP Electrical Improvements Project in Richmond, Contra Costa County, California, all as set forth in said Contract, which Contract as so executed is attached hereto, and by reference is incorporated herein and made a part hereof as fully for all purposes as if here set forth at length.

NOW, THEREFORE, if the Principal herein shall faithfully and truly observe and comply with the terms, conditions, and provisions of said Contract in all respects, and shall well and truly and fully do and perform all matters and things undertaken to be performed under said Contract, upon the terms set forth therein, and within the time prescribed therein, and shall indemnify West County Wastewater against any direct or indirect damages that shall be claimed for injuries to persons or property during the course of any work performed by or on behalf of Principal under said Contract, and until all work under said Contract is accepted and for an additional period of one year after completion and acceptance of said work by West County Wastewater and shall pay all laborers, mechanics, subcontractors, material, men, and all persons who shall supply such Contractor or subcontractor with services or supplies for carrying on such work, and shall perform said Contract according to laws, and shall complete in a satisfactory manner all repairs or replacements resulting from or caused by defective materials and/or faulty workmanship in the prosecution of the work during the one-year warranty period, then this obligation shall be void, otherwise it shall remain in full force and effect. No prepayment or delay in payment and no change, extension, addition, or alteration of any provision of said Contract agreed to between the Principal and West County Wastewater, and no forbearance on the part of West County Wastewater, shall operate to relieve any surety from liability on this Bond, and consent to make such changes, extension, additions, and alternations without further notice to or consent by any Surety is hereby given.

In the event suit is brought upon this bond by West County Wastewater and judgment is entered in its favor, the Surety or Sureties shall pay all costs incurred by West County Wastewater in such suit, including attorneys' fees to be fixed by the court.

Date_____

_____
Company Name

_____
Principal (Authorized Signature)

_____
Business Address

_____
City State

SEE NEXT PAGE FOR ACKNOWLEDGMENT OF PRINCIPAL'S SIGNATURE

[THE REMAINDER OF THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK]

ACKNOWLEDGMENT OF PRINCIPAL'S SIGNATURE:

A notary public or other officer completing this certificate verifies only the identity of the individual who signed the document to which this certificate is attached, and not the truthfulness, accuracy, or validity of that document.

State of California)
County of _____)

On _____before me _____, a Notary
(Date) (Printed Name of Notary Public)

Public, personally appeared _____
Name(s) of Signer(s)

_____

who proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies) and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

I Certify under PENALTY OF PERJURY under the laws of the State of California that the foregoing paragraph is true and correct.

WITNESS my hand and official seal.

Signature_____
Signature of Notary Public

Place Notary Seal Above

This Section is OPTIONAL completing this information can deter alteration of the document or fraudulent reattachment of this form to an unintended document

Description of Attached Document
Title or Type of Document:

_____
Document Date_____
Number of Pages_____
Signer(s) other than named within

_____
Capacity(ies) Claimed by Signer(s):
Signer's Name:_____

☐ CORPORATE OFFICER

_____
Title(s)
☐ PARTNER
☐ Limited ☐ General
☐ INDIVIDUAL
☐ ATTORNEY-IN-FACT
☐ TRUSTEE
☐ GUARDIAN / CONSERVATOR
☐ OTHER
Describe_____

SIGNER IS REPRESENTING:

Name of Person(s) or Entity(ies)
_____
_____
_____

Date_____

_____
Company Name

_____
Surety (Authorized Signature)

_____
Business Address

_____
City State

SEE NEXT PAGE FOR ACKNOWLEDGMENT OF SURETY'S SIGNATURE

[THE REMAINDER OF THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK]

ACKNOWLEDGMENT OF SURETY'S SIGNATURE:

A notary public or other officer completing this certificate verifies only the identity of the individual who signed the document to which this certificate is attached, and not the truthfulness, accuracy, or validity of that document.

State of California)
County of _____)

On _____before me _____, a Notary
(Date) (Printed Name of Notary Public)

Public, personally appeared _____
Name(s) of Signer(s)
_____

who proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies) and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

I Certify under PENALTY OF PERJURY under the laws of the State of California that the foregoing paragraph is true and correct.

WITNESS my hand and official seal.

Signature_____
Place Notary Seal Above Signature of Notary Public

This Section is OPTIONAL completing this information can deter alteration of the document or fraudulent reattachment of this form to an unintended document

Description of Attached Document
Title or Type of Document:
_____
Document Date_____
Number of Pages_____
Signer(s) other than named within
_____
Capacity(ies) Claimed by Signer(s):
Signer's Name:_____

☐ CORPORATE OFFICER
_____
Title(s)
☐ PARTNER
☐ Limited ☐ General
☐ INDIVIDUAL
☐ ATTORNEY-IN-FACT
☐ TRUSTEE
☐ GUARDIAN / CONSERVATOR
☐ OTHER
Describe_____

SIGNER IS REPRESENTING:

Name of Person(s) or Entity(ies)
_____
_____
_____

SECTION 00 61 14
PAYMENT BOND

We, _____, as Principal, and _____, as Surety, are jointly and severally bound unto the West County Wastewater, organized and existing under the laws of the State of California, in the sum of _____ dollars (_____) for the payment of which we jointly and severally bind ourselves, our heirs, executors, administrators and assigns, and successors and assigns, firmly by these presents.

THE CONDITION OF THIS BOND IS SUCH THAT, WHEREAS, on the _____ day of _____, 20__, the said _____ _____, Principal herein, executed a certain Contract with West County Wastewater, by the terms, conditions, and provisions of which Contract the said_____, _____, Principal herein agrees to construct the 20PP501, in Richmond, Contra Costa County, California, all as set forth in said Contract, which Contract as so executed is attached hereto, and by reference is incorporated herein and made a part hereof as fully for all purposes as if here set forth at length.

AND WHEREAS, said Contractor is required by the provisions of Chapter 7, Title 15, Sections 3247 though 3252, California Civil Code, to furnish a bond in connection with said Contract, as hereinafter set forth.

THE CONDITIONS OF THIS OBLIGATION ARE SUCH, that if said Contractor, its heirs, executors, administrators, successors, or assigns, or subcontractors, shall fail to pay any of the persons named in Sections 3110, 3111, and 3112 of the California Civil Code, or amounts due under the Unemployment Insurance Code with respect to work or labor performed by any such claimant, or for any amount required to be deducted, withheld, and paid over to the California Franchise Tax Board from the wages and employees of the Contractor and its subcontractors pursuant to Section 18806 of the California Revenue and Taxation Code, with respect to such Contract and warranty work and labor that the surety or sureties will pay for the same, in an amount not exceeding the sum specified in this Bond, and also, in case suit is brought upon the bond, a reasonable attorney's fee, to be fixed by the court.

This Bond shall inure to the benefit of any and all of the persons name in Sections 3110, 3111, and 3112 of the California Civil Code as to give a right of action to such persons or their assigns in any

suit brought upon this Bond in accordance with said Sections 3247 though 3252 of the California Civil Code.

In the event suit is brought upon this Bond and judgment is recovered, the Surety shall pay all costs incurred by West County Wastewater in such suit, including reasonable attorney's fees to be fixed by the court.

No prepayment or delay in payment and no change, extension, addition, or alternation of any provision of said Contract agreed to between the Contractor and West County Wastewater, and no forbearance on the part of West County Wastewater, shall operate to relieve any Surety from liability of this Bond, and consent to make such changes, extensions, additions, and alternations without further notice to or consent by such Surety is hereby given.

Date_____

_____
Company Name

_____
Principal (Authorized Signature)

_____
Business Address

_____
City State

SEE NEXT PAGE FOR ACKNOWLEDGMENT OF PRINCIPAL'S SIGNATURE

[THE REMAINDER OF THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK]

ACKNOWLEDGMENT OF PRINCIPAL'S SIGNATURE:

A notary public or other officer completing this certificate verifies only the identity of the individual who signed the document to which this certificate is attached, and not the truthfulness, accuracy, or validity of that document.

State of California)
County of _____)

On _____before me _____, a Notary
(Date) (Printed Name of Notary Public)

Public, personally appeared _____
Name(s) of Signer(s)

_____

who proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies) and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

I Certify under PENALTY OF PERJURY under the laws of the State of California that the foregoing paragraph is true and correct.

WITNESS my hand and official seal.

Signature_____
Signature of Notary Public

Place Notary Seal Above

This Section is OPTIONAL completing this information can deter alteration of the document or fraudulent reattachment of this form to an unintended document

Description of Attached Document
Title or Type of Document:

_____
Document Date_____
Number of Pages_____
Signer(s) other than named within

_____
Capacity(ies) Claimed by Signer(s):
Signer's Name:_____

☐ CORPORATE OFFICER

_____
Title(s)
☐ PARTNER
☐ Limited ☐ General
☐ INDIVIDUAL
☐ ATTORNEY-IN-FACT
☐ TRUSTEE
☐ GUARDIAN / CONSERVATOR
☐ OTHER
Describe_____

SIGNER IS REPRESENTING:

Name of Person(s) or Entity(ies)
_____
_____
_____

Date_____

_____
Company Name

_____
Surety (Authorized Signature)

_____
Business Address

_____
City State

SEE NEXT PAGE FOR ACKNOWLEDGMENT OF SURETY'S SIGNATURE

[THE REMAINDER OF THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK]

ACKNOWLEDGMENT OF SURETY'S SIGNATURE:

A notary public or other officer completing this certificate verifies only the identity of the individual who signed the document to which this certificate is attached, and not the truthfulness, accuracy, or validity of that document.

State of California)
County of _____)

On _____before me _____, a Notary
(Date) (Printed Name of Notary Public)

Public, personally appeared _____
Name(s) of Signer(s)

_____

who proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies) and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

I Certify under PENALTY OF PERJURY under the laws of the State of California that the foregoing paragraph is true and correct.

WITNESS my hand and official seal.

Signature_____
Signature of Notary Public

Place Notary Seal Above

This Section is OPTIONAL completing this information can deter alteration of the document or fraudulent reattachment of this form to an unintended document

Description of Attached Document
Title or Type of Document:

_____
Document Date_____
Number of Pages_____
Signer(s) other than named within

_____
Capacity(ies) Claimed by Signer(s):
Signer's Name:_____

☐ CORPORATE OFFICER

_____
Title(s)
☐ PARTNER
☐ Limited ☐ General
☐ INDIVIDUAL
☐ ATTORNEY-IN-FACT
☐ TRUSTEE
☐ GUARDIAN / CONSERVATOR
☐ OTHER
Describe_____

SIGNER IS REPRESENTING:

Name of Person(s) or Entity(ies)
_____
_____
_____

END OF GROUP 00 61 00

SECTION 00 72 00
GENERAL CONDITIONS

Section	Title
00 72 01	Authority of the Engineer and Contractor's Appeal Procedure
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00 72 58	(Not Used)
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GENERAL CONDITIONS

00 72 01 AUTHORITY OF THE ENGINEER AND CONTRACTOR'S APPEAL PROCEDURE

A. Authority of the Engineer

1. The "Engineer" is the Infrastructure and Planning Department Manager of West County Wastewater or the Engineer's duly authorized representative during the life of the Contract. The engineer will observe the work in progress on behalf of West County Wastewater. All questions and requests of the Contractor regarding compensation (including additional compensation), interpretation of the Contract, instructions, or extensions of time, shall be submitted in writing to the Engineer for determination.

2. The Engineer may determine the amount, quality, acceptability, and fitness of all work, materials, and equipment required by the Contract.

3. The Engineer will decide all questions which may arise as to the quality or acceptability of materials furnished and work performed and as to the manner of performance and rate of progress of the work, and the Engineer's decision will be final.

4. The Engineer will decide all questions which may arise as to the coordination and interpretation of the plans and specifications, and the Engineer's decision will be final.

5. The Engineer will decide all questions as to the acceptable fulfillment of the Contract by the Contractor, and the Engineer's decision will be final.

6. The Engineer will decide all questions as to measurement and payment, and the Engineer's decision will be final.

7. The Engineer may reject defective work and materials whenever such rejection may be necessary to assure execution of the Contract in accordance with the intent of the Contract Documents.

8. The Engineer will determine all amounts owing to the Contractor.

9. The Engineer will prepare/issue contract change orders for all authorized changes or approved extra work in the Contract.

10. The Engineer will monitor project schedules and enforce project schedule requirements, and take such measures as may be necessary to maintain overall project schedules.

11. The Engineer may enforce and to make effective such decisions and orders which the Contractor fails to carry out promptly.

12. All determinations and instructions of the Engineer, whether in response to a question or otherwise, will be final unless the Contractor files a written protest with the Engineer as set forth in this Section.

B. Contractor's Responsibilities and Appeal Procedure

1. The Contractor shall be solely responsible for requesting instructions or interpretations as required by the Contract, and any costs and expenses, including attorneys' fees, arising from its failure to do so shall be borne by the Contractor.

2. The Contractor shall proceed without delay to perform the work as directed, instructed, determined, or decided by the Engineer and shall comply promptly with such directions, instructions, determinations, or decisions. If the Contractor has any objection thereto, the Contractor may, no later than ten calendar days after receiving any such directions, instructions, determinations, or decisions, require that any such direction, instruction, determination, or decision be put in writing. No later than ten calendar days after receipt of any such written determination, the Contractor may file a written protest with the Engineer stating clearly and in detail the Contractor's objections, the reasons therefor, and the nature and amount of additional compensation or extension of time, if any, to which the Contractor contends it will be entitled thereby. The Contractor shall perform the work that the Contractor may contend as being outside the scope of the Contract while the Contractor's protest is being considered. However, unless the Contractor has been ordered by West County Wastewater pursuant to Section 00 72 12.E., Request for Additional Compensation, to perform changes or extra work, Contractor will not be entitled to additional compensation. The Contractor shall prepare daily cost records and obtain an acknowledgment by the Engineer in accordance with 00 72 12C, Cost Plus Change Orders.

3. The Engineer will issue a decision upon each protest. If the Engineer determines that the facts support the protest, the Contract will be modified accordingly, in writing. If the Engineer determines that the facts do not support the protest, the request for modification, the Engineer will deny the request. The Engineer will provide its determination to the Contractor and that determination will be final and conclusive. the Contractor shall at all times proceed with the work in accordance with the direction, instruction, determination, or decision of the Engineer. Unless the Contractor follows the requirements of this Section 00 72 01, the Contractor will be deemed to have waived all grounds for protest of direction, instruction, determination, or decision and all claims for additional compensation, extensions of time, or damages resulting therefrom for which protest could have been made under

this Section 00 72 01, and Contractor will also be deemed to have accepted the direction, instruction, determination, or decision.

4. If the Contractor has outstanding claim issues upon acceptance of the contract work by West County Wastewater, the Contractor shall, no later than 30 calendar days after the date of acceptance, submit to the Engineer a written statement of all claims it maintains exist arising under or by virtue of the Contract. No claim will be considered that is not clearly identified in the written statement of claims, and no claim will be recognized for which a notice or protest is not prosecuted as provided in Sections 00 72 11, Differing Site Conditions,; 00 72 12, Changes and Extra Work; 00 72 42, Liquidated Damages; and 00 72 53, Utility and Other Existing Facilities within these General Conditions.

    a. Claims filed by the Contractor must be presented in sufficient detail to enable the Engineer to ascertain each claim's basis and amount. The Engineer will review and consider each claim; however, the Contractor must furnish, within a reasonable time, such further information and details as Engineer requests to ascertain the facts or contentions underlying the Contractor's claim. If the Contractor fails to submit such requested information and details for a claim, that failure will be sufficient to permit West County Wastewater to deny that claim.

    b. Upon final determination of all claims, the Engineer will prepare and issue a final payment in the entire sum found due on the claims.

00 72 02 INTENT OF THE CONTRACT

A. All obligations of West County Wastewater and the Contractor are fully set forth and described in the Contract. All parts of the Contract are intended to be correlative and complementary, and any work required by one part and not mentioned in another part must be performed to the same extent and purpose as though required by all parts.

B. The organization of the Contract Documents into sections, parts, and subsections and the arrangement of the contract plans shall not necessarily control the Contractor in dividing any work among any of its subcontractors or in establishing the extent of work to be performed by any trade or craft. The headings or titles of any article, section, subsection, paragraph, provision, or part of the Contract will not limit or restrict the content, meaning, or effect of such article, section, subsection, paragraph, provision, or part. Titles assigned to the various sections and subsections do not necessarily limit the scope of the topic, but are assigned solely to designate a central theme which may be further addressed by either volumes, parts, sections, or subsections for particular applications. The absence of a reference in any one to other such sections, parts, or subsections will not waive the requirements otherwise applicable to the work in its entirety. All sections of the Specifications and Project Drawings are interdependent and applicable to the Project as a whole.

C. Where the words "as shown," "as detailed," "as indicated," or similar words are used in the Contract, such references relate to the Project Drawings unless the context clearly indicates a different meaning. Where the words "required," "approved," "determined," "acceptable," "favorably reviewed," "reviewed," "selected," "directed," "equivalent," "equal," "satisfactory," or similar words are used in the Contract, action by the Engineer or West County Wastewater is indicated unless the context indicates otherwise, and the Contractor shall perform all work in accordance therewith. Such action, or failure to act, will not relieve the Contractor of its contractual responsibilities for performing the Contract.

D. The Contractor shall perform the work in accordance with the terms of the Contract. The Specifications and all notes on the Project Drawings are directed to the Contractor and Contractor shall perform all work even though phrases such as "the Contractor shall" or "shall be done by the Contractor" are omitted. Where portions of the work are described in general terms, but not in complete detail, the Contractor shall perform the work utilizing skilled trade persons and high quality material. Unless otherwise specified such as deep excavation/shoring, traffic control, or detail design where a registered professional engineer shall be required, the Contractor shall furnish all labor, materials, tools, equipment, and incidentals and do all the work involved in executing the Contract in a timely, satisfactory, and workmanlike manner.

E. The misplacement, addition, or omission of a word or character does not change the intent of any part of the Contract from that set forth in the Contract as a whole.

F. The masculine/feminine pronoun may be used to designate who performs the work and for other purposes and, in all cases, applies equally to all persons. The word "Contractor" as used in the Contract applies to the General Contractor. If the Contractor is a partnership or joint venture, the members of the partnership or joint venture will be jointly and severally liable notwithstanding any agreement as between themselves to the contrary.

00 72 03 DISCOVERY OF ERRORS, OMISSIONS, OR DISCREPANCIES IN THE CONTRACT

A. By execution of the Contract, the Contractor agrees that no request for additional compensation, and/or claim under Government Code Section 900 et seq. will be made against West County Wastewater for any damages in excess of the aggregate sum of $50,000 or five percent (5%) of the construction costs (whichever is greater) for alleged damage that it or its subcontractors may suffer due to the inadequacy of the Contractor's bid on account of any alleged errors, omissions, or other deficiencies in the Contract Documents supplied to it by West County Wastewater. This limitation will not apply to claims for compensation for extra work authorized by West County Wastewater pursuant to Section 00 72 12, Changes and Extra Work, and Section 00 72 11, Differing Site Conditions.

B. If the Contractor discovers any errors, omissions, discrepancies, or conflicts in the Contract, it shall immediately so inform the Engineer in writing. The Engineer will promptly clarify such matters by issuing addenda or change orders. The Engineer's failure or delay to act upon such a notice will not constitute a waiver of any right afforded West County Wastewater or the Engineer in the Contract Documents or constitute an implied approval. Any work affected by such discoveries that the Contractor performs before it receives authorization by West County Wastewater to perform the work shall be at the Contractor's risk.

00 72 04 SUBCONTRACTS, SUBCONTRACTORS, AND RECORDS ACCESS

A. By written agreement, if legally required for validity, the Contractor shall require each subcontractor, to the extent of the work to be performed by the subcontractor, to be bound to the Contractor by the terms of the Contract, and to assume toward the Contractor all of the obligations and responsibilities which the Contractor, by this contract, assumes toward West County Wastewater. Such agreements must preserve and protect the rights of West County Wastewater under the Contract with respect to the work to be performed by the subcontractors so that the subcontractors will not prejudice such rights. Where appropriate, the Contractor shall require such subcontractor to enter into similar agreements with its subcontractors, and for each tier thereafter. The Contractor shall make available to each proposed subcontractor, prior to execution of the subcontract, copies of the Contract Documents for which the subcontractor will be bound by this paragraph of this subsection and identify to the subcontractor any terms and conditions of the proposed subcontract which may be at variance with the Contract.

1. Each subcontractor shall make copies of these Contract Documents, including, but not limited to, the above specific provisions, available to its sub-subcontractors and for each tier thereafter.

2. The Contractor shall give its personal attention to the fulfillment of the Contract and shall keep the work under its control in accordance with the Contract.

B. Neither Contractor nor any subcontractor may enter into any subcontract and the Contractor shall not substitute any person as subcontractor in place of a subcontractor listed in its bid without West County Wastewater's prior written consent. West County Wastewater, at its discretion, may consent to a subcontractor substitution as provided by law. No subcontract may relieve the Contractor of any of its liabilities or obligations under the Contract; the Contractor shall be fully responsible to West County Wastewater for the acts and omissions of its subcontractors at any tier and of persons either directly or indirectly employed by subcontractors in the performance of the Contract. The Contractor shall assure that each subcontractor at any tier fully complies with the provisions of the applicable Workers' Compensation Act or any similar law having application to subcontractor's employees.

C. Unless otherwise provided in the Contract, the Contractor shall at its expense, upon request of the Engineer, furnish the Engineer with one (1) copy of all of its purchase orders and subcontracts, all applicable drawings and specifications, bills of lading, and data, at all tiers, provided that only the prices thereon may be deleted. The Contractor shall ensure that all subcontracts at all tiers contain a provision for furnishing the Contractor with copies of the subcontracts and purchase orders, with the prices thereon deleted. The Contractor shall include Section 00 52 13, Contract, in all subcontracts at all tiers. Failure of the Contractor or any of its subcontractors at any tier to comply with this provision will be considered as grounds for termination of the Contract at the Contractor's expense in accordance with Section 00 72 36, Termination of Right To Proceed.

D. Nothing contained in the Contract creates any contractual relationship between any subcontractor and West County Wastewater.

E. The Contractor shall at all times be responsible for the safety of its subcontractors' employees at any tier and for its subcontractors' plant and equipment at any tier; and Contractor's method of prosecuting the work and shall ensure the compliance, by all subcontractors' employees at any tier, with all local, state, and federal safety regulations and West County Wastewater's Safety Requirements as may be applicable to the performance of the work.

F. The Contractor shall at all times be responsible for the adequacy, efficiency, and sufficiency of its subcontractor at any tier or persons employed by the subcontractors. All workers shall have sufficient knowledge, skill and experience to properly perform the work assigned to them.

G. When a portion of the work subcontracted by the Contractor is not being prosecuted in a manner satisfactory to West County Wastewater, the Contractor shall cause that subcontractor's forces to be removed immediately upon the request of the Engineer and that subcontractor's forces may not again be employed on the work.

00 72 05 ASSIGNMENT

A. The Contractor, its heirs, executors, administrators, or successors may not assign any performance of work under this Contract without the prior written consent of West County Wastewater. West County Wastewater will not provide consent for any proposed assignment that would, by any instrument, relieve the original Contractor or its Surety of their obligations under the Contract.

B. The Contractor may assign monies due or to become due it under the Contract, to the extent permitted by law. West County Wastewater will recognize such an assignment if Contractor provides written notice of the assignment to the Engineer no later than ten calendar days before a payment is due. Any assignment of monies will be subject to all proper set-offs in favor of West County Wastewater and to all deductions provided for in the Contract. All monies withheld, whether assigned or not, will be subject to being used by West County Wastewater for the completion of

the work in the event that the Contractor should be in default or for the payment of claims or liens against the work from any source.

00 72 06 WAIVER OF CONTRACT PROVISIONS

A. None of the provisions of the Contract shall be considered waived by West County Wastewater unless such waiver is expressly given in writing by the Engineer. No such waiver shall be a waiver of any past or future default, breach, or modification of any of the terms, provisions, conditions, or covenants of the Contract unless expressly set forth in such waiver.

00 72 07 DELIVERY OF NOTICE

A. The Engineer or West County Wastewater may deliver any written notice under this Contract to the Contractor in person to the Contractor's authorized representative or may mail the notice to the address last given in writing by the Contractor.

B. The Contractor shall mail or deliver to West County Wastewater's authorized representative on this Contract any written notice under this Contract. West County Wastewater's will identify its authorized representative in its award letter.

00 72 08 INDEMNITY

A. The Contractor shall indemnify, defend, and hold harmless West County Wastewater, its officers, directors, employees, representatives, and agents and each of them, from and against any and all suits, actions, legal or administrative proceedings, claims, demands, damages, consequential damages, liabilities, interest, attorneys' fees and costs, and expenses of whatsoever kind or nature whether arising before or after Final Acceptance and in any manner, whether or not well founded in fact or in law and, directly or indirectly caused, occasioned, or contributed to in whole or in part, or claimed to be caused, occasioned, or contributed to in whole or in part, by reason of any act, omission, fault, or negligence whether active or passive of the Contractor or of anyone acting under the Contractor's direction, control, or on the Contractor's behalf in connection with or incident to performance of the Contract. Without limiting the generality of the previous sentence, Contractor's indemnity obligations under this Section 00 72 08 include injury to or death of any person or persons and damage to any property, regardless of where located, including without limitation the property of West County Wastewater, the Contractor's employees, and all other persons. The Contractor's indemnity and hold -harmless obligations set forth in this Section 00 72 08 are not applicable to any liability caused by the active negligence or willful misconduct of West County Wastewater, its officers, directors, employees, representatives, or agents.

B. The Contractor shall include in each agreement with each of its subcontractors at all tiers a provision requiring that the subcontractor indemnify and hold harmless West County Wastewater, its officers, directors, employees, representatives, and agents and each of them, from and against claims, damages, losses, and expenses including, but not limited to, attorneys' fees arising out of or resulting from the

performance of the subcontractor's work under the Contract, provided that such claim, damage, loss, or expense is attributable to bodily injury, sickness, disease or death, or to injury to or destruction of property, including loss of use resulting therefrom, to the extent such loss or injury is caused in whole or in part by the negligent acts or omissions of the Subcontractor, anyone directly or indirectly employed by the Subcontractor, or anyone for whose acts the Subcontractor may be liable. The Subcontractor's indemnity and hold-harmless obligations set forth in this Section 00 72 08 are not applicable to any liability caused by the active negligence or willful misconduct of West County Wastewater, its officers, directors, employees, or agents.

00 72 09 PATENT INDEMNITY

A. The Contractor shall pay all licenses, copyrights, fees, and royalties and assume all costs incident to the use and performance of the work, or the incorporation in the work, of any invention, design, process, product, or device which is the subject of patent rights or copyrights held by others. The Contractor shall indemnify, defend, and save harmless West County Wastewater, its officers, directors, employees, representatives, and agents, and each of them, from and against all claims, losses, costs, damages, consequential damages, and expenses, including attorneys' fees, incurred by West County Wastewater, its officers, directors, employees, representatives, and agents as a result of or in connection with any claims or actions based upon infringement or alleged infringement of any patent and/or copyright and arising out of the use of the materials, equipment, and/or products furnished under the Contract by the Contractor, or out of the processes or actions employed by, or on behalf of, the Contractor in connection with the performance of the Contract. The Contractor shall, at its expense, promptly defend against any such claim or action whether or not well founded in fact or in law, provided that West County Wastewater shall have notified the Contractor upon becoming aware of such claims or actions, and provided further that the Contractor's aforementioned obligations shall not apply to equipment, materials, and/or products furnished or specified by West County Wastewater. The Contractor may, in order to avoid such claims or actions, substitute at its expense non-infringing equipment, materials, and/or products, or to modify at its expense such infringing equipment, materials, and/or products so they become non-infringing, provided that such substituted and modified equipment, materials, and/or products meet all the requirements and are subject to all the provisions of the Contract.

00 72 10 WARRANTY

A. The Contractor represents that the work performed pursuant to the Contract will be of the quality specified or of the highest quality if no quality is specified, and will conform to the Specifications, Drawings, samples, and all other parts of the Contract. The Contractor warrants all equipment, material, products, and workmanship furnished and all work performed under the Contract against defects for a period of one year after final acceptance regardless of whether the same were furnished or performed by the Contractor or by any of its subcontractors or suppliers of any tier.

B. The Contractor shall make, at its own expense, all repairs and/or replacements made necessary by defects in the equipment, materials, and/or products and in the workmanship provided by the Contractor or any of its subcontractors that become evident within the warranty period.

C. The Contractor shall, upon receipt of written notice from West County Wastewater of any breach of warranty during the applicable warranty period, redesign, repair or replace the affected item, and the Contractor shall perform such tests as West County Wastewater may require to verify that such redesign, repair, and replacement comply with the requirements of the Contract. West County Wastewater may operate and use such equipment, materials, and/or products until they can, without damage to West County Wastewater, be taken out of service for correction or replacement by the Contractor. The Contractor warrants all redesigned, repaired, or replaced work against defective design, equipment, materials, products, and workmanship for a period of one year from and after the date of satisfactory completion of such redesigned, repaired, or replaced work. West County Wastewater may require that the Contractor perform such repair or replacement work.

D. West County Wastewater also reserves the right to make such repairs or replacements, if, within seven calendar days after mailing a notice in writing to the Contractor and Surety, the Contractor does not make or undertake with due diligence the aforesaid repairs or replacements and Surety within seven calendar days after mailing a notice in writing of such failure of the Contractor neglects to make or undertake with due diligence the aforesaid repairs or replacements itself, provided, however, that in the case of an emergency where in the opinion of West County Wastewater delay would cause hazard to health or serious loss or damage, repair may be made without notice being sent to the Contractor or Surety, and the Contractor shall pay the cost of the repair.

E. All costs including workforce and materials incidental to such redesign, repair, replacement, and testing, including the removal, replacement, and reinstallation of equipment necessary to gain access, and all other costs incurred as the result of a breach of warranty shall be borne by the Contractor whether performed by West County Wastewater or the Contractor.

F. Nothing in this section may be construed to limit, relieve, or release the Contractor's, any subcontractor's, and any equipment, materials, and/or products suppliers', and any other service providers' liability to West County Wastewater for damages sustained as the result of latent defects in the workmanship, equipment, materials, and/or products done and/or furnished by the Contractor, its subcontractors, suppliers and/or other service providers.

G. The Performance Bond shall extend for a period of one year after West County Wastewater's acceptance of the Contract and shall cover the Contractor's obligations resulting from the warranty requirements specified in this Contract.

00 72 11 DIFFERING SITE CONDITIONS

A. The Contractor shall promptly, and before the following conditions are disturbed, notify the Engineer in writing of any:

1. Material that the Contractor believes may be hazardous waste, as defined in Section 25117 of the Health and Safety Code, that is required to be removed to a Class I, Class II, or Class III disposal site in accordance with provisions of existing law.

2. Subsurface or latent physical conditions at the site differing materially from those indicated in the Contract Documents.

3. Unknown physical conditions at the site of any unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in work of the character provided for in the Contract.

B. If Contractor disturbs or covers differing site conditions as described in Subsection A of this section before Contractor notifies the Engineer of or before the Engineer has had the opportunity to investigate the conditions, Contractor will waive any and all rights to recover additional compensation for increases in the Contractor's cost of, or receive an extension of the time required for, performance of any part of work impacted by such differing site conditions.

C. If Contractor determines that materially differing site conditions may be the basis for a request for additional compensation, the Contractor must follow the requirements of Section 00 72 12, Changes and Extra Work, Subsection E.

D. The Engineer will promptly investigate all claimed differing site conditions, and if the Engineer finds that the conditions: (1) are materially differing site conditions, or that they do involve hazardous waste: and (2) cause a decrease or increase in the Contractor's cost of, or the time required for, performance of any part of the work, the Engineer will issue a change order in accordance with Section 00 72 12, Changes and Extra Work.

E. If a dispute arises between West County Wastewater and the Contractor as to whether site conditions materially differ, or involve hazardous waste, or cause a decrease or increase in the Contractor's cost of, or time required for, performance of any part of the work, the Contractor will not receive an extension of time to meet any scheduled completion date provided for by the Contract, and Contractor shall proceed with all work to be performed under the Contract. If such a dispute arises, the Contractor retains any and all rights provided either by Contract or by law which pertain to the resolution of disputes and protests between the Parties.

00 72 12 CHANGES AND EXTRA WORK

A. General

1. The Engineer may, without invalidating the Contract and without notice to the Contractor's sureties, order changes in the work or extra work and/or furnish materials which may be required for the proper completion of the work or construction of the whole of the Project. The Contractor shall perform the work when so ordered. Any such change or request must be authorized in writing by the Engineer, provided that in the event of an emergency, which the Engineer determines endangers life or property, any work required by reason of such an emergency shall be performed in accordance with oral orders from the Engineer, which will be confirmed in writing as soon as practicable. Any such authorization by the Engineer, whether written or oral, may be accompanied by drawings and data as are necessary to show the extent of such change or extra work.

2. If the Engineer orders emergency work, the Contractor shall keep accurate records of its actual cost in accordance with Subsection 00 72 12.C, Cost Plus Change Orders, until such time as the Parties agree on compensation. Contractor's maintenance of such records does not require West County Wastewater to use the records as the means for determining compensation for the emergency work, and does not preclude the Parties' entry of an agreement for payment for the emergency work on a unit price or lump sum basis. Upon the determination of the compensation due to the Contractor for performing any emergency work, the Contract will be amended in writing by a Contract Change Order.

3. The Contractor shall commence and perform such changed or extra work to meet all requirements set forth in the Contractor's current Construction Schedule. If the Engineer determines that the performance of any such changes or extra work will cause any material change in that schedule, Contractor shall revise the schedule to reflect such change. Contractor shall submit a copy of the revised schedule to the Engineer.

4. If any change causes an increase or decrease in the Contractor's cost of, or any increase in the time required for, performance under the Contract, the Contract will be adjusted through a Contract Change Order. If the Parties agree on the basis of compensation as described in Subsection 00 72 12.B, Agreed Price Change Order, West County Wastewater shall issue a Contract Change Order. If the Parties do not reach agreement on the basis of compensation, the Contractor shall, upon receipt of written direction from the Engineer, proceed with the work in accordance with the provisions of Subsection 00 72 12.C, Cost Plus Change Orders.

5. West County Wastewater may engage another contractor to perform the work if such engagement is in West County Wastewater's best interest.

6. Should the Contractor, prior to opening of the bids, fail to notify West County Wastewater of patent ambiguities in the Contract Documents, the Contractor will not be eligible for an adjustment of the contract price or time extension on the basis of such ambiguities.

B. Agreed Price Change Orders

1. Unless otherwise required, the Contractor shall, no later than five calendar days after receipt of written authorization from the Engineer, submit in writing to the Engineer a proposal for accomplishing the changed or extra work. If the Contractor does not submit a proposal within the five calendar day period, the Engineer shall take into consideration Contractor's delay in submitting the proposal in evaluating any extensions of time requested by Contractor in conjunction with the changed or extra work. Contractor's proposal shall set forth any increase or decrease in cost to West County Wastewater in comparison to such cost had such change or extra work not been authorized. The proposal must state the basis of compensation for all work in connection with any such change or extra work.

2. The Contractor's proposal must contain sufficient detail to permit the Engineer to make a thorough analysis of the proposal. The Contractor's proposed basis for compensation shall be one of the following, which are listed in order of preference:

    a. Contract unit or lump sum prices, if applicable.

    b. New unit or lump sum prices.

    c. Cost plus with a price ceiling.

C. Cost Plus Change Orders

1. If the Contractor does not propose the method of compensation for such work or any part thereof, or if any proposed method is not acceptable, or if a method of compensation cannot be agreed upon, the Contractor shall proceed with the work and compensation will be made on a cost plus basis as set forth below. If at any time after the Contractor commences such work the Parties agree on a method of compensation other than cost plus, compensation will be made in accordance with that agreement.

2. The Contractor shall keep accurate records of the actual cost to the Contractor for the work. The Contractor shall keep the cost records as provided in the following subsections.

3. The Contractor will be paid its direct costs for labor, materials, and equipment used in performing the work as provided in paragraphs 12.C.6a, 12.C.6b, and 12.C.6c.

4. The total of the direct costs computed as provided in paragraphs 12.C.6a, 12.C.6b, and 12.C.6c, will be marked up as specified below. A markup of thirty-three (33) percent to the cost of labor, fifteen (15) percent to the cost of materials, and fifteen (15) percent to the equipment rental.

    a. When extra work is performed by a subcontractor, an additional markup of 5 percent will be added to the total cost of said extra work including all markups specified in this Section. This additional 5 percent markup will fully reimburse the Contractor for additional administrative costs, and West County Wastewater will not be required to pay any additional amount for performance of the extra work by a subcontractor.

5. The markups identified in this Subdivision C constitute full compensation of the Contractor for all profit and overhead costs. Such costs will include all items of expense not specifically designated below in C.6. as cost or equipment rental.

    a. Markups include, but are not limited to, compensation for field overhead, home office overhead, profit, builder's risk insurance, general and auto liability insurance, and performance and payment bond premiums.

        i. Home office overhead includes, but is not limited to:

            01. office rent, utilities, clerical staff, bidding and estimating, officer's salary, advertising, professional association dues, supplies, telephone, office equipment, transportation, staff consultants, and miscellaneous business expenses related to the project.

ii. Field overhead includes, but is not limited to:

01. job site utility expenses (including telephone), superintendent, project engineer, office engineer, secretary and other field office staff, field office, field office equipment and supplies, portable toilet, fencing, transportation for field office staff, general project cleanup.

b. The total payment made as provided is deemed to be the actual costs of such work and constitutes full compensation therefor.

6. Costs for labor, materials, and equipment that are eligible for inclusion in cost plus work, are described below:

a. Labor - The Contractor will be paid the cost of labor for the workers (including foremen when authorized by Engineer) used in the actual and direct performance of the work. The cost of labor, whether the employer is the Contractor or subcontractor will be the sum of the following:

i. Actual Wages - The actual wages paid include basic pay, overtime and shift premiums, any employer payments to or on behalf of the workers for health and welfare, pension, vacation, holidays and other miscellaneous payments (e.g. administration, occupational, health and research, annuity trust fund, supplemental unemployment benefits).

ii. Labor Surcharge – A labor surcharge will be added to the actual wages as defined above. The allowable markup rate shall be as set forth in the California Business and Transportation Agency's Department of Transportation publication entitled, Labor Surcharge and Equipment Rental Rates, that is in effect on the date upon which the work is accomplished and which is made a part of the Contract. The labor surcharge will constitute full compensation for all other payments made to, or on behalf of, the workers including workers' compensation insurance with a waiver of subrogation, social security, State unemployment insurance, and Federal unemployment insurance and excluding actual wages as defined above and subsistence and travel allowance as specified below.

iii. Subsistence and Travel Allowance - The actual subsistence and travel allowance paid to such workers.

b. Materials –The Contractor may be compensated for the cost of materials furnished by the Contractor for use in performing any change or extra work provided use of the materials was as specifically authorized, and the actual use was verified by the Engineer. Compensable charges will be calculated as the net cost to the Contractor delivered at the job. West County Wastewater reserves the right to furnish such materials as it deems advisable, and the Contractor will not be compensated for costs and markup on those materials.

   i. Contractor shall document the use of all materials for extra work with copies of vendor's invoices. Such invoices shall be submitted with the related Daily Extra Work reports or, if not available for submittal with the Daily Extra Work reports, they must be properly identified and promptly transmitted to the Engineer. The vendor's invoices must be submitted to the Engineer no later than 60 days after the date of delivery of the material or within 15 days after the acceptance of the Contract in accordance with Section 00 72 41, Final Payment and Release, or West County Wastewater will establish the cost of such materials at the lowest wholesale prices at which the materials are available in the quantities required, F.O.B. at the required locations of work, less any cash or trade discounts provided.

c. Equipment Rental - The Contractor will be paid for the use of the equipment at the rental rates listed for such equipment in the State of California Department of Transportation publication entitled Labor Surcharge and Equipment Rental Rates in effect on the date upon which the work is accomplished that is a part of the Contract, regardless of ownership and any rental or other agreement for the use of such equipment entered into by the Contractor. If it is deemed necessary by the Engineer to use equipment not listed in that said publication, the Engineer shall established a suitable rental rate for that equipment. The Contractor may furnish any cost data which might assist the Engineer in the establishment of such rental rate.

   i. The rental rates paid as provided above include the cost of fuel, oil, lubrication, supplies, small tools, necessary attachments, repairs and maintenance of any kind, depreciation, storage, insurance, and all incidentals.

   ii. Individual pieces of equipment or tools not listed in the publication which have a replacement value of five hundred dollars ($500) or less, whether or not consumed by use, will be considered to be small tools and no payment will be for that equipment or those tools.

   iii. Rental time will not be allowed while equipment is inoperative due to breakdowns.

iv. Equipment on the Work - The rental time to be paid for equipment used will be the time the equipment is in operation on the extra work being performed and, in addition, the time required to move the equipment to the location of the extra work and return it to the original location or to another location requiring no more time than required to return it to its original location. Moving time will not be paid for if the equipment is used at the site of the extra work on work other than the extra work. Loading and transporting costs will be allowed, in lieu of moving time, when the equipment is moved by means other than its own power, except that no payment will be made if the equipment is used at the site of the extra work on work other than the extra work. The following shall be used in computing the rental time of equipment on the work:

01. When hourly rates are listed, less than thirty (30) minutes of operation will be considered to be one-half hour of operation.

02. When daily rates are listed, less than four hours of operation will be considered one-half day of operation.

v. Equipment not on the Work - For the use of equipment moved in on the work and used exclusively for extra work, the Contractor will be paid the rental rates listed in the State of California Department of Transportation publication entitled Labor Surcharge and Equipment Rental Rates is in effect on the date upon which the work is performed and which is a part of the Contract, or determined as provided in this subsection, and for the cost of transporting the equipment to the location of the work and its return to its original location, all in accordance with the following provisions:

01. The Contractor and the Engineer shall agree in advance as to the original location of the equipment to be hauled to the location of the work.

02. West County Wastewater will pay the costs of loading and unloading such equipment.

03. The cost of transporting equipment shall not exceed the applicable minimum established rates of the Public Utilities Commission.

04. The rental period begins at the time the equipment is unloaded at the site of the extra work and will include each day that the equipment is at the site of the extra work, excluding Saturdays, Sundays, and West County Wastewater-observed holidays and days of temporary suspension of the work unless the equipment is used to perform the extra work on such days. The rental period terminates at the end of the day on which the Engineer directs the Contractor to discontinue the use of the equipment. The rental time to be paid per day will be in accordance with the following:

Hours Equipment is in Operation	Hours to be Paid
0.5	4.25
1.0	4.50
1.5	4.75
2.0	5.00
2.5	5.25
3.0	5.50
3.5	5.75
4.0	6.00
4.5	6.25
5.0	6.50
5.5	6.75
6.0	7.00
6.5	7.25
7.0	7.50
7.5	7.75
8.0	8.00

- The hours to be paid for equipment that is operated less than eight hours due to breakdowns will not exceed eight hours less the number of hours the equipment is inoperative due to breakdowns.

- When hourly rates are listed, less than 30 minutes of operation will be considered one-half (½) hour of operation.

- When daily rates are listed, payment for one-half (½) day will be made if the equipment is not used. If the equipment is used, payment will be made for one day.

- The minimum rental time to be paid for the entire rental period on an hourly basis will not be less than eight 8 hours or if on a daily basis not less than one day.

- If the Contractor opts to return the equipment to a location other than its original location, West County Wastewater will pay the cost of transportation in accordance with the above provisions, providing that the payment does not exceed the cost of moving the equipment to the work.

- West County Wastewater will not pay for transporting, loading, and unloading equipment if the equipment is used on the work in any other way than upon extra work.

vi. If the Contractor elects to move equipment to perform the work before the equipment is used or elects to delay the return of the equipment to its original location, West County Wastewater will not compensate the Contractor for the time the equipment is idle before and after it has been used on the extra work.

d. Bonds - The markups referred to in this subsection shall include full compensation for all additional bonding costs the Contractor may incur as a result of the extra work. No additional percentage increase will be allowed to these markups for bonding costs.

e. Contractor shall remove, repair or reconstruct defective work performed under cost plus procedures to the satisfaction of the Engineer at no additional cost to West County Wastewater.

7. The Contractor shall maintain its cost records and records of its subcontractors and special forces to provide a clear distinction between the costs of other operations and the direct costs of extra work paid for in accordance with this Section 00 72 12, Changes and Extra Work. Contractor must document its performance of extra work on a daily basis in accordance with the following:

   a. The Contractor shall furnish the Engineer with completed daily extra work reports, on forms furnished by West County Wastewater, for each day's work Contractor contends is payable on an extra work basis. The daily extra work reports must itemize the materials used, the direct cost of applicable labor, and the charges for equipment used, whether furnished by the Contractor, subcontractor, or other forces. The daily extra work report itemizations for labor must provide names or identifications and classifications of all workers, the hourly rate of pay, and hours worked on extra work. Itemized equipment records must provide the size, type, and identification number of equipment and hours operated for extra work.

b. All daily extra work reports shall be signed by the Contractor or its authorized representative.

c. The Engineer will compare its records with the completed daily extra work reports furnished by the Contractor and make any necessary adjustments. When the daily extra work reports are agreed upon and signed by both parties, the reports will be the basis of payment for the work performed. These reports may be adjusted based upon later audits that may be performed by West County Wastewater.

D. The quantities set forth in Section 00 41 43, Schedule of Bid, are approximations only. If there is a variation in the estimated quantity by more than 150 percent or less than 50 percent of the bid quantity, either West County Wastewater or the Contractor may notify the other party of its intention to renegotiate the contract unit price with respect to those quantities outside of the permitted range of 50 percent below to 150 percent above the bid quantity.

1. Any estimated quantity from a maximum of 150 percent of the bid quantity to a minimum of 50 percent of the bid quantity will be paid for at the contract unit price. Such quantities will be determined by the Engineer at the Engineer's discretion in accordance with the applicable measurement provisions of the Contract using such methods as the Engineer considers appropriate for the class of work to be measured, including, but not limited to, the method of average end area computed from cross sections grid system or topographic contours. If the Engineer determines it to be necessary , prismoidal corrections, or corrections for curvature in alignment, will be employed. The planimeter shall be considered an instrument of accuracy adapted to measurement of areas. The dividing limits, lines, or planes between adjacent items or classes or excavation, concrete, or other types of work, where not specifically set forth in the Contract, will be as determined by the Engineer.

E. Requests for Additional Compensation

1. Unless the Contractor has been ordered by West County Wastewater to perform changes or extra work pursuant to Section 00 72 12, Changes and Extra Work, West County Wastewater will not consider payment of additional compensation to the Contractor unless the Contractor follows the procedures set forth in this subsection. For the purposes of the Contract, a request for additional compensation means any request for compensation in excess of the contract amount (as amended by addenda and/or change orders) arising out of the conduct of the work and includes, but is not limited to, requests for compensation arising out of changed site conditions, delays occasioned by the owner or third parties, and such other compensation arising out of interference with the work which is not the responsibility of the Contractor.

2. Immediately upon learning of a condition, occurrence, or circumstance that potentially will give rise to a request for additional compensation the Contractor must notify the Engineer of that condition, occurrence or circumstance. If the Contractor's initial notification is oral, it must confirm the notification in writing no later than five calendar days after the oral notification. The Contractor may not proceed with the work involving a potential request for additional compensation without notifying the Engineer of the subject conditions, occurrence or circumstance unless an emergency exists or unless it is impossible to notify the Engineer without creating an unreasonable delay in the work.

3. No later than 14 calendar days after learning of such condition, occurrence or circumstance, the Contractor shall submit to the Engineer a detailed written statement setting forth the causes of extra costs, potential and/or actual incurred costs as well as engineering and technical data supporting the request for additional compensation. The Contractor shall submit sufficient data to reasonably enable the Engineer to make a thorough analysis and investigation regarding the request for additional compensation. If the Contractor cannot reasonably provide the detailed statement within the 14 calendar day period, Contractor must provide such data as it can be reasonably provide. The Contractor shall request from the Engineer, before the expiration of the five (5) calendar day period, an extension for a specific period of time in which to file the required documentation supporting the request for additional compensation.

4. Without modifying or waiving any of the Contractor's obligations set forth in paragraph 3 above, the Contractor must submit to the Engineer a detailed written statement setting forth the final costs and any supplemental engineering and technical data related to any requests for additional compensation no later than 60 days after the date of substantial completion of the work. If the Contractor determines that extraordinary circumstances exist, the date for submission of final costs and technical backup may be extended by written agreement with West County Wastewater. This statement of final costs and supplemental reporting data must be sufficiently detailed to enable the Engineer to thoroughly analyze and make a reasonable determination regarding the request for additional compensation. If the Contractor fails to immediately notify the Engineer of a condition, occurrence or circumstance that potentially will give rise to a request for additional compensation or to make reasonable efforts to provide an adequate initial submittal within the 14 calendar day period, or any extension of that period agreed to by the Engineer as set forth in paragraph 3 above, and/or failure of the Contractor to provide such statement of final costs and technical submittals within 60 days of the date of substantial completion, or by such date as that period may be extended, will be a waiver by the Contractor of any and all rights to additional compensation for such conditions, occurrences, or circumstances for which costs and other required data has not been timely submitted. The waiver by the Contractor of its rights to compensation due to failure to comply with the requirements of this General

Condition shall operate as a waiver of all rights of the Contractor under the Contract, at law, and in equity to receive additional compensation whether through the Government Code claims process or otherwise.

00 72 13 INDEPENDENT CONTRACTOR, SUPERINTENDENT, AND EMPLOYEES

A. The Contractor is an independent Contractor performing work under the Contract, maintaining complete control over its employees and all of its subcontractors. The Contractor shall perform all work in an orderly, timely, and workmanlike manner, enforce strict discipline and order among its employees, and assure strict discipline and order by its subcontractors in complying with the Contract Documents.

B. Before starting work, the Contractor shall designate in writing its authorized representative who will have the authority to represent and act for the Contractor. The Contractor shall provide a clear written definition of the scope of the authorized representative and assistant's authority to act for the Contractor, and shall specify any and all limitations of such authority. The Contractor's representative shall be present or be duly represented at the site of work at all times when work is actually in progress. When work is suspended, Contractor shall make arrangements acceptable to the Engineer for performing any emergency work that may be required. The Contractor's authorized representative must be supported by competent assistants, as necessary, and the authorized representative and its assistants must be satisfactory to the Engineer. West County Wastewater reserves the right to have the Contractor remove the authorized representative from the project and replace the representative with another person who is acceptable to the Engineer. All requirements, instructions, and other communications given to the authorized representative by the Engineer are as binding as if given to the Contractor. Before starting work, the Contractor shall give West County Wastewater a written list of the addresses and telephone numbers where the Contractor's project manager, project superintendent, and foremen can be reached during hours when the work is not in progress.

1. Contractor's authorized representative must be present or be duly represented at the Project site at all times while work is actually in progress. When work is not in progress and during periods when work is suspended, the Contractor shall make arrangements acceptable to the Engineer for one or more persons to be contacted for any emergency work which may be required.

2. The Contractor shall employ only competent and skilled workers to perform any work in numbers sufficient to carry the work to satisfactory completion within the time limits specified or required to meet approved construction schedules. The Contractor shall maintain satisfactory conduct of its employees at the jobsites.

3. Each machine or unit of equipment shall be operated by an operator competent in handling the particular make of machine or unit or equipment in use, at a speed or rate of production not to exceed that recommended by the manufacturer.

C. If any subcontractor or person employed by the Contractor appears to the Engineer to be incompetent, or be under the influence of alcohol or illegal drugs, or to act in an unsafe, disorderly, or improper manner, the Engineer may require that such person not again be employed on the work. However, nothing contained in this paragraph will shift the responsibility for supervision of persons employed by the Contractor from the Contractor or require the Engineer to take any action with regard to an employee of the Contractor or subcontractor who is subject to discipline.

D. The Contractor shall maintain labor relations in such manner and by such methods as will provide for harmony among workers. The Contractor shall assure that its subcontractors of all tiers comply with the provisions set forth in this Section. Failure of the Contractor or any of its subcontractors at any tier to comply with this provision will be grounds for termination of the Contract in accordance with Section 00 72 36, Termination of Right to Proceed.

00 72 14 CONTRACTOR'S PLANT, CONSTRUCTION EQUIPMENT, AND FACILITIES

A. The Contractor shall provide and ensure the use of, on any work, only such construction plant and equipment capable of producing the quality and quantity of work and materials required by the Contract and within the time or times specified. Before proceeding with any contract work or with erection of any facilities including but not limited to temporary structures, machinery, equipment, offices, warehouses, and camps, the Contractor shall, at its expense, furnish the Engineer with such information and drawings relative to such equipment, plant, and facilities as the Engineer may request. Upon written order of the Engineer, the Contractor shall promptly remove unsatisfactory equipment and facilities from the site and shall discontinue operation of unsatisfactory plant.

B. The Contractor shall furnish and maintain such potable water supplies and proper sanitation facilities as it determines necessary for its forces at the jobsite.

C. The Contractor shall maintain all portions of the jobsite in a neat, clean, and sanitary condition at all times. The Contractor shall furnish toilets where needed for use of its employees and shall strictly enforce their use.

1. The Contractor may not make use of West County Wastewater's existing sanitary facilities.

00 72 15 EQUIPMENT, MATERIALS, AND/OR PRODUCTS, SUBSTITUTION OF SPECIFIC ITEMS AND TRADE NAMES, WORKERS' SKILLS

A. The work, unless otherwise permitted or approved by the Engineer, must be completed with the incorporated use of equipment, materials, and/or products where specified. Substitutions and equal alternatives will be permitted as provided in this Section; however, neither the request for substitution nor the offer of alternatives obligates West County Wastewater to assent to any such request or offer. If the Contractor fails to either submit requests for substitutions or to offer alternatives within the required times provided in this General Condition, West County Wastewater will presume that the work will be accomplished with the trade-named equipment, materials, and/or products as identified in the Technical Specifications and/or the Project Drawings.

1. Unless otherwise provided in the Contract, all equipment, materials, and/or products incorporated into the work must be new and, where not specified, must be of the highest quality of the respective kinds for the intended use, and all workmanship must meet or exceed applicable construction industry standards and practices. If equipment, materials, and/or products are designated by listing named manufacturers of particular equipment, materials, and/or products followed by the words "or equal," then the Contractor may furnish the named equipment, materials, and/or products or any equal equipment, materials, and/or products. The first-named manufacturer of particular equipment, materials, and/or products is the basis for the design shown on the Project Drawings. A subsequently-named manufacturer or particular equipment, materials, and/or products has been determined to be an acceptable substitution but may require modifications in the Project's design and its ultimate construction to accommodate its use. If such subsequently-named items are selected by the Contractor for incorporation into the work, the Contractor assumes all costs required for modifications to the equipment, materials, and/or products, and Project design and construction as may be required for said items' use. The Engineer will permit substitutions for an unnamed "equal" item of material if the Contractor complies with the procedures set forth in Paragraph B of this Section. If a Contractor makes use of an unnamed "equal" product as a substitute for a specifically-named material or product, the Contractor will assume all costs required to make the necessary revisions or modifications to accommodate the use of the unnamed product.

2. Before beginning the work and no later than 35 days after award of the Contract, the Contractor shall submit a List of Materials to the Engineer for review. The List must include all items of equipment, materials, and/or products to be incorporated into the work and the names of suppliers with whom purchase orders have been placed. The names on the List must be arranged in the same order as in the specifications, and the List must contain sufficient data to identify precisely the items of equipment, materials, and/or products that the Contractor proposes to furnish. The List must include

specification or Project Drawing references. Once the submission is determined to be acceptable to the Engineer, the Engineer will return it to the Contractor.

3. If the Contractor is required to furnish sample specimens of materials, the Contractor shall comply with the provisions of 00 72 28, Inspection and Sample Specimens.

B. Substitution for equipment, materials, and/or products specified will only be permitted when the proposed unnamed "equal" product or material to be furnished is both equal in quality and utility and after the Contractor has complied with the following provisions: (1) The Engineer shall review all proposed substitutions. (2) The Engineer must approve each substitution in writing prior to its incorporation into the work. (3) Unless otherwise authorized in writing by West County Wastewater, the Contractor shall, no later than 35 days after award and prior to placing any purchase orders, but no later than 30 days before it requires approval of any such alternative item, submit to West County Wastewater sufficient data, drawings, samples, literature, or other detailed information as will demonstrate to the Engineer that the proposed substitute is equal in quality and utility to the equipment, materials and/or products specified. Contractor shall submit a side-by-side comparison of the proposed equipment specification to the contract specification.

1. Within 30 calendar days following receipt of all requested information from the Contractor, the Engineer will determine whether the proposed alternative is equal in quality and utility and meets the requirements of the Contract and will inform the Contractor in writing of this determination. The Contractor will bear the burden of substantiating the quality and utility of alternatives, and the Contractor shall furnish all necessary information requested and required by the Engineer. The Engineer will be the sole judge as to the quality and utility of alternative equipment, materials, and/or products, and the Engineer's decision will be final. Acceptance by the Engineer of a substitution will not relieve the Contractor from complying with the requirements of the Project Drawings and Specifications. Acceptance by the Engineer will not relieve the Contractor from full responsibility for the efficiency, sufficiency, and quality and performance of the substitute equipment, materials, and/or products, in the same manner and degree as equipment, materials, and/or products specified by name.

2. Failure of the Contractor to submit proposed substitutions for review in the manner described above and within the time prescribed will be sufficient cause for rejection by West County Wastewater of the proposed substitutions.

3. The Engineer is not restricted to basic issues as performance and durability in determining whether a proposed product is equal in quality and utility, but may consider any other issues that the Engineer, in its discretion , deems appropriate. Issues that may be considered in making this determination may

include, but are not limited to, factors such as comparable performance, reliability, efficiency of operation, ease of operation, adaptability, ease of maintenance, capital costs, life-cycle costs, operational characteristics, costs of training personnel, maintenance history, warranties, problems created by the resulting overall warranty system, availability of qualified service, availability of parts, the history of any supplier and compatibility with existing facilities.

4. No one factor or group of factors, including such issues as savings on capital costs, will be determinative of whether the proposed product or material is equal in quality and utility. The decision of the Engineer will be based on those factors deemed by the Engineer to be relevant and any data, drawings, samples, literature, or other detailed information furnished by the Contractor with respect to the proposed substitution.

5. Each decision as to whether a product or material is equal in quality and utility will be made by the Engineer on a case-by-case basis.

6. The Contractor will pay any and all costs, including consultant costs, incurred by West County Wastewater with respect to the proposed substitution that exceed the costs inherent in the normal and reasonable review of drawings and other standard data, information, and documents concerning any proposed substitution. The Contractor's responsibility for this cost will not depend upon whether the Engineer approves the substitution.

C. Unless otherwise provided in the Contract, the title and interest in the right to the use of all water, and the title to all soil, stone, gravel, sand, minerals, timber, and all other materials developed or obtained within the Project limits from operations by the Contractor or any of its subcontractors, of any of their representatives or employees, and the right to use or dispose of the same are reserved to West County Wastewater where located within its boundaries; and neither the Contractor nor any of its subcontractors, nor any of their representatives or employees, will have any right, title, or interest in or to any such substances or materials.

1. All material used under the Contract after it has been attached or affixed to the work or soil and after partial payment has been made therefor will become the property of West County Wastewater.

2. In the event that the Contractor or any of its subcontractors or any of their representatives or employees discovers any Indian relics or items that may possess archaeological or historical value, the Contractor shall immediately notify the Engineer and await the Engineer's decision before proceeding with any work. The Contractor will have no property right in such relics and items.

3. The Contractor shall satisfy himself as to the quantity of acceptable materials or products which may be produced or obtained at local sources, and West County Wastewater will not assume any responsibility as to the quantities or quality of acceptable materials or products available.

4. The Contractor, with the permission of the Engineer, may use in the proposed construction such stone, gravel, sand, or other material found in the excavation that the Engineer determines is suitable.

5. Existing equipment, materials, and/or products to be salvaged will shall remain the property of West County Wastewater. The Contractor shall refurbish as required any salvage to be reinstalled in the work before reinstallation. The Contractor shall carefully remove and handle other work to be salvaged to avoid damage and shall deliver such work to storage at a location designated by the Engineer.

00 72 16 CONTRACTOR-FURNISHED DRAWINGS AND DATA

A. No later than 30 days after receiving the Notice to Proceed (NTP), the Contractor shall submit at its own expense Shop Drawings and details of all structural and reinforcing steel, equipment, electrical controls, structural fabrications, pipe, pipe joints, special pipe sections, and other appurtenances. The Engineer must find acceptable a Shop Drawing or detail before the item or items shown are manufactured or used in the work. The acceptance of Drawings by the Engineer applies for general design only and will not relieve the Contractor of its responsibility for errors or omissions contained therein. Acceptance by the Engineer will not relieve the Contractor of its obligation to meet safety requirements and all other requirements of law. The Engineer will begin reviewing the Contractor's submittals only after the NTP is issued by West County Wastewater except for some unusual long lead items which may require submittals prior to issuance of the NTP.

B. The Contractor bears full responsibility for shop drawing submittal and coordination; this responsibility may not be delegated in whole or in part to subcontractors or suppliers. Any designation of work "by others" shown on Shop Drawings means that the Contractor shall be responsible for the work shown rather than the subcontractor or supplier who has prepared the Shop Drawings.

C. Submittals must permit data to be identified with the applicable Specification paragraph. The data must clearly demonstrate compliance with the Project Drawings and Specifications and must relate to the specific equipment to be furnished. Where manufacturer's standard drawings are employed, they must be clearly marked to show what portions of the data are applicable to this Project.

D. The Engineer's review of shop-drawing submittals is primarily intended to provide for completion for West County Wastewater of a Project in full conformance with the Project Drawings and Specifications, unmarred by field corrections, and within the time provided. In addition to this primary objective, shop-drawing review is secondarily intended to assist the Contractor in its procurement of equipment that will meet all requirements of the Project Drawings and Specifications, will fit the structures detailed on the Project Drawings, will be complete with respect to piping, electrical, and control connections, will have the proper functional characteristics, and will become an integral part of a complete operating facility. Acceptance of

Shop Drawings and submittals does not constitute a change to the Contract requirements.

E. Where the Contractor is required by these Specifications to make submittals, they must be submitted to the Engineer with a letter of transmittal and in a sufficient number of copies to allow a distribution of at least one (1) copy to all parties needing a copy to carry out the provisions of the Specifications, including three (3) copies to be retained by the Engineer. The Engineer shall identify the appropriate number of such copies required at the time of the preconstruction conference.

F. The Engineer will return the appropriate number of copies of each of the Contractor's submissions and all appurtenant data within 21 days of receipt, with one of the following notations:

1. Resubmittal not required; correction, if any, noted.

2. Correct and resubmit corrections noted.

G. Returned copies of Drawings marked with Notation "1" permit the Contractor to proceed with the operations covered by such returned copies, provided that such operations will be subject to the comments, if any, shown on such returned copies.

H. The Contractor shall correct, as necessary and required, returned copies of Drawings marked with Notation "2" and shall submit them in the same manner as before.

I. When the Engineer determines that a submittal is acceptable, the Engineer will retain three copies and will return all other copies to the Contractor. When submittals are not accepted, the Engineer will retain only two copies and will return all others to the Contractor. The Parties intend that the Contractor make a complete and acceptable submission to the Engineer at least by the second submission of data. West County Wastewater may deduct monies from payments due the Contractor to cover additional costs of the Engineer's review of submittals beyond the second submission.

J. The Engineer's determination that a submittal is acceptable will not constitute acceptance by the Engineer of any responsibility for the accuracy, coordination, and completeness of the Shop Drawings or the items of equipment represented on the Drawings. The Contractor shall be solely responsible for the accuracy, coordination, and completeness of Shop Drawings, and this responsibility will include back checking comments, corrections, and modifications from the Engineer's review before fabrication.

K. Supplemental, specific requirements for Shop Drawings and details are contained in the applicable technical sections of these Specifications.

L. The Contractor shall provide sufficient copies of schedules and Shop Drawings to the Engineer for review to provide three copies for the Engineer's files, and such additional copies as the Contractor may desire for its own office files and/or for distribution by it to subcontractors or vendors. Exceptions will be noted in specific sections of the Technical Specifications.

M. The Contractor shall submit all Shop Drawings and supporting data, catalogs, and schedules as its instruments, and the Contractor will be responsible for their accuracy and completeness. These submittals may be prepared by the Contractor, subcontractors, or suppliers, but the Contractor must ascertain, before submitting them to the Engineer, that submittals meet all of the requirements of the Contract, while conforming to structural, space, and access conditions at the point of installation. The Contractor shall check all submittals before submitting them to the Engineer.

N. The Engineer will check and review schedules, drawings, etc., submitted by the Contractor only for general design conformance with the concept of the Project and compliance with the Contract.

O. Shop Drawings may not be used to order products' fabrication or delivery for construction or installation unless they have been submitted to and determined to be acceptable by the Engineer.

P. Determination by the Engineer that any drawings, method of work, or any information regarding materials and equipment the Contractor proposes to furnish are acceptable will not relieve the Contractor of its responsibility for any errors therein and will not constitute an assumption of risks or liability by the Design Engineer or West County Wastewater, or any officer or employee thereof, and the Contractor shall have no recourse against West County Wastewater under the Contract on account of the failure or partial failure or inefficiency or insufficiency of any plan or method of work or material and equipment so accepted. Such acceptance shall mean merely that the Engineer has no objection to the Contractor using, upon its own full responsibility, the plan or method of work proposed or furnishing the materials and equipment proposed.

00 72 17 STANDARDS AND CODES

A. The Contractor shall construct all work in full accordance with the requirements of local building codes, the National Board of Fire Underwriters, the Pacific Fire Rating Bureau, the State Fire Marshall, the Safety Orders issued by the Division of Industrial Safety of the State of California, and all other prevailing codes and regulations having jurisdiction over construction included in the Contract Documents.

B. Where references are made in the Contract to the respective standards and codes in accordance with which work is to be performed or tested, the edition or revision of such standards and codes in effect on the date of the Notice to Contractors shall

apply, unless otherwise specified in the Technical Specifications; references to such standards and codes is solely for technical information. Nothing in these specifications is to be construed to permit work not conforming to governing codes. In case of conflict between referenced standards and codes or between standard(s) or code(s), and the requirements of the Contract, the Engineer will determine which will govern. For purposes of bidding, it is assumed that the more restrictive one is required.

00 72 18 SAFETY

A. The Contractor will be solely and completely responsible for conditions on the jobsite, including safety of all persons and property during performance of the work. This requirement will not be limited to normal working hours. The Contractor shall promptly and fully comply with and carry out safety requirements as prescribed by federal, state, or local laws or regulations and industry standards.

B. The services of the Engineer in conducting review and inspection of the Contractor's performance is not intended to include review of the adequacy of the Contractor's work methods, equipment, bracing or scaffolding, or safety measures, in, on, or near the construction site.

C. The Contractor shall take such measures as may be necessary or required to assure that the safety and health of the employees and of the public may be safeguarded.

D. THE CONTRACTOR ACKNOWLEDGES THAT WORK ON THIS PROJECT COULD BE PHYSICALLY DANGEROUS TO WORKERS. THE CONTRACTOR SHALL CAREFULLY INSTRUCT ALL PERSONNEL WORKING ON THIS PROJECT AS TO POTENTIAL DANGERS, WHICH COULD BE POTENTIALLY HAZARDOUS TO WORKERS' HEALTH, AND SHALL PROVIDE SUCH NECESSARY SAFETY EQUIPMENT AND INSTRUCTIONS AS ARE NECESSARY TO PREVENT INJURY TO PERSONNEL AND DAMAGE TO PROPERTY. THE CONTRACTOR SHALL EXERCISE SPECIAL CARE RELATIVE TO WORK UNDERGROUND.

E. The conveyance and treatment of raw sewage and its by-products can introduce pathogenic organisms which may cause diseases such as salmonellosis, typhoid fever, paratyphoid fever, bacillary dysentery, cholera, infectious hepatitis, polio, amoebic dysentery, and others.

F. The Contractor shall direct and control the work assigned and shall assure that all workers on the Project understand the hazards of the work involved and the safe work procedures required for each job. The Contractor shall assure that its subcontractors of all tiers shall, without expense to West County Wastewater, comply with this safety responsibility. No work may proceed until each worker and subcontractor understands the scope of the work and all safety rules and work procedures to be followed. The Contractor may not allow a new employee or new

subcontractor to begin work on West County Wastewater projects without a full and proper safety orientation.

G. Use of alcoholic beverages and/or nonprescription drugs are strictly prohibited. Workers who use prescription drugs that interfere with workers ability to work safely are prohibited from the work site.

H. The Contractor is advised that, in certain locations and under certain conditions, the work may take longer and may require special equipment in order to properly conform to safety regulations. In such cases, no additional compensation will be allowed the Contractor therefor.

I. The Contractor's personnel shall wear hard hats at all times while on the project work site, except in offices or vehicles.

J. Before starting work, the Contractor shall submit a written safety program for West County Wastewater's review. The objective of the safety program will be accident prevention. Such program shall include, but not be limited to, the following:

1. An organization chart and accompanying narrative which describes the responsibility for employee and public safety of those individuals who control each phase of operations and set forth in writing the policies and procedures to be followed by all personnel. The chart shall also show the Contractor's internal lines of communication (including subcontractors) for the program.

2. The designation of a competent person.

3. A specific program for communication between the Contractor and West County Wastewater on safety matters. The Contractor shall also designate one person with whom official contact can be made by West County Wastewater on safety matters.

4. Evidence that the Contractor has become thoroughly familiar with the potential hazards of the work and applicable federal and state regulations. This will be in the form of a signed affidavit per Section 00 45 17 titled Contractor Safety Acknowledgment.

5. Specific safety procedures and guidelines for conduct of the work.

K. West County Wastewater's review, comment upon, and/or acceptance of the Contractor's safety program and/or plan will not negate Contractor's obligations for safety or place any responsibility upon West County Wastewater for such safety. Any review comments and/or acceptance will not limit the Contractor's obligations to undertake any action which may be necessary or required to establish and maintain safe working conditions at the site.

L. The Contractor shall promptly comply with any directive from West County Wastewater in connection with safety. West County Wastewater may stop the work if West County Wastewater reasonably believes that there is an imminent danger to safety. West County Wastewater may also require the Contractor to revise the Contractor's safety program and/or plan to eliminate future occurrences of the imminent danger. West County Wastewater's reservation of these rights to be exercised in its sole discretion and will not constitute obligations of West County Wastewater to monitor or enforce the Contractor's safety program, plan, and/or method of operation. West County Wastewater's exercise of these rights will not provide any basis for any request by the Contractor for delay damages, extra compensation, and/or additional compensation to complete the work.

M. It is the intent of West County Wastewater that the Contractor provide a safe working environment under normal conditions. HOWEVER, BECAUSE OF POTENTIALLY HAZARDOUS CONDITIONS SUCH AS CONFINED SPACES, POTENTIALLY EXPLOSIVE ATMOSPHERES, HANDLING OF CERTAIN CHEMICALS, POSSIBLE EXPOSURE TO PATHOGENS, ETC., SPECIALIZED EQUIPMENT MAY BE NECESSARY AND STRICT CONFORMANCE WITH SAFETY REGULATIONS WILL BE REQUIRED.

N. The Contractor shall keep adequate first aid facilities and supplies available and shall provide for instruction in first aid.

O. The Contractor shall assure that its subcontractors of all tiers shall, without expense to West County Wastewater, comply with this Section and the provisions of Section 00 72 14, Contractor's Plant, Construction Equipment, and Facilities.

00 72 19 PUBLIC ACCESS AND SAFETY; PROTECTION OF PROPERTY

A. The design of the facilities included in this Project has been based on the concept that the structures are not accessible to and usable by the handicapped and the general public. Consequently, stairs, landings, platforms, railings, ladders, exits, and the like, for treatment facilities were designed to conform only to the requirements for industrial use by authorized persons.

B. The Contractor will be responsible for the work and protection thereof, and for preventing injuries to persons and damage to the work and property and utilities on or about the work, until completion and final acceptance of the work. The Contractor will not be relieved of any of its responsibility because of the Engineer's discretion to give permission or directions relating to any part of the work, by any such permission or directions given, or by failure of the Engineer to give such permission or directions.

C. The Contractor shall provide and maintain all necessary safety equipment such as fences, barriers, signs, lights, walkways, guards, and fire-prevention and fire-fighting equipment and shall take such other action as is required to fulfill its obligations under this Section.

D. The Contractor shall conduct its operations so as not to close or obstruct any portion of any railroad, highway, road, or other property until permits therefor have been obtained from the governmental or other authorities having jurisdiction thereof. If any of the above are required to be kept open and will be damaged or rendered unsafe by the Contractor's operations, the Contractor shall, at its expense, make such repairs and provide such temporary guards, bridges, lights, and other signals as necessary or required for public safety and as will be acceptable to the governmental or other authorities having jurisdiction thereof. Fences which interfere with any work may, upon prior written approval of West County Wastewater, be removed by the Contractor but must then be restored to their original condition prior to final acceptance. Such removal and restoration shall be performed by and at the expense of the Contractor.

E. Unless otherwise specifically provided in the Contract, the Contractor shall not perform any work that may affect any pipeline, telephone, telegraphic, or electric transmission line, irrigation ditch, or other structure, nor enter upon the rights-of-way or lands appurtenant thereto, until notified by the owners that West County Wastewater has obtained proper authority to do so from the owners of such property or improvements. Thereafter and before it begins such work, the Contractor shall give such owners convenient access and reasonable cooperation in the Contractor's removal, shoring of, support of , or otherwise protecting such lines, ditches, and structures and for replacing same.

1. The Contractor shall exercise care to prevent damage to adjacent walks, streets, culverts, and gutters; where the Contractor's equipment will pass over these obstructions, it shall place suitable planking.

2. The Contractor will not be entitled to any extension of time or any extra compensation on account of any postponement, interference, or delay caused by any such line, ditch, or structure being on or adjacent to the site of work except as provided in Section 00 72 11, Differing Site Conditions.

3. The Contractor shall preserve and protect all cultivated and planted areas, and vegetation such as trees, plants, shrubs, and grass on or adjacent to the premises, which, as determined by the Engineer, do not reasonably interfere with the performance of work. The Contractor must compensate the owner for damage to any such areas and vegetation and for unauthorized cutting of trees and vegetation, including without limitation, damage arising from the performance of its work through operation of equipment or stockpiling of materials. All costs in connection with any repairs or restoration necessary or required by reason of any such damage or unauthorized cutting shall be borne by the Contractor.

00 72 20 LAWS AND REGULATIONS

A. The Contractor shall keep itself fully informed of, and shall observe and comply with, all laws, ordinances, and regulations which in any manner affect those engaged or employed on any work, or the materials and equipment used in any work or, which in any way affect the performance of any work, and of all orders and decrees of agencies having any jurisdiction or authority over work performed under the Contract.

B. If the Contractor discovers any discrepancy or inconsistency between the Contract and any such law, ordinance, regulation, order, or decree, the Contractor shall immediately report the same in writing to West County Wastewater. The Contractor shall be responsible for compliance by its subcontractors of all tiers with the provisions of this Section.

    1. The Contractor is particularly directed to Part 7, Chapter 1, Section 2, Sections 1770 et seq. of the Labor Code of the State of California. Reference is hereby made to the provisions for minimum per diem wages contained in Section 00 21 13, Invitation to Bid.

C. The Contractor and each subcontractor engaged in the work shall pay each respective employee thereof an amount not less than the general prevailing rate of per diem wages established in compliance with Section 1770 et seq. of the Labor Code of the State of California and as determined by the Director of Industrial Relations to be effective and applicable for the various crafts, trades or type of worker needed or required to execute the contracts. In accordance with Section 1770 of said Labor Code, nothing otherwise provided under Article 2 of said Code shall prohibit the payment of wage rates to any worker in excess of such prevailing rates of wages as determined by the Director of the Department of Industrial Relations. However, should the Contractor or a subcontractor have a contractual relationship with workers whereby per diem rates of wages are paid in excess of such determined prevailing rates of wages, the Contractor or subcontractor shall identify and submit a certified listing of such workers and the amounts payable prior to beginning construction operations applicable thereto in accordance with this General Condition.

    1. Failure of the Contractor or any subcontractor to certify and list workers and actual wages in excess of those effective as determined by the Director of Industrial Relations will constitute an express statement by the Contractor or such subcontractor that actual wages will be as determined by the Director of Industrial Relations and will be paid to all workers and be applicable to all work required and ordered under the Contract.

    2. The possibility of labor cost increases within the periods of time established and specified for completion of the Project is one of the elements to be considered by bidding Contractors and their subcontractors. West County Wastewater will not, at any instance of increase thereof, whether initiated by

contractors, subcontractors, particular bargaining agreements, Director of Industrial Relations determinations, or otherwise, consider such as the basis of a request for additional compensation to West County Wastewater for work bid as specified and shown.

a. The Contractor shall comply with the provisions of Article 2, Chapter 1, Part 7, Division 2 (commencing with Section 1770), of the Labor Code, and in particular, Section 1775. In accordance with Section 1775, the Contractor shall forfeit to West County Wastewater or the Division of Labor Standards, as a penalty, up to $50 per each calendar day or portion thereof, for each worker paid less than the prevailing rates for such work or craft in which such worker is employed for any work done under the Contract by him/her or by any subcontractor under the Contractor in violation of the provisions of the Labor Code and in particular, Labor Code Sections 1770 to 1780, inclusive. The amount of the daily penalty will be as determined by the Labor Commissioner in accordance with Section 1775. In addition to such penalty and pursuant to said Section 1775, the difference between the prevailing wage rates and the amount paid to each worker for each calendar day or portion thereof for which each worker was paid less than the prevailing wage rate shall be paid to each worker by the Contractor.

b. Where prevailing wage determinations have been predetermined to change during the Contract (beyond expiration dates as indicated on the forms), the Contractor shall obtain such changes from the Prevailing Wage Unit, Division of Labor Statistics and Research, Department of Industrial Relations, 525 Golden Gate Avenue, San Francisco, California 94102, telephone (415) 557-0561, and deliver a copy of the same to the Engineer.

c. If a Contractor intends to use a craft or classification not shown on the general prevailing wage determinations, the Contractor may be required to pay the wage rate of the craft or classification most closely related to it as shown in the general determinations effective at the time of bid opening.

3. The Contractor stipulates and agrees that pursuant to the provisions of Labor Code, Sections 1810 and 1813, eight hours labor shall constitute a legal day's work, and no worker shall be required or permitted to work more than eight hours in any one calendar day and 40 hours in any one calendar week, except as provided below. Nothing in this provision may be construed to relate to wage determination or in any way affect contractual provisions related to compensation.

a. As a penalty, the Contractor shall forfeit to West County Wastewater or the Division of Labor Standards $25 for each worker employed in the execution of the Contract by it or by any subcontractor, for each calendar

day during which any worker is required or permitted to labor more than eight hours in any one calendar day and 40 hours in any one calendar week in violation of the provisions of the Labor Code of the State of California and in particular, Section 1810 to Section 1815 thereof, inclusive, except that work performed by employees of Contractors in excess of eight hours per day and 40 hours during any one week will be permitted upon compensation for all hours worked in excess of eight hours per day at not less than one and one-half (1-1/2) times the basic rate of pay, as provided in said Labor Code, Section 1815.

4. Payroll Records: The Contractor and subcontractor's attention is directed to the provisions of Section 1776 of the Labor Code of the State of California and to the requirements therein pertaining to the keeping, availability, and filing of accurate payroll records of all journeymen, apprentices, and other workers performing work under this Contract. The Contractor shall comply with the requirements of said section.

    a. Prior to each monthly progress payment, the Contractor shall deliver to the Engineer copies of certified payrolls of its and all subcontractors' forces performing work at the jobsite (or sites established primarily for the work), for labor compliance purposes, and Extra/Force Account considerations. Such records shall be kept current on an effective day or period basis and in form acceptable to the Engineer. At a minimum, the form shall include the following information:

        i. Employee identification by name.

        ii. Employee's address and social security number.

        iii. Employee's craft and classification (in accordance with Director of Industrial Relations' wage determinations).

        iv. Employee's actual per diem wages (in compliance with Section 00 11 16, Invitation to Bid, and this Section 00 72 20, Laws and Regulations).

        v. Employee's subsistence and travel allowance (as applicable).

        vi. Employee's straight time and overtime hours worked each day and week.

        vii. Itemized deductions made from employee's wages.

        viii. Apprentices and ratio of apprentices to journeymen.

        ix. Contractor's or subcontractor's firm or company name, date or period for which applicable wage rates and allowances are effective, and the employer's signature.

b. The certified payroll records shall be kept on forms provided by the Division of Labor Standards Enforcement, or shall contain the same information as the forms provided by the Division in addition to the above-listed information.

c. The Contractor shall inform West County Wastewater of the location of the above payroll records, including the street address, city and county, and shall, within five (5) working days, provide a notice of change of location and address.

d. The Contractor shall have ten (10) days in which to comply subsequent to receipt of written notice specifying in what respects the Contractor must comply with the provisions of California Code of Labor Section 1776. In the event that the Contractor fails to comply within the ten-day period, the Contractor shall, as a penalty to the state or to West County Wastewater, forfeit twenty-five dollars ($25) for each calendar day, or portion thereof, for each worker, until strict compliance is effectuated. Upon the request of the Division of Apprenticeship Standards, or the Division of Labor Standards Enforcement, these penalties shall be withheld from progress payments then due.

e. Any copy of records made available for inspection as copies and furnished upon request to the public or any public agency by West County Wastewater shall be marked or obliterated in such a manner as to prevent disclosure of an individual's name, address, and social security number.

f. Compliance with the above provisions of 00 72 20 and California Code of Labor Section 1776 shall be the responsibility of the Contractor.

5. Apprentices: The Contractor shall comply with the provisions of Section 1777.5 and 1777.6 of the California Labor Code in regard to employment of apprentices.

6. Labor Discrimination: Attention is directed to Section 1735 of the Labor Code, which reads as follows:

a. No discrimination shall be made in the employment of persons upon public works because of race, religious creed, color, national origin, ancestry, physical disability, mental disability, medical condition, marital status, or sex of such persons, except as provided in Section 12940 of the Government Code, and every contractor for public works violating this Section is subject to all the penalties imposed for violation of this Chapter.

7. As required by Section 1773.8 of the California Labor Code, the Contractor shall pay travel and subsistence payments to each worker needed to execute the work, as such travel and subsistence payments are defined in any applicable collective bargaining agreements filed in accordance with this section.

8. The Contractor shall comply with all applicable federal, state, and local laws, ordinances, rules, and regulations, and lawful orders of all authorities having jurisdiction for the safety of persons and protection of property, as more particularly described under Sections 00 72 18, Safety, Sanitary, and Medical Requirements, and 00 72 19, Public Access and Safety; Protection of Property of this document.

9. Lateral and Subjacent Support: Attention is directed to Section 832 of the Civil Code of the State of California relating to lateral and subjacent supports. Wherever structures or improvements adjacent to the excavation may be damaged by such excavation, the Contractor shall comply with this law. As provided in Labor Code, Section 6707, a separate bid item is provided for costs of shoring and bracing of excavations five feet or more in depth.

10. The Contractor shall comply with Sections 25102 through 27001 of Title 27, California Code of Regulations The Contractor shall warn all persons at the work site of their exposure to chemicals known to the State to cause cancer or birth defects or other reproductive harm. The Contractor shall be responsible for compliance by its subcontractors with this Section.

11. The Contractor shall comply with Bay Area Air Quality Management District Regulation 11, Rule 2, as it applies to the demolition, renovation, or removal or any building elements and to the disposal of any asbestos-containing waste material.

    a. No regulated asbestos-containing material (RACM) may be stripped or removed unless Contractor has provided at least one on-site representative and certified that that representative is familiar with the provisions of Regulation 11, Rule 2, as it pertains to demolition and renovation and the means of compliance. The representative must be present during all removal and/or stripping of RACM. Contractor shall provide evidence as required under 11-2-303.9 of the Regulation that the required training of the representative has been completed.

    b. The Contractor shall comply with all state laws and regulations regarding asbestos and asbestos-related work, including, but not limited to, the provisions of Labor Code Sections 6501.5 through 6510.

    c. The Contractor shall so perform its work as not to discharge into the atmosphere from any source whatsoever smoke, dust, or other air contaminants in violation of the laws, rules, and regulations of the governmental entities having jurisdiction.

D. Project Labor Stabilization Agreement

All Contracts for which the Contract Price is more than $1,000,000 are subject to the provisions of the Project Labor Stabilization Agreement—West County Wastewater District ("PLSA"), effective January 1, 2021, which is available upon request. Contractor shall comply with the provisions of the PLSA and shall execute the Agreement to be Bound by the PLSA in the form set forth in Addendum A to the PLSA.

E. Agreement to Assign (Contractors and Subcontractors)

1. The Contractor's and subcontractors' attention is directed to the provisions of Government Code, Section 4552, which requires that, in entering into a public works contract or subcontract, contractors and subcontractors agree to assign to the purchasing body all rights arising from violations of antitrust regulations. In pertinent part, Government Code, Section 4552, reads as follows:

"In submitting a bid to a public purchasing body, the bidder offers and agrees that if the bid is accepted, it will assign to the purchasing body all rights, title, and interest in and to all causes of action it may have under Section 4 of the Clayton Act (15 U.S.C. Sec. 15) or under the Cartwright Act (Chapter 2 (commencing with Section 16700) of Part 2 of Division 7 of the Business and Professions Code), arising from purchases of goods, materials, or services by the bidder for sale to the purchasing body pursuant to the bid. Such assignment shall be made and become effective at the time the purchasing body tenders final payment to the bidder."

F. The Contractor's attention is directed to the provisions of Health and Safety Code, Section 7050.5, relating to the discovery of human remains. Upon any such discovery, Contractor shall not further excavate or disturb the site. The Contractor shall immediately notify West County Wastewater and the Contra Costa County Sheriff-Coroner's Office of any such find and shall comply with all other applicable laws and regulations.

G. The Contractor's attention is directed to the provisions of Health and Safety Code, Section 7050.5 and Public Resources Code, Sections 5097.5, 5097.94, 5097.98, and 5097.99, relating to the excavation, removal, destruction, injury, and defacement of historic or prehistoric ruins, burial grounds, archeological or vertebrate paleontological sites, or any other archeological, paleontological or historical feature. The Contractor shall immediately stop work in the area of any archeological discovery and notify West County Wastewater and comply with all other laws and regulations upon discovery of any such remains in the construction site. Compensation to the Contractor, if any, for lost time or changes in construction to avoid the find will be determined in accordance with changed conditions or change order provisions of the Contract.

H. Claims and Actions Against Public Entities and Employees

1. The Contractor's and subcontractors' attention is directed to Government Code Section 900 et seq., dealing with claims and actions against public entities and employees. Nothing contained in this Contract, including but not limited to Section 00 72 12, Changes and Extra Work, Subsection E, is intended to modify or remove the requirements set forth in these Government Code sections.

2. If the Contractor intends to file a claim with West County Wastewater for compensation in excess of the Contract amount or for the return of liquidated damages, the claim must be in writing and include all documents necessary to substantiate the claim. These documents may include invoices, cost breakdowns, and other documentation explaining the details of how the Contractor calculated the amount claimed. The claim must be filed on or before the date of final payment. Nothing in this subdivision will extend the time limit or supersede notice requirements otherwise provided by this Contract or by law relating to requests for extra compensation or extensions of time.

3. For claims of less than fifty thousand dollars ($50,000), West County Wastewater will respond in writing to any written claim within 45 days of receipt of the claim, or may request, in writing, within 30 days of receipt of the claim, any additional documentation supporting the claim or relating to defenses or claims West County Wastewater may have against the Contractor.

    a. If additional information is thereafter required by West County Wastewater, it shall be requested and provided by the Contractor pursuant to this subdivision within 20 days of the request from West County Wastewater or as otherwise mutually agreed upon by West County Wastewater and the Contractor.

    b. West County Wastewater's written response to the claim, as further documented, shall be submitted to the Contractor within 15 days after receipt of the further documentation or within a period of time no greater than that taken by the Contractor in producing the additional information, whichever is greater.

4. For claims of over fifty thousand dollars ($50,000) and less than or equal to three hundred seventy-five thousand dollars ($375,000), West County Wastewater shall respond in writing to all written claims within 60 days of receipt of the claim, or may request, in writing, within 30 days of receipt of the claim, any additional documentation supporting the claim or relating to defenses or claims West County Wastewater may have against the Contractor.

a. If additional information is, thereafter, required, it shall be requested and provided pursuant to this subdivision within 30 days of the request by West County Wastewater or otherwise mutually agreed upon by West County Wastewater and the Contractor.

b. West County Wastewater's written response to the claim, as further documented, shall be submitted to the Contractor within 30 days after receipt of the further documentation, or within a period of time no greater than that taken by the Contractor in producing the additional information or requested documentation, whichever is greater.

5. If the Contractor disputes West County Wastewater's written response, or if West County Wastewater fails to respond within the time prescribed, the Contractor may so notify West County Wastewater, in writing, either within fifteen (15) days of receipt of West County Wastewater's response or within fifteen (15) days of the West County Wastewater's failure to respond within the time prescribed, respectively, and demand an informal conference to meet and confer for settlement of the issues in dispute. Upon a demand, West County Wastewater shall schedule a meet and confer conference within (thirty) 30 days for settlement of the dispute.

6. If following the meet and confer conference the claim or any portion remains in dispute, the Contractor may file a claim pursuant to Chapter 1 (commencing with Section 900) and Chapter 2 (commencing with Section 910) of Part 3 of Division 3.6 of Title 1 of the Government Code. For purposes of those provisions, the running of the period of time within which a claim must be filed shall be tolled from the time the Contractor submits its written claim pursuant to paragraph 2 above until the time the said claim is denied pursuant to the procedures set forth herein, including any period of time utilized by the meet and confer conference.

00 72 21 PERMITS

A. West County Wastewater's Permits, Easements, and Agreements

1. The Contractor's attention is directed to the Project Drawings and to any parcel numbers appearing thereon which relate to an easement, permit, or agreement acquired by West County Wastewater for rights-of-way and land use to perform the work and which is contained in the easements, permits, and agreements on file at the West County Wastewater Administrative Offices, identified in Section 00 11 16, Invitation to Bid of the Contract Documents.

2. All work within the various private and public properties shown containing a parcel number must be accomplished in conformance with any specific conditions, instructions, and/or requirements or the respective easement, permit, or agreement.

3. Where the conditions and/or requirements of such easements, permits, or agreements are greater than the conditions and/or requirements of West County Wastewater's Standard Specifications or supplementary conditions and/or requirements prescribed in other portions of the Contract, the conditions and/or requirements of such easements, permits, or agreements will govern.

4. West County Wastewater will, at its expense, provide the appropriate easements for the work included in the Contract. West County Wastewater-provided easements will be shown in the Contract Documents. West County Wastewater may provide additional land for working space, haul roads, and for storage of materials and equipment. If West County Wastewater provides additional land, that land will be shown in the Project Drawings or Specifications. The Contractor may use portions of such easements and land as approved, for working space, haul roads, and for storage of materials and equipment. If the Contractor finds it necessary or advantageous to use any additional land for any purpose whatever, the Contractor shall, at its expense, provide for the use of such land.

B. Construction Permits and Licenses

1. The Contractor shall obtain and pay for all construction permits and licenses necessary for the performance of the Contract and shall give all public notices necessary for the lawful performance of the Contract.

2. Where West County Wastewater has secured Project right-of-way by obtaining the required permits, easements, or agreements as stated in 00 72 21A, and said permit, easement, or agreement requires a subsequent contingent construction permit, inspection, or other related requirements, the Contractor shall meet these additional requirements. The inspection fees charged by regulatory agencies for such subsequent contingent permits shall be paid by the West County Wastewater. However, if the inspection fee is charged as a result of Contractor's noncompliance with the permit requirements, such inspection fee shall be paid by the Contractor.

C. Taxes

1. The Contractor shall pay all taxes, levies, duties, and assessments of every nature due and payable by the Contractor in connection with any work under the Contract, shall make any and all payroll deductions required by law, and shall indemnify and hold harmless West County Wastewater from any liability on account of any and all such taxes, levies, duties, assessments, and deductions.

00 72 22 RECORDS AND ACCOUNTS

A. The Contractor shall, at its expense, keep and maintain such records and accounts in connection with the performance of the Contract, and will furnish to West County Wastewater upon request, that provide an accurate written allocation of the total

amount of the price paid for the performance of the work under the Contract to the various elements of the work, as may be required by West County Wastewater for accounting purposes and for public record. Such records and accounts shall remain accessible to West County Wastewater for a period of not less than three years beyond the date of formal acceptance as provided under Section 00 72 41, Final Payment and Release.

00 72 23 TESTING

A. Contractor shall perform or arrange for performance of testing of materials or work as specified herein or by testing organizations approved by West County Wastewater.

1. General. Where the Specifications require work to be specially tested or approved, the work may be tested only in the presence of the Engineer after timely notice of its readiness for inspection and test, and the work after testing may be covered up only upon the consent of the Engineer.

   a. The results of any tests made are for the information of the Engineer. Regardless of any test results, the Contractor is solely responsible for the quality of workmanship and materials and for compliance with the requirements of the Project Drawings and Specifications.

   b. Except as specifically required under detailed materials specifications for shop testing and inspection, all tests of materials furnished by the Contractor where tests will be made by the Engineer will be done in accordance with commonly-recognized standards of national organizations. The Contractor shall furnish such samples of all materials as required by the Engineer without charge. No material may be used unless it has been determined to be acceptable by the Engineer.

   c. Where such inspection and testing is to be conducted by an independent laboratory or agency, the sample(s) of materials to be tested will be selected by such laboratory or agency, or the Engineer, not by the Contractor.

   d. Water for curing concrete will be provided from a source approved by the Engineer and shall be furnished and disposed of by the Contractor.

   e. All piping must be pneumatically or hydraulically tested for tightness.

   f. Where water testing of piping is required, the Contractor shall furnish and dispose of the water which is required for testing of piping and dispose of it in accordance with applicable regulations.

2. Costs of Testing

a. The Contractor shall be responsible for arranging, and shall pay for, all off-site tests of materials required. The Engineer, unless specified otherwise in Technical Specifications, may witness all off-site tests, and the Contractor shall furnish adequate notice of when tests will be made.

b. The Contractor shall be responsible for arranging, and shall pay for, all on-site tests, except those tests specifically noted to be performed and paid for by West County Wastewater. The Engineer may witness all on-site tests performed by the Contractor, and the Contractor shall furnish adequate notice of when tests will be made.

c. When, in the opinion of the Engineer, additional tests or inspections are required because of the manner in which the Contractor executes its work, West County Wastewater will pay for the additional tests and expenses, but the amounts paid will be deducted from the Contract price. Examples of such additional tests and inspections are: tests of materials substituted for previously-accepted materials or substituted for specified materials or retests made necessary by non-compliance of material with the requirements of the Specifications.

00 72 24 PUBLICATIONS

A. No publications or advertisements concerning the subject matter of the Contract may be made by or on behalf of the Contractor, its subcontractors, or suppliers, without the prior written authorization of West County Wastewater.

B. No advertising signs may be erected at the site of the work.

00 72 25 (NOT USED)

00 72 26 ACCESS TO WORK AREAS

A. West County Wastewater and its officers, agents, employees, and any other duly authorized representatives and employees, and all duly authorized representatives of governmental agencies having jurisdiction over work areas or any part thereof shall at all reasonable times, for the purpose of determining compliance with Contract requirements, have access to the areas and the premises used by the Contractor. The Contractor shall also arrange for West County Wastewater, and its officers, agents, employees, and any other duly authorized representatives and employees, to have access at all reasonable times to all places where equipment or materials are being manufactured, produced, or fabricated for use under the Contract.

B. The Contractor's attention is drawn to the fact that during the course of the work of this Contract, existing sewerage facilities will be used and maintained by West County Wastewater's personnel. The Contractor shall coordinate its work in such a way as to interfere as little as possible with the routine work of existing facility operation consistent with the necessity for making the connections as specified and as shown on the Project Drawings. Contractor's work force will be excluded from

access to and use of existing facilities except in direct pursuit of the work of this Contract without the prior approval of the Engineer. The Contractor shall provide safe access at all times to all existing facilities for operating personnel and equipment.

00 72 27 ILLUMINATION

A. Should any work be performed at night as provided under Section 00 72 43, Night and Weekend Work, or where daylight is shut off or obscured, the Contractor shall, at its expense, provide artificial light sufficient to permit work to be carried on efficiently, satisfactorily, and safely, and to permit thorough inspection. The Contractor shall also assure that access to the place of work is clearly illuminated. The Contractor shall install and maintain all wiring for electric light and power in accordance with all applicable standards, securely fastened in place at all points, and kept as far as possible from other electrical wires, telephone wires, signal wires, and wires used for firing blasts.

00 72 28 INSPECTION AND SAMPLE SPECIMENS

A. Unless otherwise provided in the Contract, all equipment, materials, and work will be subject to inspection and testing by the Engineer. The Engineer may reject equipment, materials, and work not in accordance with the Contract. Rejected work must be satisfactorily corrected; rejected equipment must be satisfactorily repaired or replaced with satisfactory equipment; and rejected material must be replaced with satisfactory material, all in accordance with the Contract. The Contractor shall promptly segregate and remove rejected materials and equipment from the premises. All such correction, repair, replacement, and removal must be performed by and at the expense of the Contractor.

B. The Engineer will perform inspections so as not to delay the work unreasonably, and the Contractor shall perform its work in such manner as not to delay inspection unreasonably. The Contractor shall give the Engineer reasonable advance notice of operations requiring special inspections or tests, and it may request inspection of a portion of any work at any time by reasonable advance notice to the Engineer. The Contractor shall, at its expense, furnish promptly all facilities, labor, and materials necessary and required for such inspection and tests.

C. The Contractor will bear any additional inspection costs resulting from its failure to have a portion of work ready for inspection at the time requested by it for inspection, or from inspection of any previously rejected portion of work where the defects requiring such rejection were caused by the Contractor. The costs may be deducted, in whole or in part, from any monies due or that may become due to the Contractor under the Contract.

D. The Contractor shall furnish the Engineer with all reasonable facilities for the Engineer's safety and convenience in inspecting work, at all times and at all places where inspection may take place. If the Engineer finds that conditions are unsafe for

inspection at a particular location, the Engineer may, upon notice to the Contractor, refuse to inspect in that location until the unsafe conditions are corrected. The Contractor shall bear any additional costs resulting from the Engineer's determination, including any costs incurred to permit subsequent inspection of any portion of work covered or completed at the location before correction of the conditions, whether or not that work is found to meet Contract requirements.

E. The Engineer may inspect materials and finished articles to be incorporated into any work at the place of production, manufacture, or shipment. When the Engineer is to perform such an inspection, no such materials or finished articles may be shipped from the place of inspection or incorporated in any work prior to inspection or without the written approval of the Engineer. Equipment, materials, and work not in conformity with the Contract must be corrected or replaced with satisfactory equipment and materials by and at the expense of the Contractor so as to conform to the Contract as determined by the Engineer.

F. Inspections by the Engineer of equipment, materials, or work do not constitute acceptance by West County Wastewater of such equipment, materials or work. Any such inspections, tests or waivers will not relieve the Contractor of its responsibility for meeting the requirements of the Contract.

G. Where required in the Contract, or whenever requested by the Engineer, the Contractor shall, at its expense, promptly furnish to the Engineer sample specimens of materials to be incorporated into any work. The Contractor shall submit samples in an orderly sequence so that dependent materials or equipment can be assembled and reviewed without causing delays in the work. Samples of material from natural sources must be taken in the presence of the Engineer; otherwise, the sample will not be considered for testing. The Contractor shall tag or securely label samples and samples shall fully identified as to manufacturer, type, size or capacity, lot, and date, all as applicable and by reference to the applicable section and paragraph of the Contract. Materials for which samples are required may not be used in any work until approved in writing by the Engineer. Materials incorporated in any work must conform to such samples as the Engineer determines meet the requirements of the Contract. Samples will be returned to the Contractor only at the discretion of the Engineer.

00 72 29 PROGRESS

A. The construction plant and equipment provided by the Contractor, its labor force, and its methods and organization for handling work, must achieve the necessary quality of work and rate of progress required by the Contract.

B. If at any time during the progress of work, the Contractor's actual progress, as determined by the Engineer, is inadequate to meet the requirements of the Contract, the Engineer may notify the Contractor of such imminent or actual noncompliance with the Contract. The Contractor shall thereupon take such steps as may be necessary to improve its progress including, but not limited to, an increase in the

labor force, the number of shifts, and/or overtime operations, days of work and/or the amount of construction equipment, all without additional cost to West County Wastewater. Neither such notice by the Engineer nor the Engineer's failure to issue such notice will relieve the Contractor from its obligations to achieve the quality of work and rate or progress required by the Contract.

C. The Contractor's failure to comply with the Engineer's instructions pursuant to the Contract may be grounds for the Engineer's determination that the Contractor is not prosecuting work with such diligence as will assure completion within the times specified. Upon such determination, West County Wastewater may terminate the Contractor's right to proceed with the performance of the Contract, or any separable part thereof, in accordance with Section 00 72 36, Termination of Right to Proceed.. Such termination will be without prejudice to any other remedies available to West County Wastewater.

D. In the event of a dispute between the Parties as to performance of the work, the interpretation of this Contract, or payment or nonpayment of work performed, the parties shall attempt to resolve the dispute. If the dispute is not resolved and West County Wastewater has not terminated the Contract in accordance with Section 00 72 36, Termination of Right to Proceed, then the Contractor shall continue the work diligently to completion and will neither rescind this Contract nor stop the progress of the work. In the event any litigation is commenced with respect to this Contract, such litigation will not suspend Contractor's obligation to continue performance of the work hereunder.

00 72 30 (NOT USED)

00 72 31 RESPONSIBILITY FOR WORK; PRECAUTIONS; SECURITY

A. The Contractor bears all responsibility for material and skilled application of all work furnished and performed under this Contract, including any Amendments to this Contract. At the completion of this Contract, the construction must constitute a complete and operable facility. In the event an error or omission is discovered in the Contract during the course of the work, the Contractor shall promptly notify the Engineer in writing. If the Engineer determines that remedial measures are necessary requiring extra work clearly outside the scope of the Contract work, the Parties will negotiate a Change Order in accordance with Section 00 72 12, Changes and Extra Work.

1. The Contractor will bear any and all risk of loss of, or damage to, any work and all materials and equipment until final acceptance under the Contract, unless such loss or damage results from the active negligence of West County Wastewater or any Act of God as defined herein.

B. As provided in Sections 7105 California Public Contract Code, the Contractor will not bear responsibility for the cost of repairing or restoring damage to the work if the damage is determined to have been proximately caused by an Act of God, in

excess of five percent of the contracted amount, provided that the work damaged was built in accordance with accepted and applicable building standards and the Project Drawings and Specifications of West County Wastewater. For purposes of this section, the term "Acts of God" shall include only the following occurrences or conditions and effects: earthquakes in excess of a magnitude of 3.5 on the Richter Scale and tidal waves. The Contractor shall promptly take all necessary precautions against any conditions created during the performance of the Contract which involve a risk of bodily harm to others or a risk of damage to work or to property, including the property of West County Wastewater. The Contractor shall inspect all work, materials, and equipment to discover any such conditions.

C. Existing fences may enclose some or all portions of the Project site. The fences are for the protection and security of existing facilities. While it may be necessary for the Contractor to remove some of the fences for the installation of new structures, fences, and pipelines, the Contractor's operations may not reduce the present protection and security. If the present fences are removed, an equivalent temporary continuous perimeter protection shall be provided, and new fence shall be installed in the locations shown, prior to completion of the work.

D. The Contractor may not assume that any fence or other existing enclosure about existing facilities provide appropriate security for either equipment, plant, or materials intended to be employed or incorporated in the work.

E. The Contractor shall assume all liability for its failure to comply with the foregoing regardless of any right the Engineer may have to inspect the Contractor's work.

00 72 32 STORAGE OF MATERIALS AND EQUIPMENT

A. The Contractor shall, at its expense, store all materials and equipment as specified in the Contract or, where not specified, in such a manner as to assure the preservation of their quality and fitness, and so as to facilitate prompt inspection by the Engineer.

00 72 33 USE OF COMPLETED PORTIONS OF THE WORK

A. Partial Beneficial Use. "Partial beneficial use" means the use of a portion of the Contract work by West County Wastewater before that portion of work is to be put in service and before acceptance of the Contract by West County Wastewater. The portion of the contract work is usually a system or facility which can be operated or used independently from other systems or facilities included in the Contract and is not required for the proper operation of other systems or facilities.

1. West County Wastewater may, at any time, in a written order to the Contractor (1) declare that West County Wastewater intends to use a specified part of the work, which in West County Wastewater's opinion is sufficiently complete to permit use of said work, (2) enclose a tentative list of items remaining to be completed or corrected within the area designated for partial beneficial use, and (3) fix the date of commencement of partial beneficial use.

2. The warranty period for a part of the work which is specified for partial beneficial use will start on the date which is fixed for commencement of partial beneficial use.

3. If, as a result of the Contractor's failure to comply with the provisions of the Contract, such partial beneficial use proves to be unsatisfactory to West County Wastewater, West County Wastewater may continue such use until such portion of work can, without adversely affecting West County Wastewater, be taken out of service for correction of defects, errors, omissions, or replacement of unsatisfactory materials or equipment, as necessary for such work to comply with the Contract. The time for the Contractor to complete of corrections or replacements may not exceed six months from the date of acceptance of the Contract, unless otherwise agreed in writing by the Parties.

4. The Contractor may not use any portions of the work that have been accepted for partial beneficial use nor any facilities which existed prior to the date it commenced work on the Project unless the Engineer approves such use in writing. Where the Contractor's written request is granted for the use of portions of the work located at facilities declared as being subject to partial beneficial use, the Contractor shall properly use and maintain, and upon completion of the Contractor's use and at the Contractor's expense, recondition said portions of the work or facilities to the satisfaction of West County Wastewater.

B. Substantial Completion. "Substantial completion" means construction sufficiently completed in accordance with the Contract so that West County Wastewater can occupy or utilize all portions and all systems of the work for all of the uses for which said work was intended, including seven continuous days of successful operation of the entire system.

1. When the Contractor determines that the work is substantially completed, the Contractor shall prepare and submit to West County Wastewater a list of items to be completed or corrected and request an inspection for substantial completion. The Contractor's failure to include any items on the list does not alter the Contractor's responsibility to complete all work in accordance with the Contract. If West County Wastewater determines on the basis of the inspection that all portions and all systems of the work are substantially complete, West County Wastewater will prepare a certificate of substantial completion which will: (1) establish the date of substantial completion of the work; (2) state the responsibilities of West County Wastewater and the Contractor for security, maintenance, operation, and insurance; and (3) fix the time within which the Contractor must complete the items listed in the certificate. West County Wastewater shall submit the Certificate of Substantial Completion to the Contractor.

2. Approval by West County Wastewater of a Certificate of Substantial Completion will not constitute acceptance of the work nor start the warranty

period. Approval of a Certificate of Substantial Completion will fix the date for lowering the amount of liquidated damages to the value specified in the Contract for the period after substantial completion.

00 72 34 CLEANING UP

A. The Contractor shall, at all times, keep the premises occupied by it in relation to this Contract, in a neat, clean, and safe condition and at all times provide reasonable access to the premises. The Contractor shall, at a minimum, conduct daily inspections to verify its compliance with this Section.

B. During the progress of the work, the Contractor shall:

1. Retain all stored items in an orderly arrangement allowing maximum access, not impeding drainage or traffic, and providing the required protection of material.

2. Provide adequate storage of all items awaiting removal from the jobsite, observing all requirements for fire protection and protection of the environment.

3. Remove any accumulation of scrap, debris, waste material, and other items not required for construction of this work.

4. Dispose of existing materials and equipment to be demolished and removed and all trash such as broken concrete, wood blocking, shipping containers, etc., resulting from the contract work off the premises occupied by the Contractor, including West County Wastewater property, at the Contractor's expense. Contractor may not use West County Wastewater-leased dumpsters and other disposal containers on West County Wastewater's property except for those specifically provided by the Contractor.

5. Maintain all excavation, embankments, haul roads, permanent access roads, Plant site, waste disposal areas, borrow areas, and all other work areas within contract work limits free from dust, as determined by the Engineer. Industry-accepted methods of dust control suitable for the area involved, such as sprinkling, chemical treatment, light bituminous treatment, or similar methods, are permitted. West County Wastewater will not make any separate payment to the Contractor for dust control.

C. If the Contractor fails to comply with any of the foregoing provisions, West County Wastewater will transmit written notification of noncompliance to Contractor. If, the Contractor fails to comply within five days after the written notification West County Wastewater may undertake cleanup at the Contractor's expense.

D. Upon its completion of any portion of any work, the Contractor shall promptly remove all of its equipment, temporary structures, and surplus construction and other materials not to be used at or near the same location during later stages of

work. Upon completion of any work and before final inspection is made, the Contractor shall, unless otherwise specifically directed by the Engineer:

1. Remove from the job site all plant, buildings, tools, surplus materials, equipment, forms, rubbish, scrap, debris, and waste.

2. Hose down all paved areas on the site. Completely remove all resultant debris.

3. Visually inspect all interior surfaces, and remove all traces of soil, waste material, smudges, and other foreign matter. Remove all traces of splashed materials from adjacent surfaces. Remove all paint droppings, spots, stains, and dirt from finished surfaces. Use only approved cleaning materials and equipment.

4. Restore any improved area used for the Contractor's work or material storage to its condition at the time the Contractor moved onto the site or to the satisfaction of the Engineer.

5. Schedule final cleaning and improvement restoration to enable West County Wastewater to accept a completely clean and restored project.

00 72 35 PROGRESS, COMPLETION, DELAYS, AND EXTENSIONS OF TIME

A. The time limits stated in the Contract are of the essence of the Contract. By executing the Contract, the Contractor confirms that the time limits set forth in the Contract, including interim or milestone dates, are reasonable periods for the performance of the work. The Contractor will not be entitled to extensions of time limits during the progress of the work unless it demonstrates that: (1) the delay is occasioned by an act or neglect of West County Wastewater; or (2) the delay in the completion of the work arises from unforeseeable causes beyond the control and without fault or negligence of both the Contractor and its subcontractors or suppliers. Such unforeseeable causes may include: acts of God; acts of a public enemy; acts of a governmental entity not occasioned by the Contractor's, subcontractor's or supplier's conduct; acts of another contractor in performance of a contract with West County Wastewater; fires; floods; epidemics; quarantine restrictions; freight embargoes; unusually severe weather; or other delays of subcontractors or suppliers arising from unforeseeable causes beyond the control and without the fault or negligence of both the Contractor and such subcontractors or suppliers.

B. If the Contractor seeks an extension of time for the completion of any phase of the work, the Contractor must file with the Engineer a written request for an extension of time for the portion of the work so delayed no later than ten days after the onset of the delay, and the request must fully state the reasons for the delay. When such a request is received, the Engineer will ascertain the reasons for and the extent of such delay. If the Engineer determines that the facts justify an extension of time, the Parties will modify the Contract accordingly, in writing. The Engineer will deny any request that is determined not to justify an extension of time. The Engineer will

provide the Contractor with the factual findings regarding either determination of a request for time extension. The Engineer's findings will be final unless the Contractor files a protest under Section 00 72 1, Authority of the Engineer and Contractor's Appeal Procedure. West County Wastewater will not a time extension for any portion of any delay unless the Contractor has timely made the required written request and the Engineer finds justification for the request.

C. West County Wastewater may make changes to the work or suspend the work. Regardless of the number of such changes made by West County Wastewater, such changes or suspensions are within the contemplation of the Parties and will not be a basis for compensable delay to the Contractor.

D. No time extensions except for a delay that:

1. impacts the Project's critical path,

2. consumes all available float, slack time, or schedule contingency within the construction schedule (the time between the Contractor's scheduled early completion date and the Contract completion date), and

3. extends work beyond the Contract completion date.

E. Float, slack time, or schedule contingency within the construction schedule is not for the exclusive use nor benefit of the West County Wastewater or the Contractor but is a resource available to both parties as needed.

00 72 36 TERMINATION OF RIGHT TO PROCEED

A. If the Contractor refuses or fails, except in cases for which extension of time is provided, to supply enough properly skilled workers, proper equipment and proper appliances or proper materials for the work, or if it should fail to make prompt payments to subcontractors or for material or labor, or disregard laws, ordinances, or the instructions of the Engineer, or otherwise be guilty of a substantial violation of any provision of this contract, then West County Wastewater, upon certification of the Engineer that sufficient cause exists to justify such action, may without prejudice to any other right or remedy serve written notice upon the Contractor and Surety of its intention to terminate the performance of the Contractor and of the reasons for such termination. Unless Contractor ceases the cause for such intention to terminate and makes satisfactory arrangement for correction no later than seven days after West County Wastewater serves the notice, the Contractor's right to proceed with the work will terminate. If Contractor: (1) is terminated pursuant to this Section 00 72 36; (2)is adjudged as bankrupt:(3) makes a general assignment for the benefit of its creditors; or (4) has a receiver should be appointed on account of its insolvency, West County Wastewater shall serve notice thereof upon the Surety and Contractor. No later than seven days after service of this notice by West County Wastewater, the Surety may perform the Contract. However, if the Surety does not commence performance of the Contract within the period mentioned in the preceding sentence, West County Wastewater may take possession of the premises

and of all materials, tools, equipment, and appliances on the premises and finish the work by whatever method West County Wastewater may deem expedient. In that instance, the Contractor will not receive any further payment until the work is complete. If the unpaid balance of the Contract price exceeds the expense of finishing the work, including compensation for additional managerial and administrative services performed by or for West County Wastewater, West County Wastewater shall pay such excess to the Contractor. If such expense exceeds the unpaid balance, the Contractor and Surety shall pay the difference to West County Wastewater. The Engineer shall certify the expense incurred by West County Wastewater and the damage incurred through the Contractor's default. Service of any notices under this Section 00 72 36 hereunder will be complete upon the deposit of the notice in the United States mail, postage prepaid, addressed to the address of the Contractor and Surety as shown on records on file with West County Wastewater.

B. Termination of the Contractor under this Section 0072 36 will not limit any other remedies available to West County Wastewater.

C. Upon receipt of any written notice of termination of right to proceed, the Contractor shall, at its expense, for the work affected by the termination:

1. Assist West County Wastewater in making an inventory of all materials and equipment in storage at the site, en route to the site, and on order from suppliers.

2. Assign to West County Wastewater any subcontracts, supply contracts, and equipment rental agreements so designated by West County Wastewater.

3. Remove from the site all construction materials, equipment, and plant listed in the inventory other than any construction materials, equipment, and plant which are designated in writing by West County Wastewater to be used by West County Wastewater in completing the work.

00 72 37 TERMINATION FOR CONVENIENCE

A. Including, but not limited to, because of termination in the event of national emergency pursuant to Section 4410 et. seq. of the Government Code of the State of California, West County Wastewater may, at its option, cancel and terminate the Contract in whole or in part at any time by written notice of termination to the Contractor, whether or not the Contractor is in default.

B. Upon any such cancellation and termination, the Contractor will not be entitled to assert claims for damages, including loss of anticipated profits, on account of the cancellation and termination. The Contractor's sole remedy in such event will be the payment of the Contractor by West County Wastewater in accordance with subparagraph B.2, below. Any such payment will be made subject to the survival, in full force and effect, of the provisions of the Contract which by their nature survive final acceptance under the Contract to the extent provided in such provisions.

1. Upon receipt of any such notice, the Contractor shall, unless the notice requires otherwise:

    a. Immediately discontinue work on the date and to the extent specified in the notice.

    b. Place no further orders or subcontracts for materials, services, or facilities, other than as may be necessary or required for completion of such portion of work under the Contract that is not terminated.

    c. Promptly make every reasonable effort to obtain cancellation upon terms satisfactory to West County Wastewater of all orders and subcontracts to the extent they relate to the performance of work terminated.

    d. Assist West County Wastewater as specifically requested, in writing, in the maintenance, protection, and disposition of property acquired by West County Wastewater under the Contract.

2. Upon any termination for convenience, West County Wastewater will pay the Contractor an amount determined in accordance with the following (without duplication of any item):

    a. All amounts due and not previously paid to the Contractor for work completed in accordance with the Contract prior to the notice, and for work thereafter completed as specified in the notice.

    b. The cost of settling and paying claims arising out of the termination of work under subcontracts or orders as provided in subparagraph B.1.c, above.

    c. The reasonable costs incurred pursuant to subparagraph B.1.d, above.

    d. Any other reasonable costs incidental to the termination of work.

    e. The foregoing amounts will include a reasonable sum, under all of the circumstances, as profit for any work performed by the Contractor.

00 72 38 SUSPENSION

A. West County Wastewater may, in its sole discretion, suspend at any time the performance of all or any portion of work to be performed under the Contract by notice in writing to the Contractor. . Upon such notice, West County Wastewater shall designate the amount and type of plant, labor, and equipment to be committed to the Project. During the period of suspension, the Contractor shall use its best efforts to utilize its plant, labor, and equipment in such a manner as to minimize costs associated with suspension.

1. Upon receipt of such notice, the Contractor shall, unless the notice requires otherwise:

    a. Immediately discontinue work on the date and to the extent specified in the notice.

    b. Place no further orders or subcontracts for material, services, or facilities with respect to suspended work other than to the extent required in the notice.

    c. Promptly make every reasonable effort to obtain suspension upon terms satisfactory to West County Wastewater of all orders, subcontracts, and rental agreements to the extent that they relate to the performance of the work suspended.

    d. Unless otherwise specifically stated in the notice, the Contractor shall continue to protect and maintain the Project including those portions on which work has been suspended.

2. As full compensation for a period of suspension, the Contractor will be reimbursed for the following costs, reasonably incurred, without duplication of any item, to the extent that such costs directly result from the suspension of work:

    a. A standby charge to be paid to the Contractor during the period of suspension of work which will be sufficient to compensate the Contractor for keeping, to the extent required in the notice, its organization and equipment committed to the Project in a standby status.

    b. All reasonable costs associated with mobilization and demobilization of the Contractor's plant, forces, and equipment.

    c. A reasonably supported amount to reimburse the Contractor for the cost of maintaining and protecting that portion of the Project upon which work has been suspended.

    d. If, as a result of any such suspension of work, the cost to the Contractor for subsequently performing work is increased or decreased, West County Wastewater will adjust the cost of performing the remaining portion of the work.

B. Upon its receipt of notice to resume suspended work, the Contractor shall immediately resume work on the suspended work to the extent required in the notice. The Contractor shall file with West County Wastewater any request for a time extension or compensation for costs incurred during the suspension no later than ten days after its receipt of the notice to resume work, and the Contractor shall also submit for review a revised construction schedule.

00 72 39 MEASUREMENT AND PAYMENT

A. Where the weight of parts and items furnished by Contractor relates to measurement and payment under the Contract, unless otherwise provided in the Contract, the Engineer will decide the method to be used in determining the weight of the parts and items, such as the use of shipping weights, scale weights, manufacturers' weights, catalog weights, or computed weights. West County Wastewater will pay Contractor only on the basis of net weight which will exclude the weight of all tare, packing, blocking, shop welds, and the weight of materials which are required to be placed or applied at the site of construction, such as grout, wedges, and caulking materials. The Contractor shall, if required by the Engineer, and at its expense, furnish scales and provide assistance for weighing and measuring such materials without additional charge.

B. Wherever the measurement and payment provisions of the Contract provide that payment for the item(s) listed therein will be made at the Contract-unit price or at Contract lump-sum price, whichever is set forth in Section 00 41 43, Schedule of Bid, payment under such provisions will fully compensate Contractor for all work referred to in the applicable provision, including but not limited to the following: all labor, supervision, tools, materials, equipment, the performance of all operations, all other direct expenses and items of overhead, general and administrative expense, and profit for the applicable Contract item.

C. Wherever in the Contract it is provided that the Contractor shall perform certain work "at its expense" or "without charge," or that certain work "will not be paid for separately," the quoted words mean that the Contractor may not recover any additional compensation from West County Wastewater for such work. The cost of such work will, unless otherwise specified, be considered as inherently included in the payment for other items of work identified in Section 00 41 43, Schedule of Bid.

00 72 40 PROGRESS PAYMENTS

A. Unless otherwise provided in the Specifications, West County Wastewater shall make monthly progress payments as the work proceeds. Such payments will be made in accordance with estimates of the amount and value of work satisfactorily performed by the Contractor up to the time of each estimate.

1. Prior to preparation of the first estimate for a progress payment, the Contractor shall submit for review by the Engineer a detailed cost breakdown of the work under each bid item awarded. Bond and insurance costs will not be a separate item of cost for this purpose but shall be included in mobilization/demobilization.

2. Partial payments for mobilization/demobilization costs will be as follows:

    a. West County Wastewater shall pay thirty-five percent (35%) of the amount bid for mobilization/ demobilization or 1.75 percent of the

original contract amount, whichever is less, in each of the first two progress payments.

b. West County Wastewater shall pay the balance of the amount bid for mobilization/demobilization upon the completion of all work on the project.

B. In most instances, the Contractor will not be compensated for materials and equipment delivered to the site until after they are incorporated in the work. If the Engineer determines that the progress of the work will benefit by the delivery to the site of certain materials and equipment in advance of their actual requirement, and if such materials and equipment are delivered in accordance with the following conditions, the Contractor may be paid a portion of the cost of the materials and equipment in progress payments. The conditions for such partial payments are as follows:

1. The Contractor shall, no later than four weeks prior to the delivery of materials and equipment for which it seeks partial payment, submit a list of such materials and equipment for review by the Engineer.

2. The Engineer must review and accept shop drawings and technical data for such materials and equipment prior to delivery.

3. Upon delivery, the Contractor shall submit written evidence, satisfactory to the Engineer, that the Contractor is the unconditional owner of such materials, free from all claims, liens, and security interest, and a bill of sale or other equivalent document with warranty of title to such materials and equipment.

4. Title to the delivered material will be vested in West County Wastewater at it is delivered to the site. The Contractor shall, notwithstanding such transfer of title to West County Wastewater, be responsible for such materials and equipment until they have been completely installed, tested, and accepted.

5. Such equipment and materials must be properly stored or stockpiled to the satisfaction of the Engineer. The Contractor shall at its own cost replace any materials and equipment damaged or lost.

6. Contractor shall assure that stored or stockpiled materials are available for inspection by the Engineer.

7. If any defects are discovered in delivered material, whether caused by defective manufacture or damage occurring during delivery or storage (including storage at West County Wastewater or the construction site), the Contractor shall remove such materials and replace them with suitable material at its expense.

8. The Contractor's insurance must include coverage for such material against theft, fire, vandalism and malicious mischief.

9. The maximum portion of cost to be included in progress payments for materials and/or equipment qualifying under this section will be 75 percent of the total cost of the delivered materials and/or equipment eligible for partial payment. The payment will not exceed the bid price or assigned value for the item of work for which the material and/or equipment is furnished, and the accumulated total payment for all material delivered but not yet incorporated into the work will not exceed ten percent of the total value of the Contract.

10. In estimating progress payments, the Engineer may use the unit prices bid by the Contractor. In the event that there are no unit bid prices, or the bid unit prices do not, in the opinion of the Engineer, represent the actual value of the equipment and materials furnished, the Engineer may estimate progress payments based on prices reflecting the actual value.

11. Nothing in this subparagraph B will relieve the Contractor of its responsibility for incorporating the materials in the work in conformity with the Contract.

C. If the Engineer does not accept the initial detailed cost breakdown, the Contractor shall submit additional cost breakdowns until the Engineer determines that the cost breakdown is acceptable. The approved breakdown will then become the basis for partial payment determination. The Contractor shall make progress payment estimates and submit them to the Engineer for review and concurrence. Once West County Wastewater has agreed to the items of cost, the Contractor shall prepare a progress payment request on a form furnished by West County Wastewater and submit the request for payment. The burden of requesting payment is on the Contractor. West County Wastewater will not pay for a separate item of cost unless that item of cost is included in a progress payment request by the Contractor.

D. West County Wastewater shall retain five percent of the cumulative estimated amount of each progress payment until the final acceptance of all work under the Contract pursuant to Section 00 72 41, Final Payment and Release. The Contractor may substitute securities for any monies otherwise to be retained pursuant to Section 22300 of the California Public Contract Code. If the Contractor opts to substitute securities pursuant to Section 22300, it shall execute the Escrow Agreement for Security Deposits in Lieu of Retentions in the form contained in Section 00 45 15, of the Contract Documents. Any payments otherwise payable under the Contract may be withheld, in whole or in part, by West County Wastewater as may be necessary to protect West County Wastewater from loss because of:

1. Defective work which is not remedied;

2. Third party claims filed or reasonable evidence indicating probable filing of such claims against the Contractor;

3. Failure of the Contractor to make payments properly to subcontractors or for labor, materials, or equipment;

4. The existence of reasonable evidence that the work cannot be completed for the unpaid balance of the contract sum;

5. Failure of the Contractor to submit an acceptable construction schedule or failure to update the schedule.

6. Damage to West County Wastewater or another contractor;

7. The existence of reasonable evidence that the work will not be completed within the time provided for in the Contract; or

8. Contractor's failure or inability to obtain or maintain insurance coverage and bonds as required by the Contract throughout the course of the job; or

9. Persistent failure to carry out the work in accordance with the Contract.

10. Failure to deliver copies of certified payrolls, as specified in this Section 00 72 20, Laws and Regulations.

11. In addition, West County Wastewater may deduct from payments otherwise due the Contractor any amounts West County Wastewater may be currently or in the future authorized to retain pursuant to federal, state, or local laws or regulations, any amounts due to West County Wastewater from the Contractor, and any other amounts which West County Wastewater is otherwise authorized to retain as specified in Section 00 73 00, Supplementary Conditions.

E. West County Wastewater will retain an amount from any payment otherwise due the Contractor in an amount not to exceed twice the value of repairs, corrections, or replacements as required by the Contract to assure that the Contractor completes such repairs, corrections, or replacements. The Contractor will receive payments of such retained amounts when the repair, correction, or replacement work is completed.

F. The Contractor may prevent withholding of additional amounts of the Progress Payment by, (1) correcting such defects in workmanship or materials as may exist, (2) curing any default existing in any of the conditions of the Contract, or (3) paying, satisfying, or discharging any claim of West County Wastewater or any other person against the Contractor arising out of or in any way connected with the work to be performed under the Contract. The Engineer may, in its sole discretion determine whether conditions exist as set forth above to justify withholding payment(s), in whole or in part, and/or whether the Contractor has properly remedied such claims, defects, or failures.

G. If the Contractor does not promptly meet its obligations under this section after its receipt of a written notice from the Engineer, West County Wastewater may discharge such obligations and deduct all costs in connection with discharging Contractor's obligations from payments(s) to the Contractor. If the amount which may be withheld from payment(s) is insufficient to meet such costs, or if any claim

or charge against the Contractor is discharged by West County Wastewater after the final contract payment is made, Contractor and its Sureties shall promptly pay West County Wastewater all costs it incurred, regardless of when such claim arose or whether such claim imposed a lien upon the Project.

H. Contractor's shall submit progress payment requests in writing on or about the 25th day of each calendar month, and West County Wastewater shall pay the Contractor within 21 days after the Engineer verifies that the request has been properly filed and submitted and is properly supported. The Contractor's progress estimates will not be required to be made by strict measurement, but may be made by measurement or by estimation or partly by one method and partly by another.

I. Pursuant to Section 9204 of the Public Contract Code, West County Wastewater will pay interest on progress payments held over sixty (60) calendar days from the date of submission so long as the Engineer determines that Contractor's request for payment was properly filed and submitted. A request for payment may not be determined to be properly filed or submitted until West County Wastewater determines that the Record Drawings are current The date of submission for a progress payment is the date on which West County Wastewater's representative signs the progress payment request form in the space provided for the resident engineer. This signature will verify that the request has been properly filed and submitted.

J. West County Wastewater will deem the Contractor's submission of an invoice without the proper, required accompanying submittals, or with incorrect calculations, or in a format not acceptable to West County Wastewater, as a disputed request for payment and not a properly submitted request for payment. West County Wastewater will return such invoices to the Contractor for resubmittal.

K. The Contractor need not make a progress estimate or payment when, in the Engineer's judgment, the total value of the work performed since the last estimate amounts to less than five thousand dollars ($5,000).

L. All equipment, materials, and work covered by progress payments will, upon payment, become the property of West County Wastewater. However, this subdivision does not connote acceptance of any work and does not relieve the Contractor from its sole responsibility for all equipment, materials, and work upon which payments have been made, including the restoration of any damaged work until final acceptance thereof other than as provided in Section 00 72 33, Use of Completed Portions of the Work, and does not waive West County Wastewater's right to require fulfillment of all of the terms of the Contract.

00 72 41 FINAL PAYMENT AND RELEASE

A. When the Contractor deems that its obligations under the Contract have been fulfilled, the Contractor shall, in writing, so notify the Engineer. Upon receipt of the notice, the Engineer will, in company with the Contractor, inspect the work that has

been performed. If the Engineer determines that all work which, by the terms and conditions of the Contract, is to be performed, has been satisfactorily performed, the Engineer will recommend acceptance of the work. After acceptance of the work by West County Wastewater, West County Wastewater will cause to be filed in the office of the Engineer and the office of the County Recorder of Contra Costa County, in accordance with Section 4005 of the Government Code of the State of California, a notice of completion of all work under the Contract. Upon expiration of the statutory period for filing of liens and stop notices and provided no liens or stop notices have been filed, West County Wastewater will pay to the Contractor the amount remaining due after deducting from such amount all such amounts as will have been previously paid to the Contractor under the Contract, and also any amounts which, by the terms of the Contract, West County Wastewater is or may be authorized or required to reserve or retain. All prior progress payments, being estimates, will be subject to adjustment in the final payment.

B. The Contractor is obligated to provide West County Wastewater with a release of all claims arising out of work related to undisputed contract amounts. Final payment shall be subject to the Contractor executing a release in favor of West County Wastewater, its directors, officers, representatives, agents, and employees as to all claims of and liability to the Contractor or any third party for anything done or furnished for, or in relation to, any work related to undisputed contract amounts; and for any act or omission of West County Wastewater, its directors, officers, representatives, agents and employees, respectively, or of any person relating to or affecting any work related to such final payment.

C. Claims by the Contractor for additional compensation or damages remaining in dispute as set forth in the final payment release will be excluded from the terms of the release. West County Wastewater may withhold from the final payment up to one hundred fifty percent (150%) of the estimated value of claims by West County Wastewater or third parties against the Contractor, including but not limited to claims regarding amounts previously paid to the Contractor by West County Wastewater.

D. The release signed by the Contractor as part of the final payment shall be in substantially the following form:

Final Payment and Release

Project Name

_____

West County Wastewater Project Number_____

The acceptance by Contractor of the final contract payment in the sum of $_____ covering undisputed contract amounts releases West County Wastewater, West County Wastewater's directors, officers, representatives, agents, and employees, respectively, from all claims of and liability to the Contractor (except as set forth below), including claims of the Contractor as the successor in interest by assignment or otherwise, to claims of laborers, mechanics, subcontractors, consultants, and material men and including claims by laborers, mechanics, subcontractors, consultants, and material men as successors in interest by assignment, or otherwise, arising out of the work performed under the Contract which are related to said undisputed Contract amounts. This Release will be effective as to all claims of the Contractor arising out of or in connection with the performance of the work under this Contract with respect to said undisputed Contract amounts, including tort claims, which are known to the Contractor or reasonably should have been known to the Contractor at the date of the signing of this Release. The Contractor's acceptance of the final contract payment described above waives all claims described herein and any entitlement by Contractor to additional payment arising out of the Contract, except as to those claims by the Contractor and their respective estimated dollar amounts listed below. The Contractor acknowledges that the amounts set forth below are good faith estimates and may be subject to reasonable modification. It is intended that this Release be construed in accordance with the limitations set forth in California Public Contract Code, Section §7100.

DESCRIPTION OF DISPUTED CLAIM	ESTIMATED AMOUNT OF DISPUTED CLAIM
_____	$ _____
_____	
_____	

Signed:_____

By: _____
(typed or printed)

Title_____

Company Name:_____ Dated:_____

E. West County Wastewater may elect to issue final payments directly to subcontractors, or to issue joint check payments, payable to the Contractor and subcontractor involved. Contractor shall verify the correctness of any final payments to be made to subcontractors by West County Wastewater and shall acknowledge the same in writing to West County Wastewater no later than five days of a written request therefor from West County Wastewater. If the Contractor disputes the correctness of any final payment to be made to a subcontractor, the Contractor shall so notify West County Wastewater, in writing, of the matters in

dispute and the amounts thereof. The notice must be in a writing delivered to West County Wastewater no later than five days after the date of a written request from West County Wastewater. West County Wastewater shall make such payments in accordance with estimates made by the Contractor and/or subcontractor and approved by the Engineer of the amount and value of work satisfactorily performed by the subcontractor. Amounts paid to the subcontractor will be deducted from any amounts due the Contractor under the terms of the Contract and any change or extra work orders. However, to the extent that the Contractor disputes any portion or all of the estimated payment due a subcontractor, West County Wastewater shall withhold from the payment to the subcontractor an amount not to exceed 150 percent (150%) of the disputed amount. If the entire amount due the subcontractor is disputed by the Contractor, then up to 150 percent (150%) of this entire amount may be deducted from payments to Contractor until the dispute is resolved.

F. If West County Wastewater elects to issue final payments to a subcontractor or subcontractors or to issue joint check payments, West County Wastewater may request, as part of its payment to the subcontractor or subcontractors involved, that the subcontractor or subcontractors sign a Conditional Waiver and Release Upon Final Payment to the subcontractor which shall be in substantially the following form:

Conditional Waiver and Release Upon Final Payment to Subcontractor

Upon receipt by the undersigned of a check from West County Wastewater in the sum of
$_____ payable to _____ and when the check has been properly endorsed and has been paid by the bank upon which it is drawn, this document releases any mechanic's lien, stop notice, or bond right the undersigned has on this Contract. This release covers the final payment of the undersigned for all labor, services, equipment, or material furnished on the job, except for disputed claims for additional work described in the attached sheet, if any, in the amount of $__.

Before any recipient of this document relies on it, said party should verify evidence of payment to the undersigned.

Dated: _____ _____
Company Name

By:_____

Title:_____

00 72 42 LIQUIDATED DAMAGES

A. If the Contractor fails to complete the work in a manner satisfactory to West County Wastewater on or before the dates of completion agreed upon and fixed in this Contract or as duly extended as provided in this Contract, the Contractor, pursuant to the provisions of this Contract and California Government Code Section 53069.85, shall pay to West County Wastewater the sum set forth under Section 00 73 21, Amount of Liquidated Damages, for each calendar day of such delay. The Parties acknowledge that this daily Amount of Liquidated Damages is a reasonable estimate of future damages as of the date of this Contract, and the Parties further acknowledge that the sum specified as liquidated damages is not manifestly unreasonable under the circumstances existing at the time the Contract was made. West County Wastewater may deduct said sums from the payments due the Contractor each month. If the payments due the contractor are less than the amount of such liquidated damages, said damages shall be deducted from any other monies due or to be due the Contractor. The Contractor or its Surety shall pay the balance to West County Wastewater.

B. This liquidated damages provision is intended to apply only to the normal administrative, construction, engineering, supervision, design, redesign, operation, and other analogous costs associated with delays in projects similar to the project involved herein. This liquidated damages provision shall not apply to other damages, including consequential damages other than as specified above nor shall preclude West County Wastewater from seeking said other damages not covered by the liquidated damages provision. Specifically, this liquidated damages provision shall not apply to or include consequential damages resulting from the delay itself, as opposed to the direct-cost-type damages described above, incurred as a result of typical day-to-day project costs normally associated with on-going work. These excluded consequential and other damages shall include, but not be limited to, first- and third-party claims for torts, claims of inverse condemnation, environmental costs and claims, and/or regulatory fees or fines imposed in whole or in part due to Contractor's failure to complete the work in the manner, including time, as set forth in the Contract.

00 72 43 NIGHT AND WEEKEND WORK

A. The Contractor may be required to perform the work at night if the Engineer at any time determines that it is necessary for the progress of the work, or if emergencies arise. The Contractor shall promptly comply with any such requirements that are made in writing by the Engineer. The Contractor may be permitted to work at night if it obtains the approval of the Engineer to do so in order to maintain the required progress or protect the work from the elements. When required, ordered, or permitted to work at night, the Contractor shall provide sufficient and satisfactory lighting and other facilities for the work. For night work, the Contractor shall employ a crew organized and prepared for regular and continuous night work. The Contractor will not be entitled to any additional payment for performing night work, and compensation for such work will be included in the Contract price.

B. The Contractor may not work on weekends except:

1. to perform usual protective work, such as pumping;
2. for work done in case of emergency threatening injury to persons or property; or
3. when, in the sole judgment of the Engineer, the work will be of advantage to the West County Wastewater.

C. Before the Contractor performs night and weekend work, it must first obtain all necessary permits from all entities having jurisdiction (for example noise ordinances) prior to starting such work.

00 72 44 INTOXICATING LIQUORS AND DRUGS

A. The Contractor may not sell and shall neither permit nor suffer the introduction or use of intoxicating liquors or non-prescribed illegal narcotics or drugs upon or about the work.

00 72 45 MEETINGS

A. The Parties shall hold a pre-construction meeting after the award of the Contract to resolve any remaining pre-construction submittal issues as required by the Contract, and discuss various administrative items (including, but not limited to: the overall project construction schedule, the frequency of progress meetings, and the length of the look-ahead schedules). At this meeting, West County Wastewater may request that the Contractor provide it with certified payroll forms containing the classifications of workers who will be employed on the project and the wage each classification will be paid. The Contractor shall also be prepared to discuss all of the referenced items, as well as the methods of implementing the various work items.

B. the Project Manager will, no less often that once per month, conduct progress meetings for the purpose of discussing and resolving matters concerning the various elements of the work. The Contractor shall furnish look-ahead schedules at each of the progress meetings.

C. West County Wastewater may notify the Contractor regarding other meetings which the Contractor and subcontractors may be required to attend.

D. The time and place for the meetings described above and the names or titles of persons and subcontractors required to be present will be as directed by the Project Manager. The Contractor shall comply with these attendance requirements and shall also require, if needed, its subcontractors to comply.

00 72 46 LIENS AND STOP NOTICE

A. If at any time any notices of lien are filed for labor performed or materials or equipment manufactured, furnished, or delivered to or for the work, the Contractor

shall at its own cost and expense promptly discharge, remove, or otherwise dispose of the same. Until such discharge, removal, or disposition, the Engineer may retain from any monies payable to the Contractor an amount which, in the Engineer's sole judgment, is necessary to satisfy such liens and pay the costs and expenses, including attorneys' fees, of defending any actions brought to enforce the same or otherwise incurred in connection with the notice of lien.

B. If West County Wastewater is served with a Stop Notice as provided pursuant to Civil Code sections 9350 through 9510 before the expiration of the period for service of a Stop Notice, West County Wastewater shall, until the discharge thereof, withhold from the monies under its control as much of monies otherwise due or to become due the Contractor as is sufficient to answer the claim stated in such Stop Notice and to provide for the reasonable cost of any litigation thereunder. However, if the Engineer, in its discretion, permits Contractor to file with West County Wastewater the bond referred to in Section 9364 of the Civil Code, West County Wastewater will not withhold such moneys thereafter on account of such Stop Notice. The monies which West County Wastewater withholds will be a minimum of 125% of the face value of the Stop Notice.

00 72 47 NO WAIVER

Neither inspections by the Engineer, nor any order, measurement, approval, determination, decision, or certificate by the Engineer, nor any order by West County Wastewater for the payment of money, nor any payment for or use, occupancy, possession, or acceptance of the whole or any part of the work by West County Wastewater, nor any extension of time, nor any other act or omission of West County Wastewater or of the Engineer will be: (1) an acceptance by West County Wastewater of any defective or improper work, materials, or equipment nor operate as a waiver of any requirement or provision of the Contract; (2) a waiver by West County Wastewater of any remedy, power, or right reserved to West County Wastewater under the Contract; or (3) a waiver of any right to damages for breach of Contract. Any and all rights and/or remedies provided for in the Contract are cumulative; and, in addition to each and every other right and remedy provided for herein or by law, West County Wastewater reserves the right to seek a writ of injunction against any breach or threatened breach of the Contract by the Contractor, by its subcontractors, or by any other person or persons.

00 72 48 QUALITY OF EQUIPMENT, MATERIAL, PRODUCTS, AND/OR WORKMANSHIP

A. The Contractor shall furnish all equipment, materials, and/or products required to complete the work, except those equipment, materials, and/or products that are designated in the Contract Documents to be furnished by West County Wastewater.

1. Only equipment, materials, and/or products meeting the requirements of the Contract Documents may be incorporated in the work. The equipment, materials, and/or products furnished and used by Contractor must shall be new

and must be manufactured, handled, and installed in a workmanlike manner to ensure a completed project in accordance with the Contract Documents. The Contractor shall deliver manufacturers' warranties, guarantees, instruction sheets, and parts lists which are furnished with certain equipment, materials, and/or products incorporated in the work to the Engineer before the Contract will be accepted.

2. If no detailed specifications for certain equipment, materials and/or products are set forth in the Contract, the Contractor shall furnish such equipment, materials, and/or products in conformance with the latest standards, specifications, manuals or codes of an acceptable technical society, organization or association, or to the laws or regulations of any applicable governmental authority, whether such reference be specific or by implication, in effect at the time of opening of bids. In general, the work performed shall be in full conformity and harmony with the intent prescribed in Section 00 72 02, Intent of the Contract.

B. The Engineer may disapprove or reject work, whether in place or not, which the Engineer believes to be defective, or that the Engineer believes will not produce a completed project that conforms to the Contract Documents or that will prejudice the integrity of the design concept of the completed project as a functioning whole as indicated by the Contract Documents. The Contractor shall immediately remove such equipment, materials, and/or products from the work site unless otherwise directed by the Engineer. The Contractor shall not use rejected equipment, materials, and/or products, the defects of which have been subsequently corrected, in the work unless the Engineer has approved such use in writing. If the Contractor fails to comply promptly with any order of the Engineer made under the provisions in this Article, the Engineer may cause the removal and replacement of rejected work including equipment, materials, and/or products. The Engineer may deduct the costs incurred due to the failure of the Contractor to remove and replace rejected work from any monies due or to become due the Contractor.

1. The lack of disapproval or rejection by the Engineer of any part of the work or any of the equipment, materials, and/or products supplied in connection with that work does not create any automatic acceptance of any such part of the work or any such equipment, materials, products, and/or workmanship.

00 72 49 WEST COUNTY WASTEWATER'S OWNERSHIP OF PROJECT MATERIALS AND SALVAGE

A. Unless otherwise provided in the Contract, West County Wastewater reserves all title and interest in the right to the use of all water, the title to all soil, stone, gravel, sand, minerals, timber, and all other materials developed or obtained within the Project limits from operations by the Contractor or any of its subcontractors, any of their representatives or employees, and the right to use or dispose of the same. Neither the Contractor nor any of its subcontractors, nor any of their representatives

or employees, shall have any right, title, or interest in or to any part of such materials or substances.

1. All material used under the Contract after it has been attached or affixed to the work or soil and for which partial payment has been made therefor will be the property of West County Wastewater.

B. The Contractor shall satisfy itself as to the quantity of materials that meet the specifications that may be produced or obtained at local sources, and West County Wastewater is not responsibility with regard to the quantities or quality of materials available.

1. The Contractor, with the written permission of the Engineer, may use in the proposed construction such stone, gravel, sand, or other material that the Engineer determines is suitable for use as may be found at the project site.

2. Existing items to be salvaged shall remain the property of West County Wastewater. Contractor shall refurbish as required items to be reinstalled in the work before reinstallation. Items the Contractor seeks to be salvage must be carefully removed and handled in such a manner as to avoid damage and shall be delivered to storage at a location designated by the Engineer.

00 72 50 (NOT USED)

00 72 51 PROVISIONS REQUIRED BY LAW DEEMED INSERTED

A. Each and every provision of law and clause required by law to be inserted in the Contract is deemed to be inserted herein, and the Contract is to be read and enforced as though they were included in full herein. If through mistake or otherwise any such provision is not inserted, or is not correctly inserted, then upon the application of either party, the Contract shall be physically amended to make such insertion.

00 72 52 CONFLICT OR INCONSISTENCY

A. Unless otherwise noted below, conflicts or inconsistencies between parts of the Contract will be resolved by the Engineer with a change order or an addendum, if necessary and if the order of precedence set forth below does not apply. Addenda and change orders bearing the most recent date prevail over addenda or change orders bearing earlier dates. Any reference to addenda-changed specifications or drawings will be considered as modified accordingly.

B. In resolving conflicts, errors, or discrepancies, the order of precedence shall be as follows:

1. Change Orders/Addenda (most recent in time takes precedence)

2. Contract and Bond Forms

3. Technical Specifications (Division 20 and above if required)

4. Technical Specifications (Division 1 through 16 as required)

5. Special Conditions

6. Project Drawings

7. General Conditions

8. Instructions to Bidders

9. Bid Forms

10. Notice to Contractors

C. Reference specifications will bear the same order of precedence as the document in which they are referenced. For example, a reference to West County Wastewater's Standard Specifications contained in the Technical Specifications will have the same order of precedence as the applicable Technical Specification. A reference to an Appendix contained in the Technical Specifications will have the same order of precedence as the applicable Technical Specification. If a reference specification is mentioned in more than one part of the Contract, the part with the highest order of precedence will govern.

D. With reference to the Project Drawings:

1. Figures govern over scaled dimensions.

2. Project-specific drawings govern over general and typical drawings.

3. Addenda/Change Order drawings govern over Project Drawings.

4. Project Drawings govern over standard drawings.

E. The Contractor shall resolve any conflicts between the requirements contained in permits from other agencies and the Contract to the satisfaction of the Engineer. When there is a conflict between the requirement(s) as specified in the Contract and as required by other agencies, the more restrictive requirement(s) prevail.

00 72 53 UTILITY AND OTHER EXISTING FACILITIES

A. The location of known existing utilities and pipelines are shown on the Project Drawings in their approximate locations. Some of the locations include multiple conduits. The Contractor shall exercise care in avoiding damage to those facilities which are to remain in service after the completion of the construction of the facility that is the subject of the Contract, and the Contractor will be responsible to repair such facilities if they are damaged. The Contractor shall also exercise care in maintaining those pipes and facilities required for continuing operation of the

existing facilities that will be abandoned until they are abandoned . Not all utilities or obstructions may be shown and the locations indicated may be inaccurate.

B. The Contractor must discover all existing underground installations before excavating or trenching by contacting all local utilities 48 hours in advance, and by prospecting. Contractor shall notify Underground Service Alert no less than 48 hours before it commences any excavation work.

C. When the excavation work approaches the approximate location of underground utilities, the Contractor shall determine the exact location of such utilities by careful probing or hand digging. When uncovered, the Contractor shall provide adequate protection for the existing installation.

D. The Contractor shall exercise extreme caution in working in any area adjacent to existing sewerage facilities. The Contractor shall maintain all existing facilities in service until the new work is ready for full time operation and is placed in service. The Contractor's construction of the connections between the existing facilities and the new facilities must be at times and during periods acceptable to West County Wastewater. The Contractor shall advise the Engineer in writing of its proposed construction schedule for these connections at no later than five days before commencing work on such connections.

E. The Contractor shall, before trenching or excavating for any pipe or structures, uncover and completely expose all piping where crossings, interferences, or connections are shown on the Project Drawings to determine actual elevations. Contractor shall lay new pipelines at such grade as to clear all existing facilities which are to remain in service for any period after the construction of the pipe being laid. If the Contractor does not expose all required utilities, it may not recover any additional compensation for work necessary to avoid interferences or for repair to damaged utilities. The Contractor use extreme caution in performing excavations around underground electrical ducts and conduits to prevent injury to workers or damage to the electrical ducts or conduits.

F. Notwithstanding any other provision of this Contract between the West County Wastewater and the Contractor:

1. Except as provided below, in accordance with Section 4215 of the California Government Code, West County Wastewater shall assume the responsibility between the Parties for the timely removal, relocation, or protection of existing main or trunk line utility facilities located on the site of the construction project covered by the Contract if such utilities are not identified by West County Wastewater in the Project Drawings and Specifications and made a part of the Notice to Contractors. West County Wastewater will not be responsible to indicate the presence of existing service laterals or appurtenances whenever the presence of such utilities on the site of the construction project can be inferred from the presence of other visible facilities, such as buildings, meter and junction boxes on or adjacent to the site of construction. West County

Wastewater will compensate the Contractor for the costs of locating and repairing damage and removing or relocating utility facilities that are not indicated in the Project Drawings and Specifications or that may be inferred from the presence of other visible facilities provided that the Contractor exercises reasonable care.

2. The owner of the utility will determine whether it will perform repairs or relocation work or will permit the Contractor to perform such repairs or relocation work at a reasonable price.

3. West County Wastewater will not assess liquidated damages upon the Contractor for delay in completing the Project when such delay was caused by the failure of West County Wastewater to show existing utilities or other existing facilities, excluding service laterals.

G. If interferences between existing utilities and proposed work occurs at locations other than those shown on the Project Drawings, the Contractor shall notify the Engineer, and the Engineer will supply a method for correcting the interference. West County Wastewater will pay the Contractor to correct interferences not shown on the Project Drawings in accordance with the provisions of Section 00 72 11, Differing Site Conditions.

H. Planned utility service shutdowns of any portion of the treatment plant or collection system must be accomplished during periods of minimum use. In some cases this may require night or weekend work. The Contractor shall program its work so that service will be restored in the minimum possible time, and shall cooperate with West County Wastewater to reduce shutdowns of utility systems to a minimum. No utility interruption may occur without the prior approval of the Engineer and the utility involved.

00 72 54 SURVEYS, LINES, AND GRADES

A. The Contractor shall perform all work under the Contract to the lines and grades shown on the Project Drawings, unless directed otherwise by the Engineer.

1. The Contractor shall use three consecutive points on the same slope in order to detect any variation from a straight grade. If any discrepancy occurs, the Contractor shall immediately notify the Engineer. If this discrepancy is not reported at the time of discovery to the Engineer, the Contractor shall correct any error in the finished work at no cost to West County Wastewater.

2. West County Wastewater may make any survey to accurately measure quantities for payment to the Contractor.

3. West County Wastewater may interrupt the Contractor's work schedule in order to have lines or grades checked on any work in progress. The Contractor will not receive a time extension for such interruptions, provided that the interruptions do not exceed a reasonable amount of time under the specific circumstances involved.

00 72 55 CONTRACT DOCUMENTS AND RECORD DRAWINGS

A. The Contractor may obtain from West County Wastewater, at no extra cost, up to four copies of the Contract Documents as specified in Subsection 19 of Section 00 21 13. The Contract Documents include Section 00 01 10, Table of Contents; Section 00 01 15, List of Drawings; Section 00 11 16, Invitation to Bid; Section 00 21 13, Instructions to Bidders; Section 00 41 43 Bid Forms; Section 00 43 00, Procurement Form Supplements; Section 00 45 00, Representations and Certifications; Section 00 52 00, Contract Forms; Section 00 61 00, Bond Forms; Section 00 72 00, General Conditions; Section 00 73 00, Supplementary Conditions; Technical Specifications; Project Drawings; and any addenda thereto.

B. The Contractor shall keep on the work site a copy of the Contract Documents and shall at all times give the Engineer access thereto. Any drawings included in the detailed Specifications shall be regarded as part thereto and of the Contract. Anything mentioned in these Specifications and not shown on the Project Drawings, or shown on the Project Drawings and not mentioned in these Specifications, will be construed as if shown or mentioned in both. The Engineer will furnish from time to time such detail drawings, plans, profiles, and information as it may consider necessary for the Contractor's guidance. The Contractor shall assure its work complies with the provisions of the Contract Documents irrespective of the inspection given the work during its progress by the Engineer. Any failure by the Contractor to observe the requirements contained in the Contract Documents will be sufficient cause for the Engineer to reject the work at any time before its acceptance.

C. The Contractor shall maintain, at the jobsite, one record set of Project Drawings in good order and clearly marked to show any deviations made from the Project Drawings, including concealed construction and utility features which are revealed during the course of construction. The Contractor shall update its marked prints at least once each week and shall make the prints available for the Engineer's review for currency before developing partial payment estimates. Upon completion of the work, the Contractor shall deliver the marked set of prints to the Engineer.

D. For drawings that depict the detail requirement for equipment to be assembled and wired in the factory, such as motor control centers and the like, the Contractor must update the Record Drawings by identifying those portions that are superseded by change order drawings or final shop drawings, and by including appropriate reference information describing the change orders by number and the shop drawings by manufacturer, drawing, and revision numbers.

E. West County Wastewater will not approve the Contractor's requests for partial payments if the updated set of Drawings is not in good order or is not kept current. West County Wastewater will not approve any request for final payment unless the Contractor delivers the complete and correct Record Drawings to the Engineer.

00 72 56 CONTAMINATED SOIL/MATERIALS

A. Contaminated soils and materials include, but not be limited to, pollutants and/or materials defined as hazardous substances or hazardous wastes under the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), the Hazardous Substances Account Act (Health and Safety Code Section 25300 and following), the Hazardous Waste Control Act (Health and Safety Code Section 25100 and following), or are defined as pollutants or contaminants under any other applicable state and federal laws and regulations. Contaminated soils and materials include, but not be limited to, friable asbestos, PCBs, petroleum products and its byproducts, and waste oil, among other substances.

B. Contractor shall notify West County Wastewater in person or by telephone within two hours of its discovery of any contaminated soil or materials on or beneath the jobsite, including in buildings and related structures that could be impacted by the construction project as discovered by the Contractor, its personnel, agents, representatives, consultants, or any other persons working under the direction and control of the Contractor. In addition, the Contractor shall deliver written notice of the same to West County Wastewater by the Contractor no later than 24 hours after discovery. Contractor shall require that like provisions be inserted in all contracts with its subcontractors and tiers of subcontractors. Inclusion of such provisions in subcontractors does relieve the Contractor from the obligation and responsibility to assure compliance with the provisions of this general condition.

C. The Contractor and its subcontractors must immediately cease any and all work at the location of the discovery of the contaminated soil or materials until further notice from West County Wastewater or the Engineer.

D. If the Contract Documents specifically direct the Contractor to perform appropriate cleanup work with respect to the contaminants discovered, the Contractor shall proceed with that work. In addition, the Contractor shall notify West County Wastewater of the discovery of the contaminants as set forth above. Further, if the contaminants substantially vary from the description in the Contract Documents as to type of material, quality of materials, level of concentration or toxicity, location, as to the materials' affect on groundwater, or vary in any other substantial manner from the description as set forth in the Contract Documents, the Contractor shall immediately cease operations and notify West County Wastewater as set forth above.

E. All work done by the Contractor with respect to cleanup, removal, and remedial actions concerning the contaminated soils or materials must be done in compliance with the law. The Contractor shall provide all required notices to the County Environmental Health Hazard Materials Section and other appropriate governmental agencies, including the State Department of Toxic Substances Control and the Regional Water Quality Control Board-San Francisco Bay Region, among others. The Contractor or any subcontractor doing such work for the Contractor must have the appropriate certification, licenses, and permits before commencing any cleanup, removal, and/or remedial work. West County Wastewater will not be responsible for any negligence of or the violation of any laws, rules, regulations, or ordinances by the Contractor or any of the Contractor's subcontractors, agents, consultants, employees, or representatives in performing such cleanup, removal, and remedial work.

F. If any of the cleanup, removal, containment, or remediation work substantially impacts the community, including, but not limited to, creating traffic, odor, and health issues, West County Wastewater may direct the Contractor to revise its manner of operations to reduce or eliminate the adverse effects.

00 72 57 Not used

00 72 58 Not used

00 72 59 STORM WATER POLLUTION PREVENTION

A. General

1. Prevention - The Contractor shall prevent the pollution of storm drain systems and creeks on or near the construction project site(s) resulting from the construction operation. The Contractor shall keep pollution out of storm drains by reducing the possibility of the accidental discharge of materials and wastes, by reducing erosion and sedimentation, and by any other action as required. The Contractor shall train all employees and subcontractors on the storm water pollution prevention requirements contained in these Specifications and ensure that all employees and subcontractors are aware of the consequences as described in subsection A.3. below. The Contractor shall include appropriate subcontract provisions to ensure that these requirements are met by all subcontractors.

2. Notification - If the Contractor causes or permits the spillage or overflow of any sewage, oil, or petroleum product, hazardous substance, contaminant, or waste that may result in the fluid or substance being discharged directly or indirectly into any storm drains, creeks, wetlands, or other manmade or natural waterways, the Contractor shall notify West County Wastewater as soon as possible to the extent notification can be provided without substantially impeding cleanup or other emergency measures. The Contractor shall make

such notification no later than one hour after the Contractor learns of the occurrence.

3. Cleanup – The Contractor shall, immediately upon learning of such spillage, overflow, or discharge, the Contractor shall eliminate the cause of the spillage, overflow, or discharge and take action to minimize any damages. The Contractor shall also immediately implement a cleanup program. The cleanup, including sampling and testing required by regulatory agencies to determine the nature and level of contamination, must be performed and completed to the satisfaction of the regulatory agencies involved and West County Wastewater, at the Contractor's expense. Any fines, penalties, and/or subsequent actions imposed upon West County Wastewater and/or the Contractor by regulatory agencies related to the spillage, overflow, or discharge and any subsequent monitoring, testing, and reporting, as required by regulatory agencies, shall also be at the Contractor's expense. The Contractor shall keep a stockpile of spill cleanup materials, such as rags or absorbents, readily accessible on site. The quantity of cleanup materials are an appropriate factor in determining the risk of an occurrence of a spill, overflow or discharge.

B. Management of Nonhazardous Material and/or Waste

1. Designated Area - The Contractor shall propose designated areas of the Project site, for approval by the Engineer, suitable for material delivery, storage, and waste collection that to the maximum extent practicable are near construction entrances and away from catch basins, gutters, drainage courses, and creeks.

2. Backfill or Excavated Material - The Contractor may not allow backfill or excavated material to enter the storm drains or creeks. When rain is forecast within 24 hours or during wet weather, the Contractor may be required to cover such material with a tarpaulin and to surround the material with sand bags.

3. Street Sweeping - At least once per week or more frequently as directed by the Engineer, the Contractor shall clean and sweep roadways and on-site paved areas of all materials attributed to or involved in the work. The Contractor may not use water to flush down streets in place of street sweeping.

4. Disposal - At the end of each working day, the Contractor shall collect and properly dispose of all scrap, debris, and waste material. These materials may be stored in the Contractor’s yard in stockpiles or placed in dumpsters. The Contractor shall inspect dumpsters for leaks and replace or repair any dumpsters that leak. The Contractor may not discharge onsite water from cleaning dumpsters. The Contractor shall arrange for regular waste collection before dumpsters overflow.

C. Management of Hazardous Material and/or Waste

1. Storage - The Contractor shall label and store all hazardous materials, such as pesticides, paints, thinners, solvents, and fuels, and all hazardous wastes, such as waste oil and antifreeze, in accordance with all applicable state and federal regulations. The Contractor shall store all hazardous materials and all hazardous wastes in accordance with secondary containment regulations. All such materials and wastes must be covered, as needed, to avoid the pollution of rainwater with hazardous constituents, which may require the management of collected rain water as a hazardous waste. The Contractor shall keep an accurate, up-to-date inventory, including Material Safety Data Sheets (MSDSs), of hazardous materials and hazardous wastes stored on site.

2. Usage - When rain is forecast within 24 hours or during wet weather, the Contractor shall refrain from applying chemicals in outside areas. The Contractor shall follow material manufacturer's instructions regarding use, protective equipment, ventilation, flammability, and mixing of chemicals. The Contractor shall post warning signs in areas treated with chemicals.

3. Disposal - The Contractor shall arrange for regular hazardous waste collection to comply with time limits for storage of hazardous wastes. The Contractor shall dispose of hazardous waste in accordance with Section 00 72 56, Contaminated Soil/Materials. The Contractor may not wash any spilled material into streets, gutters, storm drains, or creeks and may not bury spilled hazardous materials. The Contractor shall report any spill of hazardous materials to West County Wastewater in accordance with Section A.2 above.

D. Vehicle/Equipment Cleaning, Maintenance, and Fueling

1. General - The Contractor shall inspect vehicles and equipment arriving on site for leaking fluids and shall promptly repair any leaking vehicles and equipment. The Contractor shall use drip pans to catch leaks until it makes repairs.

    a. The Contractor shall comply with federal, state, and city requirements for above-ground storage tanks.

2. Cleaning - The Contractor shall clean vehicles or equipment with water only in a designated, bermed area that will not allow rinse water to run off site into streets, gutters, storm drains, or creeks. The Contractor may not use soaps, solvents, degreasers, steam-cleaning equipment, or equivalent methods for this cleaning.

3. Maintenance and Fueling - The Contractor must perform maintenance and fueling of vehicles or equipment in areas that will not allow run-on of storm water or runoff of spills to storm drains and will provide for confined clean-up. Examples are working in bermed areas or utilizing drip pans. The Contractor

may not contaminate the soils or groundwater with such maintenance and fueling activities.

a. The Contractor shall use secondary containment, such as a drip pan, to catch leaks or spills any time that vehicle or equipment fluids are dispensed, changed, or poured, and shall clean up leaks and spills of vehicle or equipment fluids immediately and dispose of the waste and cleanup materials as hazardous waste, as described in Section C.3 above.

E. Dewatering Operations

1. Sediment Control - The Contractor shall route water through a control measure, such as a sediment trap, sediment basin, or Baker tank, to remove settleable solids prior to discharging the water to a storm drain system. The Contractor shall place straw bales in front of storm drain inlets as required, and it may be required on a case-by-case basis to filter the water following the control measure. The control measure must be approved in advance by the Engineer. If the Engineer determines that the dewatering operation will not generate an appreciable amount of settleable solids, the Engineer may waive the control measure requirement.

2. Contaminated Groundwater - If the project is within an area of known groundwater contamination or if contamination is found, water from dewatering operations must be tested prior to discharge. If the water quality meets Regional Water Quality Control Board (RWQCB) standards, it may be discharged to a storm drain or creek. Otherwise, the water must be hauled off-site for proper disposal.

F. Paving or Oiling Operations

1. When rain is forecast within 24 hours or during wet weather, the Engineer may direct the Contractor not to pave or oil the street. The Engineer may direct the Contractor to protect drainage courses by using control measures, such as earth dikes, straw bales, and sand bags, to divert runoff or trap and filter sediment.

2. The Contractor shall prevent saw-cut slurry from entering catch basins and storm drains by limiting the area over which the slurry spreads.

3. The Contractor shall cover catch basins and manholes when paving or applying seal coat, tack coat, slurry seal, or fog seal.

4. The Contractor may not sweep or wash down excess sand (placed as part of a sand seal or to absorb excess oil) into gutters, storm drains, or creeks. The Contractor shall either collect the sand and return it to the stockpile or dispose of it in a trash container.

G. Concrete, Grout, and Mortar Waste Management

1. Concrete Truck/Equipment Washout - The Contractor may not wash out concrete trucks or equipment into streets, gutters, storm drains, or creeks. The Contractor shall wash out concrete trucks and equipment off-site or in a designated area on-site where the water will flow onto dirt or into a temporary pit in a dirt area. The Contractor shall allow the water to percolate into the soil and dispose of the hardened concrete in a trash container. If no suitable dirt area is available, the Contractor shall collect the wash water and remove it off site.

2. Exposed Aggregate Concrete Wash Water - The Contractor shall drain water from washing exposed aggregate concrete to a dirt area. If no suitable dirt area is available, the Contractor shall filter the wash water through straw bales or equivalent material before discharging it to a storm drain. The Contractor shall collect sweepings from exposed aggregate concrete for disposal.

H. Paint Disposal and Clean-up

1. Disposal of Unused Paint - The Contractor shall carefully use, store and dispose of paint, solvents, chemicals, and waste materials in compliance with all applicable state and federal regulations. The Contractor may not dispose of paint to sanitary sewer systems or storm drains. The Contractor shall utilize other recycling and disposal services as follows:

    a. "Recycling Centers" and "Waste Disposals" as may be listed in the yellow pages.

    b. Local household hazardous waste facility if appropriate.

        i. The Contractor may dispose of small amounts of leftover latex (water-based) paint by applying the paint to the surface of an item to be discarded and allowing it to dry thoroughly, then disposing of it in a dumpster.

        ii. The Contractor shall store these materials and conduct cleaning of painting equipment and tools in a designated area that will not allow run-on of storm water or runoff of spills. The Contractor may not allow wash water from cleaning painting equipment and tools into streets, gutters, storm drains, or creeks.

2. Disposal of Paint Clean-up Waste - The Contractor shall remove as much excess paint as possible from brushes, rollers, and equipment before starting cleanup.

a. The Contractor may not discharge cleaning wastes from oil-based paints, buckets, brushes or tools to the sanitary sewer system. The Contractor shall retain a certified waste hauler to recycle or to dispose of cleaning wastes from oil-based paints at the Contractor's expense.

b. The Contractor may discharge very small amounts of cleaning wastes from brushes, rollers, buckets, and tools contaminated with latex (water-based) paints to the sanitary sewer system provided they do not contain additives with pollutants of concern (e.g., mercury, tributyltin). Brushes, rollers, and tools containing latex paints may be washed over a sink with plenty of water. Buckets containing latex paints must first be emptied into the original can or discarded as specified in paragraph 1 above. If excessive amounts of paint or solvent are found in the wastewater discharged, the Contractor may be subject to enforcement action by West County Wastewater in accordance with West County Wastewater's Codes.

c. The Contractor may not discharge any of these paint clean-up wastes to storm drains, streets, gutters, or creeks.

d. Waste Disposal - The Contractor shall dispose of waste thinner, solvent, and sludge from the cleaning of equipment and tools as hazardous waste, as described in Subsection C.3 above. The Contractor shall dispose of excess thinners, solvents, and oil- and water-based paint as hazardous waste.

I. Contaminated Soil - If the project is within an area of known soil contamination or evidence of soil contamination is found, the Contractor shall comply with the requirements of Section 00 72 56, Contaminated Soil/Materials.

END OF GROUP 00 72 00

SECTION 00 73 00
SUPPLEMENTARY CONDITIONS

Section	Title
00 73 01	Insurance Coverage Requirements
00 73 02	Preconstruction Conference
00 73 03	Surveys
00 73 04	West County Wastewater Holidays
00 73 05	Responsibility
00 73 06	Conflicts, Errors, Discrepancies
00 73 07	Clean up and Restoration
00 73 08	Commencement, Prosecution, and Completion
00 73 09	Existing Utilities and Sewerage Facilities
00 73 10	Inspection by Others
00 73 11	Salvaged Material
00 73 12	Disposal of Material
00 73 13	Potential Hazards and Safety
00 73 14	Explosive
00 73 15	Dust Control
00 73 16	Fire Prevention
00 73 17	Air Pollution
00 73 18	Title to Materials Found
00 73 19	Final Acceptance
00 73 20	Attorneys' Fees
00 73 21	Amount of Liquidated Damages
00 73 22	Percentage of Progress Payments to be Retained
00 73 23	Amount of Minimum Progress Payment
00 73 24	Retention for Repairs
00 73 25	Connections to Existing Facilities
00 73 26	Certification of Labor Charges
00 73 27	Sole Source Items
00 73 28	Partial Payment for Materials and Equipment Delivered
00 73 29	Maintaining Existing Utilities
00 73 30	Permits, Easements and Agreements
00 73 31	Parking and Employee Identification
00 73 32	Work During Disputes and Litigation
00 73 33	Submittals
00 73 34	Extensions of Time for Delay Due to Inclement Weather
00 73 35	Erosion Control
00 73 36	Standard Details
00 73 37	Drawings and Project Manual
00 73 38	Initial Start-up and Operation of Facilities
00 73 39	Responsibility for Spare Parts & Special Tools

00 73 40 Manuals, Operating Instructions and Affidavits
00 73 41 Record Plans
00 73 42 Joint Survey to Establish Preconstruction Conditions
00 73 43 Construction Constraints
00 73 44 Traffic Control
00 73 45 Work Hours
00 73 46 Federal, State and Local Requirements
00 73 47 Apprentices
00 73 48 Labor, Wages and Wage Determinations
00 73 49 Disadvantaged Business Enterprise (DBE) Requirements
00 73 50 American Iron and Steel (AIS) Requirements
00 73 51 Project Signage Requirements

00 73 01 INSURANCE COVERAGE REQUIREMENTS

A. Insurance: On or before beginning the Project, the Contractor, at its own cost and expense, shall carry, maintain for the duration of the Project, and provide proof thereof in a form that is acceptable to West County Wastewater the insurance specified in subsections (1) through (5) below with insurers and under forms of insurance satisfactory in all respects to West County Wastewater. The Contractor shall not allow any subcontractor, professional or otherwise, to commence work on any subcontract until all insurance required of the Contractor has also been obtained for said subcontractor, or until West County Wastewater has approved the insurance status of the Contractor's subcontractor.

1. Commercial General Liability: Insurance Services Office Form CG 00 01, including products and completed operations, with limits of no less than five million dollars ($5,000,000) per occurrence for bodily injury, personal injury, and property damage. If a general aggregate limit applies, either the general aggregate limit shall apply separately to this project or the general aggregate limit shall be twice the required occurrence limit. The Contractor, at the Contractor's own cost and expense, shall maintain Commercial General Liability Insurance for the period covered by this Contract for risks associated with the Project.

2. Automobile Liability: Insurance Services Office Form Number CA 0001 covering Code 1 (any vehicle), with limits no less than five million dollars ($5,000,000) per accident. Such coverage shall include but shall not be limited to, protection against claims arising from bodily and personal injury, including death resulting therefrom, and damage to property resulting from activities contemplated under this Contract, including the use of owned and non-owned automobiles.

3. Workers' Compensation: Worker's Compensation Insurance as required by the State of California , with statutory limits, and Employer's Liability Insurance with limits of not less than one million dollars ($1,000,000) per accident for bodily injury or disease for any and all persons employed directly or indirectly by the Contractor. In the alternative, the Contractor may rely on a self-insurance program to meet these requirements as long as the program of self-insurance complies fully with the provisions of the California Labor Code. In such case, excess Worker's Compensation Insurance with limits of not less than five million dollar ($5,000,000) shall be maintained. The insurer, if insurance is provided, and the Contractor, if a program of self-insurance is provided, shall waive all rights of subrogation against West County Wastewater for loss arising from worker injuries sustained under this Contract. The worker’s compensation policy shall be endorsed with a waiver of subrogation in favor of West County Wastewater for all work performed by the Contractor, its employees, agents and subcontractors.

4. Builder’s Risk: (Course of Construction) insurance covering all risks of loss less policy exclusions, with limits equal to the completed value of the project and no coinsurance penalty provisions.

5. Professional Liability. If applicable (for design/build), the Contractor, at the Contractor's own cost and expense, shall maintain for the period covered by this Contract professional liability insurance for licensed professionals performing the work in an amount not less than one million dollars ($1,000,000) and a $2,000,000 policy aggregate covering the licensed professionals' errors and omissions, as follows:

    a. Any deductible shall not exceed $5,000 per claim.

    b. Notice of cancellation or non-renewal must be received by West County Wastewater at least thirty days prior to such change.

    c. The following provisions shall apply if the professional liability coverages are written on a claims made form:

        i. The retroactive date of the policy must be shown and must be before the date for the commencement of the Project.

        ii. Insurance must be maintained and evidence of insurance must be provided for at least five years after completion of the Project if reasonably available.

        iii. If coverage is canceled or not renewed and it is not replaced with another claims made policy form with a retroactive date as provided under 00 73 2 A.(5) (c) (i) above, the Contractor must provide extended reporting coverage on the expiring policy for a minimum of five years after completion of the Project.

        iv. A copy of the claim reporting requirements, including any extended reporting period provisions, must be submitted to West County Wastewater prior to the commencement of the Project.

        v. If the services involve lead based paint or asbestos identification/ remediation, the Contractors Pollution Liability.

6. Contractor's Pollution Legal Liability and/or Asbestos Legal Liability and/or Errors and Omissions (if project involves environmental hazards) with limits no less than $1,000,000 per occurrence or claim, and $2,000,000 policy aggregate.

7. Each of the following shall be included in the insurance coverage or added as an endorsement to the policy:

    a. West County Wastewater, its subsidiary districts, its officers, employees, agents and volunteers shall be covered as additional insureds as respects each of the following:

        i. Liability arising out of automobiles owned, leased, hired, or borrowed by or on behalf of the Contractor.

ii. Liability arising out of work or operations performed by or on behalf of the Contractor, including materials, parts, or equipment furnished in connection with such work or operations and the insured's general supervision of or by the Contractor.

iii. Liability arising out of premises owned, occupied or used by the Contractor.

b. General liability coverage can be provided in the form of an endorsement to the Contractor's insurance (at least as broad as ISO Form CG 20 10, 11 85 or both CG 20 10 and CG 20 37 forms if later revisions used.).

c. The coverage shall contain no special limitations on the scope of protection afforded to West County Wastewater, its subsidiary districts, its officers, employees, agents and volunteers.

d. The insurance policy form shall provide coverage on an occurrence basis, and not on the basis of claims made.

e. The insurance must cover complete contractual liability. This may be provided by amending the definition of "incidental contract" to include any written agreement.

f. Any explosion, collapse, and underground property damage exclusion must be deleted.

g. An endorsement must state that coverage is primary insurance and that no other insurance or self-insured retention carried by West County Wastewater will be called upon to contribute to a loss under the coverage.

h. The policy must contain a cross liability or severability of interests clause.

i. Any failure of the Contractor to comply with reporting provisions of the policy shall not affect coverage provided to West County Wastewater and its subsidiary districts, its officers, employees, agents and volunteers.

j. Broad form property damage liability must be afforded. A deductible that does not exceed $250,000 may be provided.

k. Insurance is to be placed with California-admitted insurers, and carrier(s) must be rated "A: VII" or above in the Best's Rating Guide unless otherwise acceptable to West County Wastewater.

l. Notice of cancellation or non-renewal must be received by West County Wastewater at least thirty days prior to such change.

8. Deductibles and Self-Insured Retentions. During the period covered by this Contract, upon express written authorization of West County Wastewater, the Contractor may increase such deductibles or self-insured retentions with respect to West County Wastewater, its subsidiary districts, its officers, employees, agents and volunteers. West County Wastewater may condition approval of an increase in deductible or self-insured retention levels upon a requirement that the Contractor procure a bond guaranteeing payment of losses and related investigations, claim administration, and defense expenses that is satisfactory in all respects to each of them.

9. Notice of Reduction in Coverage. If any coverage required under 00 73 2. A. (1), (2), (3), (4), (5) or (6) of this Contract is reduced, limited, or materially affected in any other manner, at any time during the period that insurance coverage is required under this Contract, the Contractor shall provide written notice to West County Wastewater at the Contractor's earliest possible opportunity and in no case later than five days after the Contractor is notified of the change in coverage.

10. Verification of Insurance. The Contractor shall submit acceptable proof of insurance, along with all endorsements that implement the insurance coverage required by West County Wastewater. Proof of insurance may be provided by an accurate Certificate of Insurance that identifies all insurance coverage actually in force, although it may exceed the amounts or coverages required by West County Wastewater. The original Certificate of Insurance, and signed endorsements shall be provided to West County Wastewater prior to performance of the work.

11. Builder’s Risk (Course of Construction) Insurance. The Contractor may submit evidence of Builder’s Risk insurance in the form of Course of Construction coverage. Such coverage shall name West County Wastewater as a loss payee as their interest may appear. If the project does not involve new or major reconstruction, at the option of West County Wastewater, an Installation Floater may be acceptable. For such projects, a Property Installation Floater shall provide property damage coverage for any building, structure, machinery or equipment damaged, impaired, broken, or destroyed during the performance of the Work, including during transit, installation, and testing at the project site.

12. Any exceptions to the above requirements, limits or conditions are to be made in the sole and exclusive discretion of West County Wastewater, by and through West County Wastewater's General Manager.

13. Contractor shall require and verify that all subcontractors maintain insurance meeting all the requirements stated herein.

14. Verification of Coverage. Contractor shall furnish West County Wastewater with original certificates and amendatory endorsements, or copies of the applicable insurance language, effecting coverage required by this contract. All certificates and endorsements are to be received and approved by West County Wastwater before work commences. However, failure to obtain the required documents prior to the work

beginning shall not waive the Contractor's obligation to provide them. West County Wastewater reserves the right to require complete, certified copies of all required insurance policies, including endorsements, required by these specifications at any time.

15. Special Risks or Circumstances. West Coutny Wastewater reserves the right to modify these requirements, including limits, based on the nature of the risk, prior experience, insurer, coverage, or other circumstances.

B. Indemnification

1. The Contractor and its sureties shall indemnify and hold harmless West County Wastewater, the Board, each member of the Board, and West County Wastewater's officers, agents and employees from all liability and claims of any kind, subject to the limitations set forth by law, including attorney's fees, arising out of or in connection with the work to be performed, including but not limited to:

   a. Liability or claims resulting directly or indirectly from the negligence or carelessness of the Contractor or its agents in the performance of the work, or in guarding or maintaining the same, or from any improper materials, implements, or appliances used in its construction, or by or on account of any act or omission of the Contractor or its agents.

   b. Liability or claims arising directly or indirectly from or based on the violation of any law, ordinance, regulation, order, or decree, whether by the Contractor or its agents.

   c. Liability or claims arising directly or indirectly from the use or manufacture by the Contractor, its agents, or West County Wastewater in the performance of the work of any copyrighted or non-copyrighted composition, secret process, patented or unpatented invention, article or appliance, unless otherwise specifically stipulated in the Contract.

   d. Liability or claims arising directly or indirectly from the breach of any warranties, whether express or implied, made to the West County Wastewater or any other parties by the Contractor or its agents.

   e. Liability or claims arising directly or indirectly from the willful misconduct of the Contractor or its agents.

   f. Liabilities or claims arising directly or indirectly from any breach or default of the obligations assumed herein by the Contractor.

   g. Liabilities or claims arising directly or indirectly from injuries, sickness, disease or death of employees of Contractor or his subcontractors, suppliers, or vendors in

connection with or incident to their Contract or the work to be performed hereunder.

2. Said duty to indemnify shall not be affected or in any way diminished by the fact that West County Wastewater, the Board, any member of the Board, or West County Wastewater's officers, agents or employees may have jointly caused or contributed to the liability or claim by their acts, omissions, conduct, or negligence. The indemnification obligation under this Article shall not be limited in any way by any limitation of the amount or type of damages, compensation, or benefits payable by or for the Contractor or any such subcontractor or other person or organization under the Worker's Compensation Act, Disability Benefit Act, or other employee benefit act.

3. The duty of the Contractor and its sureties to defend, indemnify and hold harmless as set forth above, shall include but not be limited to the duty to defend as set forth in Section 2778 of the California Civil Code, provided, however, that nothing herein shall be construed to require the Contractor to indemnify West County Wastewater, its subsidiary Districts, its officers, employees, agents and volunteers against any responsibility for liability in contravention of Section 2782 of the California Civil Code. The duty to defend shall include but not be limited to any costs and expenses for attorney's fees, consultants, expert witnesses, court costs and all incidental and consequential damages or costs from claims or litigation.

4. The Contractor and its sureties expressly and specifically agree to waive any and all subrogation rights they may have against West County Wastewater, its subsidiary districts, officers, employees, agents and volunteers which any insurer of Contractor may acquire by virtue of the payment of any loss. Contractor agrees to obtain any endorsement that may be necessary to affect this waiver of subrogation. Indemnification and waiver of subrogation contained in this section shall remain operative and in full force and effect regardless of any termination of this Contract.

00 73 02 PRECONSTRUCTION CONFERENCE

A. The purpose of the preconstruction conference shall be to review the Contractor's preconstruction submittals, as required by the Contract, and to execute a West County Wastewater construction permit and discuss various administrative items.

B. At the time and place established for the preconstruction conference, the Contractor shall:

1. Execute and secure a West County Wastewater construction permit for the work under Contract. This permit is for record purposes only, and no fee, therefore, will be charged to the Contractor.
2. File with the West County Wastewater's written Payroll Listing of labor costs in accordance with Section 00 73 26, Certification of Labor Charges.
3. Present the construction schedule and methods of implementing the work.

00 73 03 SURVEYS

A. The Engineer will furnish only a basic reference line, a beginning point on this line, and a bench mark from which the Contractor shall established such other control and reference point as he may need and as will be required to properly lay out the work. Monuments for principal control points shall be set by the Contractor and shall be protected by the Contractor from disturbance. If the monuments are disturbed, any work that is governed by these monuments shall be held in abeyance until the monuments are reestablished by the Contractor. Contractor shall engage a registered civil engineer or licensed land surveyor subject to approval of the Engineer for this work. The accuracy of all the Contractor's stakes, alignments, and grades is the responsibility of the Contractor. However, the Engineer has the discretionary right to check the Contractor's stakes, alignments, and grades at any time. Where such discretion is to be exercised by the Engineer, he will notify the Contractor of his intention, stating the time at which the checking will commence. Any part of the work in progress, the results of which are predicated directly upon the Contractor's stakes, alignments, or grades to be checked, shall be held in abeyance until the Engineer has notified the Contractor that the checking has been completed.

00 73 04 WEST COUNTY WASTEWATER HOLIDAYS

A. The following are the official 2020 holidays of the West County Wastewater and work shall not be scheduled for these days:
   January 1, "New Year's Day"
   January 20, "Martin Luther King Day"
   February 17, "President's Day"
   May 27, "Memorial Day"
   July 4, "Independence Day"
   September 7, "Labor Day"
   November 11, "Veteran's Day"
   November 26, "Thanksgiving Day"
   November 27, "Day After Thanksgiving"
   December 25, "Christmas Day"

00 73 05 RESPONSIBILITY

The Contractor shall assume responsibility for all new material and skilled application of all work furnished and performed under this Contract including any Amendments thereto. At the completion of this Contact, the construction shall constitute a complete and operable facility. In the event an error or omission is discovered in the Drawings or Specifications during the course of the work, the Engineer shall be promptly notified in writing. If the Engineer determines that remedial measures are necessary requiring extra work clearly outside the scope of the Contract work, a Change Order will be negotiated in accordance with Section 00 72 12, Changes and Extra Work.

00 73 06 CONFLICTS, ERRORS, DISCREPANCIES

In the case of conflicts errors, or discrepancies in any of the Contract Documents, the order of precedence shall be as follows:

1. Change Orders/Addenda (most recent in time takes precedence)
2. Contract and Bond Forms
3. Technical Specifications (Division 20 and above if required)
4. Technical Specifications (Division 1 through 16 as required)
5. Supplementary Conditions
6. Project Drawings
7. General Conditions
8. Instructions to Bidders
9. Bid Forms
10. Notice to Contractors

00 73 07 CLEAN UP AND RESTORATION

A. Upon completion of the work, remove from the site the equipment, all debris, unused materials, temporary construction buildings, and other miscellaneous items resulting from or used in the operations. Replace or repair any facility which has been damaged during the construction work. Restore the site as nearly as possible to its original condition.

1. Throughout the construction period, maintain the Contract working area neat and clean as described in this section.
2. Make final cleanup and restore landscaping for acceptance.
3. In addition to requirements of this section, comply with all requirements for cleaning up as described in various other sections of this Specification.

B. Quality Assurance

1. Inspection: As a minimum, conduct weekly inspections to verify that requirements of this section are being met.

C. Cleaning Materials and Equipment: Provide all required personnel, equipment, and materials needed to maintain the work area neat and clean.

D. Progress Cleaning- General

1. Retain all stored items in an orderly arrangement allowing maximum access, not impeding drainage or traffic, and providing the required protection of material.

2. Provide adequate storage for all items awaiting removal from the jobsite, observing all requirements for fire protection and protection of the environment.

3. Remove any accumulation of scrap, debris, waste material, and other items not required for construction of this work.

4. Mechanically clean all roadways affected by the work daily.

00 73 08 COMMENCEMENT, PROSECUTION, AND COMPLETION

The Contractor shall commence work within five calendar days from the date on the Notice to Proceed. Once work is started, it shall be diligently prosecuted to completion on or before the expiration of the time hereinafter stated.

Bid Item	Completion Required Within:
All Items	The Contract time for this project shall be deemed to start five calendar days from the date on the Notice to Proceed. The Contractor shall complete the work in One Hundred and Eighty (180) calendar days.

The Contractor shall coordinate the work to incorporate the project scope, as specified in Section 01 11 00, Work Covered by Contract Documents.

The Contractor shall furnish sufficient forces, construction plant, and equipment, and shall work such hours, including extra shifts and overtime operations, and shall furnish such other necessaries so as to assure the prosecution of the work.

At least two working days in advance of the actual date of commencement of initial operations at the jobsite, the Contractor shall give West County Wastewater written notice of its intent to commence the work under this Contract.

At least two working days in advance of any excavation work for this Project, the Contractor shall give telephone notice of its intent to occupy the jobsite and its schedule of anticipated operations to prosecute the work to:

Underground Service Alert (USA)
Phone: (800) 642-2444

Prior to commencing any excavation work required under this Contract and, pursuant to Section 6705 of the Labor Code of the State of California, the Contractor shall submit, for West County Wastewater approval, a detailed plan showing the design of shoring, bracing, sloping, or other provisions to be made for worker protection from the hazard of caving ground during such excavations.

The Contractor shall furnish West County Wastewater with a copy of all construction permits and auxiliary agreements as may be required and as may be secured by the Contractor regarding methods and appliances specially approved by jurisdictional agencies or private parties with which West County Wastewater has acquired previous permit, easement, or agreement for the work. Such copies of Contractor-secured permits and agreements shall be delivered to the Project Manager (Keith Reynolds: kreynolds@wcwd.org) and must receive approval of the Project Manager (Keith Reynolds: kreynolds@wcwd.org) at least 14 calendar days prior to prosecution of any work covered thereunder. Failure to provide copies of permits within the required time period shall result in forfeiture of permit fee reimbursement by West County Wastwater.

Pursuant to provisions under Section 00 72 35, Progress, Completion, Delays, and Extensions of Time, the Contractor shall notify the Engineer in writing of any causes which lead to an unavoidable delay in the commencement of the work within ten calendar days after any occurrence of such delays.

At the time and place established for the preconstruction conference, the Contractor shall file with West County Wastewater the written certifications prescribed under Section 00 73 26, Certification of Labor Charges to verify charges for any extra work which may be ordered and documented in a Daily Extra Work Report in accordance with Section 00 72 12, Changes and Extra Work.

00 73 09 EXISTING UTILITIES AND SEWERAGE FACILITIES

A. Notwithstanding any other provision of this Contract between West County Wastewater and the Contractor:

1. In accordance with the provisions of Section 4215 of the California Government Code, in any contract to which West County Wastewater is a party, West County Wastewater shall assume the responsibility between the parties to the contract for the timely removal, relocation, or protection of existing utility facilities except for service laterals, and appurtenances located on the site of any construction project that are a subject of the Contract if such utilities are not identified by West County Wastwater in

the Plans and Specifications and made a part of the Invitation to Bid. West County Wastewater will compensate the Contractor for the costs of locating and repairing damage not due to the failure of the Contractor to exercise reasonable care, and removing or relocating such utility facilities which are not indicated in the Plans and Specifications with reasonable accuracy.

2. The Contractor shall not be assessed liquidated damages for delay in completion of the Project when such delay was caused by the failure of West County Wastewater or the owner of the utility to provide for removal or relocation of such utility facilities except for service laterals, and appurtenances which are not identified by West County Wastewater in the Plans.

3. Nothing herein shall be deemed to require West County Wastewater to indicate the presence of existing service laterals or appurtenances whenever the presence of such utilities on the site of the construction project can be inferred from the presence of other visible facilities, such as buildings, meter and junction boxes on or adjacent to the site of the construction; provided, however, nothing herein shall relieve West County Wastewater from identifying utility relocations in the Plans and Specifications except for service laterals, and appurtenances.

4. The owner of the utility shall have the sole discretion to perform repairs or relocation work or permit the Contractor to do such repairs or relocation work at a reasonable price.

5. The Contractor is hereby notified that existing water, gas, electrical, CATV, and telephone service laterals are not shown on the project drawings. The Contractor shall include in his bid, an allowance to locate, cross, and protect these services. Full compensation for this work along with the cost of locating, crossing and protecting main or trunk lines shall be included in the prices bid for the various contract bid items of work and no additional and no additional compensation will be allowed therefor.

B. The location of known existing utilities and pipelines are shown on the Contract Drawings in their approximate locations. Some of the locations include multiple conduits. The Contractor shall exercise care in avoiding damage to those facilities which are to remain in service subsequent to the construction of the particular new facility involved, and it will be held responsible for their repair if damaged. The Contractor shall also exercise care in maintaining those pipes and facilities required for the continuing operation of the existing facilities until such time as they can be abandoned. There is no guarantee that all utilities or obstructions are shown or that the locations indicated are accurate.

1. The Contractor shall be responsible for discovery of all existing underground installations in advance of excavating of trenching, by contacting all local utilities 48 hours in advance, and by prospecting. Contractor shall notify Underground Service Alert 48 hours prior to any excavation work.

2. When the excavation work approaches the approximate location of underground utilities, the exact location shall be determined by careful probing or hand digging. When uncovered, adequate protection shall be provided for the existing installation.

3. The Contractor shall exercise extreme caution in working in the area adjacent to existing sewerage facilities. It is essential that all the existing facilities be maintained in service until the new work is ready for full time operation, and the new work is placed in service. Construction of the connections between the existing facilities and the new facilities shall be at times and during periods acceptable to West County Wastewater. The Contractor shall advise the Engineer in writing of its proposed construction schedule for these connections at least five calendar days in advance.

4. The Contractor shall uncover and completely expose all piping where crossings, interferences, or connections are shown on the Drawings, prior to trenching or excavating for any pipe or structures, to determine actual elevations. New pipelines shall be laid to such grade as to clear all existing facilities which are to remain in service for any period subsequent to the construction of the run of pipe involved. If the Contractor does not expose all required utilities, it shall not be entitled to additional compensation for work necessary to avoid interferences or for repair to damaged utilities. Excavations around underground electrical ducts and conduits shall be performed using extreme caution to prevent injury to workers or damage to the electrical ducts or conduits.

5. If interferences occur at locations other than those shown on the Drawings, the Contractor shall notify the Engineer, and method for correcting said interference will be supplied by the Engineer. Payment for correction of interferences not shown on the Drawings will be in accordance with the provisions of section 00 72 11, Differing Site Conditions.

C. Perpendicular Crossings of Existing Utilities under Pressure: The work under this Contract includes excavations which may be perpendicular to existing high pressure utilities. The Contractor shall comply with the following provisions to protect the existing utilities:

1. The Contract shall contact the owner of the utility pipeline and request that the approximate location be marked in the field.

2. After the location is marked, the Contractor shall hold a safety meeting with the representative of the pipeline company and the Contractor's field personnel. The approximate location of the pipeline and the procedure to be used in exposing the pipeline shall be reviewed.

3. The Contractor shall arrange for a pipeline company representative to be present when the excavation is started and while exposing the pipeline.

4. The Contractor shall perform the exploratory excavations at least five working days in advance of the time the new sewer will be installed in the area of the utility pipeline.

5. The Contractor shall not commence excavation if the field location marks are absent or if the pipeline representative is not present.

6. The Contractor shall exercise caution while excavating in the area which has been marked:

   a. The Contractor shall thoroughly probe the area before beginning excavation with machines and during the continuance of the excavation.

   b. When the pipeline is found by probing, the pipeline shall be completely exposed by hand throughout the limits of required excavations before excavation by machine continues.

7. The Contractor shall arrange with the owner of the utility pipeline to repair any damage done to the pipeline at no cost to West County Wastewater.

D. Parallel Excavations Near Utilities under Pressure: The work under this Contract includes excavations which may be parallel to and near existing high pressure utilities. The Contractor shall comply with the following provisions to protect the existing utilities:

1. The Contractor shall contact the owner of the utility pipeline and request that the approximate location be marked in the field.

2. After the location is marked, the Contractor shall hold a safety meeting with the representative of the pipeline company and the Contractor's field personnel. The approximate location of the pipeline, the procedures to be used in exposing the pipeline, and the schedule for exposing the pipeline shall be reviewed.

3. The Contractor shall arrange for a pipeline company representative to be present when the excavation is started and while exposing the pipeline.

4. The Contractor shall not commence excavation if the field location marks are absent of it the pipeline representative is not present.

5. The Contractor shall exercise caution while excavating in the area which has been marked.

6. The existing pipeline shall be exposed every 50 to 100 feet by the Contractor at locations where the catch point of a sloped trench would be within five feet of the centerline of the existing pipeline.

7. The Contractor shall perform the exploratory excavations at least fourteen working days in advance of the time that the new sewer will be installed in the area of the utility pipeline.

8. If the location of the existing pipeline is found by exploratory excavations to be consistently outside of the future excavation and the soil is stable, the Contractor may proceed with machine excavations:

    a. The Contractor shall be cognizant in that the existing utility pipeline is near the excavation.

    b. The Contractor shall take due caution while performing excavation operations.

    c. If the utility pipeline is exposed during excavation operations, the Contractor shall contact the Engineer.

    d. The Contractor shall stop excavating and contact the Engineer if the soil becomes unstable.

9. If through exploratory excavations, the Contractor finds the location of the existing pipeline is within the future excavation, the Contractor shall contact the Engineer.

10. The Contractor shall arrange with the owner of the utility pipeline to repair any damage done to the pipeline at no cost to West County Wastewater.

00 73 10 INSPECTION BY OTHERS

Work may be inspected at any time by appropriate federal, state, and local agencies having jurisdiction.

00 73 11 SALVAGED MATERIAL

Existing materials and equipment to be salvaged shall remain the property of West County Wastewater. Salvaged materials to be reinstalled in the work (if any) shall be refurbished as specified before reinstallation. Other material to be salvaged shall be carefully removed and handled in such a manner as to avoid damage and shall be delivered to West County Wastewater at a location within the Water Quality and Resource Recovery Plant (WQRRP) as designated by the Engineer.

00 73 12 DISPOSAL OF MATERIAL

Existing materials and equipment to be demolished, removed, and disposed of, as noted in the Drawings, and all trash such as broken concrete, wood blocking, shipping containers, etc., resulting from the Contract work shall be disposed of at the Contractor's expense.

00 73 13 POTENTIAL HAZARDS AND SAFETY

The conveyance and treatment of raw sewage and its by-products can introduce pathogenic organisms which may cause diseases such as salmonellosis, typhoid fever, paratyphoid fever, bacillary dysentery, cholera, infectious hepatitis, polio, amoebic dysentery, and others.

The Contractor is advised that, in certain locations and under certain conditions, the work may take longer and may require special equipment in order to properly conform to safety regulations. In such cases, no additional compensation will be allowed the Contractor therefor.

The Contractor's personnel shall wear hard hats at all times while on the project area.

Work under this Contract may be in areas where approved protective respiratory equipment is required pursuant to Cal/OSHA General Industrial Safety Order, Section 5144.

The Contractor shall prepare and submit its safety program for the Project work to the Engineer for the Engineer's review as required in Section 00 72 18, Safety.

The Contractor's authorized representative shall have a working knowledge of, and be responsible for, all state and federal safety regulations applicable to the Project.

00 73 14 EXPLOSIVE

The use of explosives on the work is prohibited except certain approved types of cartridge-actuated fastening tools.

00 73 15 DUST CONTROL

The Contractor, for the duration of the Contract, shall maintain all excavation, embankments, haul roads, permanent access roads, project site, waste disposal areas, borrow areas, and all other work areas within Contact work limits free from dust, as determined by the Engineer. Industry-accepted methods of dust control suitable for the area involved, such as sprinkling, chemical treatment, light bituminous treatment, or similar methods, will be permitted. No separate payment will be made to the Contractor for dust control.

00 73 16 FIRE PREVENTION

The Contractor shall not permit unauthorized fires either within or adjacent to the limits of the Project, and it shall be liable for all damage from fire due directly or indirectly to its own activities or to those of its employees or of its subcontractors or their employees. The Contractor,

at its expense, shall conform to all federal, state, and local laws and regulations pertaining to burning, fire prevention and control within or adjacent to the Project. A copy of each required permit shall be furnished to West County Wastewater.

The Contractor's forces or equipment may be required to fight fires in the vicinity, regardless of cause. West County Wastewater will not assume any responsibility for payment for fighting fire when such is ordered by government authority.

Burning or welding operations near any combustible material will require the presence of a firewatch observer equipped with a portable fire extinguisher.

00 73 17 AIR POLLUTION

The Contractor shall so perform its work as not to discharge into the atmosphere from any source whatever smoke, dust, or other air contaminants in violation of the laws, rules, and regulations of the governmental entities having jurisdiction.

00 73 18 TITLE TO MATERIALS FOUND

Unless otherwise provided in the Contract, the title and interest in the right to the use of all water, and the title to all soil, stone, gravel, sand, minerals, timber, and all other materials developed or obtained in the excavation or other operations by the Contractor or any of its subcontractors, or any of their representatives or employees, and the right to use or dispose of the same are hereby expressly reserved by West County Wastewater and neither the Contractor nor any of its subcontractors, nor any of their representatives or employees, shall have any right, title, or interest in or to any part thereof; neither shall they, nor any of them, assert or make any claim thereto. The Contractor shall as determined by West County Wastewater, be permitted to use in its work, without charge, any such materials which meet the requirements of the Contract and as to which West County Wastewater will have the right to use and consume without payment to a third party.

In the event that any Indian relics or items with archeological or historical value are discovered by the Contractor or any of its subcontractors or any of their representatives or employees, the Contractor shall immediately notify the Engineer. The Contractor shall have no property rights to such relics and items.

00 73 19 FINAL ACCEPTANCE

Whenever, as determined by the Engineer in accordance with Section 00 72 41, Final Payment and Release, the Contractor has fulfilled its obligations under the contract, the Engineer will recommend acceptance of the work. After acceptance of the work by West County Wastwater, West County Wastewater will file the Notice of Completion in accordance with Section 4005 of the Government Code. Such notice will constitute "Final Acceptance."

00 73 20 ATTORNEY'S FEES

In case any litigation is commenced with respect to this Contract, the prevailing party shall be entitled to recover from the other party, in addition to amounts found due and owing, costs of suit and reasonable expenses and fees, including reasonable attorneys' fees, incurred by the prevailing party in such litigation, all to be taxed as costs and included in any judgment rendered.

00 73 21 AMOUNT OF LIQUIDATED DAMAGES

The amount of liquidated damages for inexcusable delays to be assessed under Section 00 72 42, Liquidated Damages, shall be $500 for each calendar day of delay beyond each of the required completion dates listed in the Contract.

00 73 22 PERCENTAGE OF PROGRESS PAYMENTS TO BE RETAINED

The percentage of estimated value to be retained under Section 00 72 40, Progress Payments, shall be five percent.

The Contractor shall be allowed to substitute securities for any monies withheld to ensure performance under this Contract pursuant to Section 22300 of the California Public Contract Code. The Contractor shall execute the Escrow Agreement for Security Deposits in Lieu of Retentions in the form contained in Section 00 45 15 of the contract Documents, if applicable.

00 73 23 AMOUNT OF MINIMUM PROGRESS PAYMENT

No progress payment will be made when, in the judgment of the Engineer, the total value of the work done since the last estimate amounts to less than $5,000 as set forth in Section 00 72 40, Progress Payments.

00 73 24 RETENTION FOR REPAIRS

West County Wastewater will retain an amount from any payment due the Contractor equal to twice the value of repairs, corrections, or replacements as provided herein to assure that the Contractor completes such repairs, corrections, or replacements. The Contractor shall receive payments of such retained amounts as the repair, correction, or replacement work is completed.

00 73 25 CONNECTIONS TO EXISTING FACILITIES

The Contractor is required to connect to certain existing facilities as indicated on the Drawings; however, the Contractor must give five calendar days advance notice and receive prior approval of the Engineer for all such connections, whether such connections are "live" or "inactive."

The Contractor shall at all times conduct its operation so as to interfere as little as possible with existing works.

All work of connecting with, cutting into, and reconstructing existing pipes or structures shall be planned to interfere with the operation of the existing facilities for the shortest possible time when the demands on the facilities best permit such interference, even though it may be necessary to work outside of normal working hours to meet these requirements. Before starting

work which will interfere with the operation of existing facilities, the Contractor shall do all possible preparatory work and shall see that all tools, materials, and equipment are made ready and at hand. No connections shall be made without West County Wastewater's prior approval as specified herein.

The Contractor shall make such minor modifications in the work relating to existing structures as may be necessary, without additional compensation.

The Contractor shall have no claim for additional compensation by reason of delay or inconvenience in adapting its operations to meet the above requirements.

All materials and equipment associated with or to be incorporated into the work as herein specified shall be preassembled, prefabricated, precut, or otherwise prepared to the maximum practical degree. It shall be the Contractor's responsibility to fulfill all requirements of the work within the allotted shutdown periods.

00 73 26 CERTIFICATION OF LABOR CHARGES

A. At the time and place established for the preconstruction conference in accordance with 00 73 02 Preconstruction Conference, the Contractor shall file with the Engineer the following written certifications prescribed hereunder either by state law or for West County Wastewater's use to verify charges for any Extra and/or Force Account work which may be ordered and documented in a Daily Work Report.

   1. Certificate showing the amount(s) of Workers' Compensation Insurance applicable to forces under its supervision and, in accordance with Section 1861 of the Labor Code of the State of California, endorsed thereon as follows:

      a. "I am aware of the provisions of Section 3700 of the Labor Code of the State of California which requires every employer to be insured against liability for workers' compensation or to undertake self-insurance in accordance with such provisions before commencing the performance of the work of this Contract."

      b. Contract title, date, and signature of Contractor.

B. The Contractor and subcontractor's attention is directed to the provisions of Section 1776 of the Labor Code of the State of California and to the requirements thereon pertaining to the keeping, availability, and filing of accurate payroll records of all journeymen, apprentices, and other workers performing work under this Contract.

C. Prior to each monthly progress payment, the Contractor shall deliver to the Engineer copies of certified payrolls of its and all subcontractors' forces performing work at the jobsite (or Plant sites established primarily for the work), for labor compliance purposes, and Extra/Force Account considerations. Such records shall be kept current on an effective day or period basis and in form acceptable to the Engineer. At a minimum, the form shall include the following information:

1. Employee identification by name.
2. Employee's address and social security number.
3. Employee's craft and classification (in accordance with Director of Industrial Relations' wage determinations).
4. Employee's actual per diem wages (in compliance with Section 00 11 16 Invitation to Bid, and Section 00 72 20, Laws and Regulations).
5. Employee's subsistence and travel allowance (as applicable).
6. Contractor's or subcontractor's firm or company name, date or period for which applicable wage rates and allowances are effective, and the employer's signature.

00 73 27 SOLE SOURCE ITEMS

Some products or manufacturers may be specified as the only items allowed. Such items may have been chosen for reasons of durability or appearance. As provided in Section 00 72 15, Equipment, Materials, and/or Products, Substitution of Specific Items and Trade Names, Worker's Skills, no substitutions for these items will be reviewed by the Engineer.

00 73 28 PARTIAL PAYMENT FOR MATERIALS AND EQUIPMENT DELIVERED

Generally, the Contractor will not be compensated for materials and equipment delivered to the site until after they are incorporated in the work. If the Engineer determines that the progress of the work will benefit by the delivery to the site of certain materials and equipment in advance of their actual requirement, and if such materials and equipment are delivered in accordance with the following conditions, a portion of the cost of the materials and equipment may be included in progress payments, as specified under Section 00 72 40, Progress Payments. The conditions for such partial payments are as follows:

At least four weeks prior to the delivery of such materials and equipment, the Contractor shall submit a list of such materials and equipment for review on the acceptability for partial payments. Shop drawings and technical data for such materials and equipment must be reviewed and accepted prior to delivery. Upon delivery, the Contractor shall submit written evidence, satisfactory to the Engineer, that the Contractor is the unconditional owner of such materials. free from all claims, liens, and security interest, and a bill of sale or other equivalent document with warranty of title to such materials and equipment.

Title to the delivered material shall be vested in West County Wastewater at the time of delivery to the site. The Contractor shall, however, not withstanding such transfer of title to West County Wastewater be absolutely responsible to West County Wastewater for such materials and equipment until the same shall have been completely installed, tested, and accepted. Such equipment and materials shall be properly stored or stockpiled to the satisfaction of the Engineer. The Contractor shall at its own cost replace any materials and equipment damaged or lost. Stored or stockpiled materials shall be available for inspection by the Engineer or other authorized agent of West County Wastewater.

After delivery of material, if any defects are discovered, whether caused by defective manufacture or damage occurring during delivery or storage (including storage at West County Wastewater or the construction site), the materials shall be removed and replaced with suitable material at the Contractor's expense. The Contractor's insurance shall include coverage for such material against theft, fire, vandalism, and malicious mischief.
The maximum portion of cost to be included in progress payments for materials and/or equipment qualifying under this section will be seventy five percent of the total cost of the delivered materials and/or .equipment eligible for such partial payment. The payment will in no case exceed the bid price or assigned value for the item of work for which the material and/or equipment are furnished and the accumulated total payment for all material delivered but not yet incorporated into the work will in no case exceed ten percent of the total value of the Contract.

For sewer pipe the payment for material delivered but not yet installed in the work shall be limited to a maximum of 1,500 linear feet or the amount of footage which the Contractor has proved capable of laying in five working days , whichever is less. In estimating progress payments, the Engineer may use the unit prices bid by the Contractor in his proposal. In the event that there are no unit bid prices, or the bid unit process do not, in the opinion of the Engineer , represent the actual value of the equipment and materials furnished, the Engineer may estimate progressive payments based on prices reflecting such actual value.

Nothing in the above conditions shall relieve the Contractor of its responsibility for incorporating the materials in the work in conformity with the Contract Documents.

00 73 29 MAINTAINING EXISTING UTILITIES

The Contractor shall provide standby power if the power supply is disconnected during business hours. Flow in the West County Wastewater's existing sewers shall not be restricted or dammed for any period of time without the approval of West County Wastewter. Any rerouting and/or bypass pumping of existing flows shall be made at the Contractor's expense. The Contractor shall submit to the Engineer for approval plans for rerouting, bypassing and/or handling of existing sewage flows during construction at least fourteen (14) days prior to such work.

00 73 30 PERMITS, EASEMENTS, AND AGREEMENTS

Attention is directed to Section 00 72 21, Permits. The Contractor will obtain Encroachment Permits. West County Wastewater will reimburse the Contractor for the necessary permit and inspection fees. The contractor must pay re-inspection of the same item and any citation/fine/fees resulting from contractor's negligence or lack of completion.

00 73 31 PARKING AND EMPLOYEE IDENTIFICATION

Contractor vehicles shall not park in such a way as to impede traffic. Contractor vehicles shall not park in employee-designated parking spots. Contractor vehicles are permitted to park in public parking spots at West County Wastewater properties and in designated locations as agreed upon.

00 73 32 WORKING DURING DISPUTES AND LITIGATION

In the event of a dispute between the parties as to performance of the work, the interpretation of this Contract, or payment or nonpayment of work performed, parties shall attempt to resolve the dispute. If the dispute is not resolved, Contractor agrees to continue the work diligently to completion and will neither rescind this Contract nor stop the progress of the work, but will submit such controversy to determination in accordance with the terms of the Contract Documents. In the event any litigation is commenced with respect to this Contract, such litigation shall not serve to suspend Contractor's obligation to continue performance of the work.

00 73 33 SUBMITTALS

A. Where the Contractor is required by these Contract Specifications to make submittals, they shall be made to the Engineer with a letter of transmittal and in sufficient number of copies to allow a distribution of at least one copy to all parties needing a copy to carry out the provisions of the Specifications, allowing for two copies to be retained by the Engineer.

B. When submittals are favorably reviewed, the Engineer will retain two copies and will return all other copies to the Contractor. When submittals are not favorably reviewed, the Engineer will retain only two copies and will return all others to the Contractor.

C. In addition to those specifically required, the Contractor shall submit drawings and information describing materials and equipment in sufficient detail to determine whether the materials and equipment conform to the specifications.

D. Submittals shall comply with Section 00 72 16, Contractor Furnished Drawings and Data.

E. The Contractor shall verify that the material and equipment described in each submittal conform to the requirements of the specifications and drawings.

F. The Contractor may authorize a material or equipment supplier to deal directly with the Engineer with regard to a submittal only after it has been officially submitted by the Contractor. In all cases, however, the Contractor retains full responsibility for the accuracy and completeness of information contained in the submittals and its proper processing.

G. Key submittal schedules shall be shown on the Construction Project Schedule. Contractor shall provide adequate time for processing and reviewing, and should anticipate the potential for re-submittals where such is likely. The date a submittal is required to maintain project schedule shall be shown on the transmittal. Unreasonable dates and dates inconsistent with the schedule will not be accepted or honored. No allowances will be made for delays occasioned by the Contractor's failure to follow submittal requirements. In no case will there be compensation for any delay due to submittals.

H. Transmittal Form:The submittals shall be accompanied by a transmittal form. At a minimum, the transmittal form shall include the following information:
    a. Name and address of Contractor.

b. Date and submittal/transmittal number.
c. Project name, project number and name of Engineer to review.
d. Item number, item description, and name of supplier.
e. Identification of any deviations from the specified requirements.
f. Signature of Contractor.
g. A signature line for the Engineer to indicate approval.

00 73 34 EXTENSIONS OF TIME FOR DELAY DUE TO INCLEMENT WEATHER

Inclement weather is any weather condition or conditions resulting immediately therefrom, causing the Contractor to suspend construction operations or preventing the Contractor from proceeding with at least 75 percent of the normal labor and equipment force engaged on the work, for all project sites combined.

Should the Contractor prepare to begin work at the regular starting time at the beginning of any regular work shift on any day on which inclement weather, or the conditions resulting from the weather, or the condition of the work prevents work from beginning at the usual starting time, and the crew is dismissed as a result thereof, the Contract will not be charged for a working day whether or not conditions change thereafter during the day, and the major portion of the day could be considered to be suitable for such construction operations.

00 73 35 EROSION CONTROL

Non-paved areas disturbed during construction shall be revegetated by hydroseeding upon completion of construction to prevent soil erosion. Vegetation shall be established prior to final completion. Attention is directed to Section 00 72 59 Storm Water Pollution Prevention.

00 73 36 STANDARD DETAILS

Standard Details shall mean the West County Wastewater's Standard Details, which are available at no cost from West County Wastewater.

00 73 37 DRAWINGS AND PROJECT MANUAL

A. The Contractor may obtain from West County Wastewater, free of charge, four copies of the Drawings and Project Contact Documents. Additional sets may be procured at cost of $75 each.

B. The Contact Documents shall include the bidding conditions and requirements, Contract forms, conditions, Specifications, Supplements, Addenda, and clarifications thereto.

C. The Contractor shall keep on the work site a copy of the Contract Documents and Drawings and shall at all times give the Engineer access thereto. Any drawings included in the detailed Specifications shall be regarded as part thereto and of the Contract. Anything mentioned in these Specifications and not shown on the Drawings, or shown on

the Drawings and not mentioned in these Specifications, shall be of like effect as though shown or mentioned in both. The Engineer will furnish from time to time such detail drawings, plans, profiles, and information as he may consider necessary for the Contractor's guidance, unless otherwise provided in the Proposal or detail Specifications. It shall be the duty of the Contractor to see that the provisions of these Specifications are complied with in detail irrespective of the inspection given the work during its progress by the authorized official or his representatives. Any failure on the part of the Contractor to observe the Specifications will be sufficient cause for the rejection of the work at any time before its acceptance. Only "favorably reviewed" Shop Drawings shall be used for construction.

D. Wherever Military Specifications (MIL), ANSI, ASTM, AASHTO, AISC, AWS, AWWA, Federal Specifications (FS), Manufacturer's Standardization Society (MSS), or other specifications are referred to in these Specifications without designation of year, the reference is to the current or revised specification effective at the time of receiving proposals.

E. In all cases where reference is made to the requirements of such organizations as American Society for Testing and Materials, copies of the requirements referred to are on file with the Design Engineer and may be seen at his office.

F. Wherever the following terms are used, the intent and meanings shall be as follows:

Abbreviation	Stands For
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ABMA	American Boiler Manufacturers Association
ADC	Air Diffusion Council
AGA	American Gas Association
AGMA	American Gear Manufacturers Association
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
AMCA	Air Moving and Conditioning Association
ANSI	American National Standard Institute (formerly United States of American Standards Institute)
APA	American Plywood Association
API	American Petroleum Institute
AREA	American Railway Engineering Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
AWPA	American Wood Preservers Association
AWS	American Welding Society
AWWA	American Water Works Association

CAGI	Compressed Air and Gas Institute
Cal/OSHA	State of California Department of Industrial Relations, Division of Industrial Safety
CARB	California Air Resources Board
CBR	California Bearing Ratio
CISPI	Cast Iron Soil Pipe Institute
CMMA	Crane Manufacturers Association of America
CTI	Cooling Tower Institute
DFPA	Douglas Fir Plywood Association
EIA	Electronic Industries Association
EPA	U. S. Environmental Protection Agency
ETL	Electrical Testing Laboratory
FPS	Fluid Power Society
FS	Federal Specifications
HI	Hydraulic Institute
HMI	Hoist Manufacturers Institute
IAPMO	International Association of Plumbing and Mechanical Officials
ICBO	International Conference of Building Officials
IEEE	Institute of Electrical and Electronic Engineers
IES	Illuminating Engineering Society
IPCE	International Power Cable Engineers Association
ISA	Instrument Society of America
NBS	National Bureau of Standards
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NSF	National Sanitary Foundation
OSHA	Occupational Safety and Health Act
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SSPC	Structural Steel Painting Council
UBC	Uniform Building Code
UL	Underwriters Laboratories

00 73 38 INITIAL START-UP AND OPERATION OF FACILITIES

During the construction of this Project, use of the newly constructed facilities prior to overall acceptance may be necessary to ensure that the entire facility can be constructed. Initial lubrication of all equipment, and all lubrication and maintenance and such staff as required for test operation shall be provided by the Contractor until West County Wastewater assumes operation. After assuming operation, West County Wastewater will supply operating personnel and will pay for electricity, chemicals and lubricants. The Contractor shall train West County Wastewater's operating personnel in the proper operation and control of the new facilities as specified herein. The Contractor shall also furnish all such mechanical and electrical workers as required to make adjustments and maintain the operating equipment until acceptance. Maintenance of operating equipment shall include adjustments, replacements and modifications

as required. The Contractor shall initially lubricate all equipment and furnish West County Wastewater with a lubricant schedule indicating the type of lubricant needed, amounts and frequency of application. Use of facilities will in no way constitute acceptance of the facilities being used. The Contractor shall notify West County Wastewater at least thirty calendar days before any West County Wastewater-furnished lubricants, fuel, chemicals, gas or power will be required for the initial operating periods.

The cost of all labor, material and equipment required to be furnished by the Contractor as part of the initial start-up operation shall be included in the lump-sum bid amounts.

00 73 39 RESPONSIBILITY FOR SPARE PARTS AND SPECIAL TOOLS

The Contractor and Vendor shall provide all spare parts required for the first year's operation. The Contractor and Vendor shall provide all special tools required to assemble, disassemble and maintain all equipment provided under this contract.

00 73 40 MANUALS, OPERATING INSTRUCTIONS AND AFFIDAVITS

A. Manuals and Instructions. The Contractor shall deliver to the Engineer six (6) sets of acceptable manufacturer's operation and maintenance instructions covering each item of mechanical, electrical and instrumentation equipment or equipment assembly provided under this Contract. All information shall be submitted, reviewed and approved as received and prior to installation of the equipment. Submittal and review of the above information shall be handled in a manner similar to shop drawings as specified in Section 00 72 15, Contractor-Furnished Drawings and Data.

B. Operation and maintenance instructions shall include, as a minimum, the following data for each item of mechanical, electrical and instrumentation equipment:
   1. An itemized list of all data provided.
   2. Name and location of the manufacturer, the manufacturer's local representative, the nearest suppliers and spare parts warehouse.
   3. Recommended installation, adjustment, start up, calibration and troubleshooting procedures.
   4. Recommended lubrication, lubrication intervals and an estimate of yearly quantity needed.
   5. Recommended step-by-step procedures for all modes of operation.
   6. Complete internal and connection wiring diagrams.
   7. Recommended preventative maintenance procedures and schedule.
   8. Complete parts lists, by generic title and identification number, with exploded views of each assembly.
   9. Recommended spare parts and special tools.
   10. Disassembly, overhaul and reassembly instructions.

C. Following completion of an item, instructions and procedures shall be modified by the Contractor to reflect field changes.

D. Before final acceptance of the Project, the Contractor shall bind all six (6) sets of operation and maintenance instructions in appropriately labeled, expanding post-type binders. Each completed binder shall only contain material which can be held with the posts in the non-expanding position. A complete table of contents listing all items and their location in the set shall be included in each binder. For ready reference, the Contractor shall compile a complete list of manufacturer's local representatives for each item provided.

E. Affidavits. The Contractor shall provide field service by equipment manufacturers as a part of this Project, as required in the Technical Specifications. Equipment shall not be considered ready for operation until after the authorized factory-trained and qualified manufacturer's representative for the specific equipment has checked and adjusted the equipment and certified by written affidavit that the equipment has been properly installed, tested, adjusted, lubricated and calibrated and is ready for full time operation. Acceptable affidavits shall be submitted prior to completion of work. Affidavits shall contain the following specific wording:

"the (Name of the Equipment) has been properly installed, tested, adjusted, lubricated and is ready for full time operation. The installation has been inspected and has been found to be in conformance with our (the manufacturer's) standards and requirements."

00 73 41 RECORD PLANS

The Contractor shall maintain, at the jobsite, one record set of contract drawings in good order and clearly marked to show any deviations which have been made from the Contract Drawings, including concealed construction and utility features which are revealed during the course of construction. Marked prints shall be updated at least once each week and shall be available to the Engineer for review as to currency prior to developing partial payment estimates. Upon completion of the work, the marked set of prints shall be delivered to the Engineer.

Requests for partial payments will not be approved if the record set of drawings is not in good order or is not kept current. Request for final payment will not be approved until the complete and correct "as-built" record drawings are delivered to the Engineer.

00 73 42 JOINT SURVEY TO ESTABLISH PRECONSTRUCTION CONDITIONS

A. West County Wastewater intends to engage to perform preconstruction examinations and make an overall evaluation of the condition of structures, roads, and road crossings in the vicinity of the work, as applicable, which might be damaged during construction. Participation by the Contractor in the examination is required.

B. The examination of existing buildings, structures, roads, and other improvements located in the zone of influence of the construction operations, will be performed jointly by West

County Wastewater, and the Contractor, and the property owners under supervision of West County Wastewater. The scope of each examination shall include road damage, cracks in structures, settlement, leakage, and other visible signs of damage.

C. Records of all observations will be prepared by West County Wastewater, including survey measurements, sketches, notes, photographs, and video tapes when deemed necessary.

D. The above records, photographs and video tapes are intended for use as indisputable evidence in ascertaining the extent of any damage which may occur as a result of the Contractor's operations and are for the protection of the Contractor and West County Wastewater. They will be a means of determining whether and to what extent damage resulting from the Contractor's operations occurred during the contract work.

E. The Contractor shall take adequate precautions to prevent damage to existing buildings, structures, detour roads, road crossings, and other improvements during the prosecution of the work.

F. The West County Wastewater-funded joint survey does not relieve the responsibility of the Contractor to conduct any additional preconstruction surveys or any periodic or continuous monitoring of structures or improvements during construction activities which may be required because of the Contractor's construction techniques or work sequence. The Contractor shall conduct the additional preconstruction survey or construction monitoring as identified by the Contractor without additional compensation from West County Wastewater.

00 73 43 CONSTRUCTION CONSTRAINTS

The project area is located at one location, Water Pollution Control Plant, 2377 Garden Tract Road, Richmond, CA. It is the Contractor's responsibility to protect existing improvements, provide for safe and smooth traffic flow, minimize disruptions and noise, and ensure that the work is done with as little inconvenience to West County Wastewater and to the public as possible. The Contractor shall, at its own expense, restore any and all existing improvements equal to its preconstruction condition or better.

00 73 44 TRAFFIC CONTROL

Contractor shall coordinate with the agency having jurisdiction over the right of way. Contractor’s construction vehicles shall not block or impede public access.

If the Contractor needs any traffic rerouting or restriction to facilitate its work, it shall acquire a written permit, through the offices of the City of Richmond. No traffic restriction or rerouting shall be initiated prior to the Engineer’s receipt of such permit and all conditions prescribed therefore. In accordance with Section 00 73 30 Permits, Easements and Agreements, West

County Wastewater will Reimburse the Contractor for the necessary permit and fees. The Contractor must pay re-inspection of the same, and any fines as part of Contractor's negligence.

If required, the Contractor shall submit a detailed traffic plan for rerouting and/or restricting traffic to the City of Richmond for approval before any work can be started under the Contract. The traffic plan shall show locations of flagmen, signs and barriers relative to the working area. As a minimum, the traffic plan and lane closures shall be in accordance with the State Department of Transportation (Caltrans) current standards. The Contractor shall provide three copies of the City of Richmond-approved traffic plans to the West County Wastewater prior to the start of work.

00 73 45 WORK HOURS

Early morning, night time and weekend work will require approval from West County Wastewater.

00 73 46 FEDERAL, STATE AND LOCAL REQUIREMENTS

The Contractor shall keep fully informed of laws, ordinances, and requirements of the Federal, State of California, City of Richmond and West County Wastewater which, in any manner, affect the performance of the work or those persons engaged therein, and of all orders and decrees of governmental bodies or officials having any authority or jurisdiction over the same. The Contractor shall observe and comply with and shall cause all its agents, employees and subcontractors to observe and comply with all such ordinances, regulations, laws, orders, and decrees.

All construction and materials, and the like, shall be furnished, installed, or constructed as the case may be, by the Contractor in full accordance with the requirements of local building codes, the National Board of Fire Underwriters, the Pacific Fire Rating Bureau, the State Fire Marshall, the Safety Orders issued by the Division of Industrial Safety of the State of California, and all other prevailing codes and regulations having jurisdiction over construction of the structure.

The Contractor's authorized representative shall have a working knowledge of, and be responsible for, all state and federal safety regulations applicable to the Project.

00 73 47 APPRENTICES

The Contractor shall comply with the provisions of Section 1777.5 and 1777.6 of the California Labor Code in regard to employment of apprentices.

00 73 48 LABOR, WAGES, AND WAGE DETERMINATIONS

Pursuant to section 1770 *et seq.* of the Labor Code of the State of California, the Director of Industrial Relations has ascertained the general prevailing rate of per diem wages and the rates for overtime and holiday work in the locality in which the work is to be performed for each craft,

classification or type of worker needed to execute the contract which will be awarded to the successful bidder. Copies are on file with and available upon request from the Engineer and may also be obtained the website of the Division of Labor Statistics and Research, California Department of Industrial Relations located at www.dir.ca.gov. The successful bidder shall post a copy thereof at each job site. The requirement to pay these wage rates is further detailed in Part IV, Section E (2) of General Conditions. It shall be mandatory upon the bidder to whom the Contract is awarded, and upon any subcontractor under him to comply with all Labor Code provisions, which include, but are not limited to the payment of not less than the said specified rates to all workers employed by them in the execution of the Contract, employment of apprentices, hours of labor and debarment of contractors and subcontractors. The Federal minimum wage rates (Davis-Bacon) for this project as predetermined by the United States Secretary of Labor are set forth at the federal government website as called out below. The Federal minimum wage rates may also be examined at the offices described above where project plans, special provisions, and proposal forms may be seen. Addenda to modify the Federal minimum wage rates, if necessary, will be issued to holders of these Contract Documents. Future effective general prevailing wage rates, which have been predetermined and are on file with the California Department of Industrial Relations are referenced but not printed in the general prevailing wage rates. Attention is directed to the Federal minimum wage rate requirements included with these specifications in the supplemental conditions and also available at the federal web site Wage Determination Online (http://www.wdol.gov) go to the California, Contra Costa County file references. If there is a difference between the minimum wage rates predetermined by the Secretary of Labor and the general prevailing wage rates determined by the Director of the California Department of Industrial Relations for similar classifications of labor, the Contractor and subcontractors shall pay not less than the higher wage rate. The Department will not accept lower State wage rates not specifically included in the Federal minimum wage determinations. This includes "helper" (or other classifications based on hours of experience) or any other classification not appearing in the Federal wage determinations. Where Federal wage determinations do not contain the State wage rate determination otherwise available for use by the Contractor and subcontractors, the Contractor and subcontractors shall pay not less than the Federal minimum wage rate, which most closely approximates the duties of the employees in question.

END OF GROUP 00 73 00

SECTION 01110

SUMMARY OF WORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Detailed description of the Work.

1.02 THE WORK

A. The Work, included but not limited to, the following:
   1. Replacement of the MCC and associated VFDs in the effluent pump station building and construction of new electrical building to house new MCC and associated equipment, replacement of the VFDs in the south headworks building's raw sewage pump station, and replacement of the transformer in the maintenance building.

B. Except as specifically noted otherwise, provide and pay for:
   1. Insurance and bonds.
   2. Labor, materials, and equipment.
   3. Tools, equipment, and machinery required for construction.
   4. Utilities required for construction.
   5. Temporary facilities including sheeting and shoring.
   6. Traffic control and dust control measures.
   7. Other facilities and services necessary for proper execution and completion of the Work.

C. Secure and pay for all permits including OSHA excavation permits, Department of Transportation permits, government fees, and licenses.

D. Comply with codes, ordinances, regulations, orders, and other legal requirements of public authorities having bearing on the performance of the Work.

1.03 LOCATION OF PROJECT

A. The Work is located at the Water Pollution Control Plant, 2377 Garden Tract Road, Richmond, CA 94801.

1.04 OWNER ASSIGNED SUBCONTRACTORS

A. Assignment of subcontractors by Owner is not anticipated.

1.05 OWNER FURNISHED EQUIPMENT

A. Owner will:
   1. Arrange for and deliver necessary shop drawings, product data, and samples to Contractor.
   2. Arrange and pay for product delivery to site in accordance with construction schedule.

3. Deliver supplier's bill of materials to Contractor.
4. Inspect deliveries jointly with Contractor.
5. Submit claims for transportation damage.
6. Arrange for replacement of damaged, defective, or missing items.
7. Arrange for manufacturer's warranties, bonds, service, and inspections.
8. Arrange and pay for Programmer.

B. Contractor's responsibility for Owner-furnished products:
1. Designating delivery date for each Owner-furnished product.
2. Reviewing shop drawings, product data, and samples.
3. Submitting notification of discrepancies or anticipated problems.
4. Receiving and unloading products at site.
5. Promptly inspecting products jointly with Owner and recording shortages, and damaged or defective items.
6. Handling products at site, including uncrating and storage.
7. Protecting products from damage.
8. Installing, including assembly, connections, adjustments, and commissioning in accordance with Contract Documents.
9. Providing operating oils, lubricants, and incidental materials required for complete installation.
10. Repairing or replacing items damaged after receipt until date of Substantial Completion of the Work by Owner.

C. When Owner fails to deliver products in accordance with accepted Construction Schedule, adjustments will be made to Contract Times and Contract Price as stipulated in General Conditions.

1.06 ACTIVITIES BY OTHERS

A. Owner, utilities, and others may perform activities within Project area while the Work is in progress:
1. Schedule the Work with Owner, utilities, and others to minimize mutual interference.

B. Activities by others which may affect performance of work include:
1. Normal daily operation of the wastewater treatment plant by Owner.

C. Cooperate with others to minimize interference and delays:
1. When cooperation fails, submit recommendations and perform Work in coordination with work of others.

D. When the Work depends for proper execution or results upon work performed by others, inspect and promptly report apparent discrepancies or defects in work performed by others:
1. Assume responsibility for work performed by others, except for defects reported as specified in this paragraph and defects which may become apparent in work performed by others after execution of the Work.

1.07 PARTIAL USE OR OCCUPANCY

A. Substantially Complete following portions of Work for OWNER's occupancy including specified testing, training of OWNER's personnel, and other preparations necessary for OWNER's occupancy or use.

B. OWNER’s partial utilization of portions of Work prior to final acceptance of the completed Work will not be made.

C. Certificates of Substantial Completion will be executed for each designated portion of Work prior to OWNER occupancy.
1. Such certificate of Substantial Completion will describe the portion of the Work to be occupied by OWNER, items that may be incomplete or defective, date of occupancy by OWNER, and other information required by OWNER and CONTRACTOR.

D. After OWNER occupancy, allow access for OWNER's personnel, access for others authorized by OWNER, and OWNER operation of equipment and systems.

E. E. Following occupancy, OWNER will:
1. 1. Provide power to operate equipment and systems.
2. 2. Repair damage caused by OWNER’s occupancy.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01116

CONTRACT DOCUMENT LANGUAGE

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Explanation of arrangement, language, reference standards, and format.

1.02 REFERENCES

A. Construction Specifications Institute (CSI):
   1. MasterFormat™.
   2. SectionFormat™.
   3. PageFormat™.

1.03 PROJECT MANUAL ARRANGEMENT

A. Document and Section numbers used in Project Manual, and Project Manual arrangement are in accordance with CSI MasterFormat™, except where departures have been deemed necessary.

B. Sections are written in CSI SectionFormat™, Three-Part Section Format, except where departures have been deemed necessary.

C. Page format for Sections in the Project Manual is in PageFormat™, except where departures have been deemed necessary.

1.04 CONTRACT DOCUMENT LANGUAGE

A. Specification Section Paragraphs entitled "Section Includes" summarize briefly what is generally included in the section:
   1. Requirements of Contract Documents are not limited by "Section Includes" paragraphs.

B. Specifications have been partially streamlined by intentionally omitting words and phrases, such as "the Contractor shall," "in conformity therewith," "shall be" following "as indicated," "a," "an," "the" and "all:"
   1. Assume missing portions by inference.

C. Phrase "by Engineer" modifies words such as "accepted," "directed," "selected," "inspected," and "permitted," when they are unmodified.

D. Phrase "to Engineer" modifies words such as "submit," "report," and "satisfactory," when they are unmodified.

E. Colons (:) are used to introduce a list of particulars, an appositive, an amplification, or an illustrative quotation:
   1. When used as an appositive after designation of product, colons are used in place of words "shall be."

F. Word "provide" means to manufacture, fabricate, deliver, furnish, install, complete, assemble, erect in place, test, or render ready for use or operation, including necessary related material, labor, appurtenances, services, and incidentals.

G. Words "Contractor shall" are implied when direction is stated in imperative mood.

H. Term "products" includes materials and equipment as specified in Section 01600 - Product Requirements.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01140

WORK RESTRICTIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for scheduling the Work affected by existing site and facility, work restrictions, and coordination between construction operations and plant operations.

1.02 SUBMITTALS

A. Baseline Schedule with MOP tasks.

B. Method of Procedure (MOP) Form.

C. Method of Procedure (MOP) Log.

D. Progress Schedule with MOP tasks.

1.03 GENERAL CONSTRAINTS ON WORK AND SCHEDULING OF WORK

A. The West County Wastewater Water Pollution Control Plant is the District's only means of treating domestic and industrial wastewater prior to discharging to the San Francisco Bay. Impairing the operational capabilities of this treatment plant will result in serious environmental damage and monetary fines.

B. Conduct Work in a manner that will not impair the operational capabilities of essential elements of the treatment process or reduce the capacity of the entire treatment plant below levels sufficient to treat the quality of raw wastewater to the water quality limitations specified in the discharge permit and RARE Agreement.

C. Conduct commissioning activities as specified in Section 01756 - Commissioning in a manner that will not impair the operational capabilities of essential elements of the treatment process or reduce the capacity of the entire treatment plant below levels sufficient to treat the quality of raw wastewater to the water quality limitations specified in the discharge permit and RARE Agreement.

D. The status of the treatment plant shall be defined as "operational" when it is capable of treating the entire quantity of wastewater received to the water quality limits specified in the discharge permit.

E. Include costs in bid price for compliance with the specific limitations and constraints and the related general factors pertaining to maintaining the operational capacity of the treatment facility.

F. Work sequence and constraints:
   1. Utilize description of critical events in work sequence in this Section as a guideline for scheduling and undertaking the Work.
   2. Work sequence and constraints presented do not include all items affecting completion of the Work, but are intended to describe critical events necessary to minimize disruption of the existing facilities and to ensure compliance with National Pollutant Discharge Elimination System permit requirements and RARE Agreement.

G. Instrumentation and controls process performance testing:
   1. After the Process Operational Period, test PCIS system as specified in Section 01756 - Commissioning.

1.04 SHUTDOWN AND CONSTRUCTION CONSTRAINTS

A. General shutdown constraints:
   1. Execute the Work while the existing facility is in operation.
   2. Some activities may be accomplished without a shutdown.
   3. Apply to activities of construction regardless of process or work area.
   4. Activities that disrupt plant or utilities operations must comply with these shutdown constraints.
   5. Organize work to be completed in a minimum number of shutdowns.
   6. Provide thorough advanced planning, including having required equipment, materials, and labor on hand at time of shutdown.
   7. Where required to minimize treatment process interruptions while complying with specified constraints, provide temporary pumping, power, lighting, controls, instrumentation, and safety devices.
   8. Final determination of the permitting of shutdowns will be the sole judgment of the Owner.
   9. Owner maintains the ability to abort on the day of the scheduled shutdown.

B. General maximum plant flow work limitations:
   1. Activities that disrupt plant operations are prohibited during the following flow conditions, unless otherwise approved in writing by the Owner and Engineer.

C. Unit process availability work limitations:
   1. Shutdowns and tie-ins or other activities that disrupt plant operations are prohibited unless the following unit process availability conditions exist and unless otherwise approved in writing by the Owner and Engineer.
   2. At a minimum, the following facilities must be in service in order to proceed with a scheduled shutdown.

D. Shutdown activities:
   1. Scheduling:
      a. Perform 8-hour maximum plant shutdowns during plant shift hours as directed by Owner.
      b. A minimum of 1 day of plant operation will be required between sequential 8-hour plant shutdowns; longer durations between shutdowns may be required and is at the discretion of the Owner.

c. A 24-hour maximum plant shutdown may be allowed with approval by Owner.
d. Perform between the hours of 4 a.m. and 8 a.m**.** or as approved by Owner.

2. Unplanned shutdowns due to emergencies are not defined in this Section.

E. Dewatering of existing process and disposal of residue:
1. When the Owner has turned the process unit over to the Contractor for modification or temporary use, the Contractor is responsible for costs and procedures required to dewater and dispose of liquid, solids, etc. in the process unit:
a. Drainage and disposal of process unit liquids, solids, etc. into another treatment process unit on the plant site may be allowed if approved in advance by the Engineer and Owner, and is conducted in accordance with Owner's requirements.
b. Costs for dewatering, disposal of solids and residuals, and preparation of surfaces for the Work are Contractor's responsibility:
1) Includes tipping fees for the removal and disposal of the grit/debris.
c. Dewatering of grit/debris to meet landfill requirements is the responsibility of the Contractor.
d. Contractor shall provide adequate time in schedules for draining and cleanup of basins and channels.

F. Process area construction constraints:
1. The following constraints shall be observed while working in and around each of the following process areas:
a. Material hauling operations:
1) Contractor shall comply with restrictions regarding Contractor's use of site and premises as specified in Section 01110 - Summary of Work.

G. Possible Sequence for XFMR-1 and MCC-EPS replacement:
1. Relocate existing photovoltaic underground conduits to allow construction of new EPS electrical building. Coordinate with WCW's designated on-call photovoltaic system service staff.
2. Procure new equipment and construct new EPS Electrical Building:
a. Construct new duct banks.
b. Install new XFMR-1 and MCC-EPS.
3. Depower existing XFMR-1 and MCC-EPS by opening medium voltage switchgear feeder breaker to EPS.
4. Provide temporary generator power directly to existing MCC-EPS.
5. Construct manhole MH-EPS-3 and splice existing medium voltage cables to new MCC-EPS via new XFMR-1.
6. Disconnect temporary generator from existing MCC-EPS.
7. Repower both new and existing XFMR-1 and MCC-EPS.
8. Test new MCC-EPS and new.
9. Transfer loads from existing MCC-EPS to new MCC-EPS, one by one. Test and commission each load on new power source before proceeding to the next load.

10. When the last load is transferred, tested, and commissioned, then depower the MV circuit briefly to disconnect existing XFMR-1 and MCC-EPS from the system.
11. Demolish existing XFMR-1 and MCC-EPS.

1.05 METHOD OF PROCEDURE (MOP)

A. MOP Instructions: See Appendix A.

B. Prepare MOP for the following conditions:
   1. Shutdowns, diversions, and tie-ins to the existing facility.
   2. Process start-up activities.
   3. Power interruption and tie-ins.
   4. Switch over between temporary and permanent facilities, equipment, piping, and electrical and instrumentation systems.
   5. Process constraints requiring interruption of operating processes or utilities.

C. Other Work not specifically listed may require MOPs as determined necessary by the Contractor, Owner, or Engineer.

D. Submit MOP Log at construction progress meetings.

E. No consideration will be given to claims of additional time and cost associated to preparing MOPs required by the Owner and Engineer to complete this work in a manner that facilitates proper operation of the facility and compliance with effluent discharge criteria.

F. Where required to minimize treatment process interruptions while complying with specified constraints, provide temporary pumping, power, lighting, controls, instrumentation, and safety devices.

1.06 COMPLIANCE WITH NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT

A. The existing facility is operating under the terms of a National Pollutant Discharge Elimination System permit issued by the California Regional Water Quality Control Board San Francisco Bay Region . This permit specifies the water quality limits that the plant must meet prior to discharge of effluent. A copy of the existing permit is on file for review at the treatment plant.

B. Perform work in a manner that will not prevent the existing facility from achieving the finished water quality requirements established by regulations.

C. Bear the cost of penalties imposed on the Owner for discharge violations caused by actions of the Contractor.

1.07 REQUIREMENTS FOR OPERATION OF PLANT AND MAINTAINING CONTINUOUS OPERATION OF EXISTING FACILITIES

A. Facilities or conditions required to keep the existing plant operational include, but are not limited to, the following:
   1. Effluent pump station building.
   2. Raw sewage pump station.

3. Maintenance building.
4. Electrical power including transformers, distribution wiring, and motor control centers.
5. Piping for conveyance of raw, partially treated and finished water between treatment or storage units and basins.
6. Chemical storage, metering, conveyance, and control facilities.
7. Plant water.
8. Plant air.
9. Laboratory facilities.
10. Office, toilets, and washrooms.
11. Fencing and gates.
12. Lighting.
13. Heating, ventilation, and air conditioning.
14. Instrumentation, meters, controls, and telemetry equipment.
15. Safety equipment and features.
16. Parking for Owner's employees and vehicles required for operation and maintenance of the Water Pollution Control Plant.
17. Telephone system.
18. Storm drainage.
19. Natural gas service.

B. Conduct the Work and provide temporary facilities required to keep the existing plant continuously operational.

C. Do not remove or demolish existing facilities required to keep the existing plant operational at the capacities specified until the existing facilities are replaced by temporary, new, or upgraded facilities or equipment:
   1. Test replacement facilities to demonstrate operational success prior to removing or demolishing existing facilities.

1.08 OPERATIONS AND MAINTENANCE ACCESS

A. Provide safe, continuous access to process control equipment for plant operations personnel.

B. Provide access on 1-hour advance notice to process control equipment for plant maintenance personnel and associated maintenance equipment.

1.09 UTILITIES

A. Provide advance notice to and utilize services of Underground Services Alert (U.S.A.) for location and marking of underground utilities operated by utility agencies other than the Owner.

B. Maintain electrical, telephone, water, gas, sanitary facilities, and other utilities within existing facilities in service. Provide temporary utilities when necessary.

C. New yard utilities were designed using existing facility drawings:
   1. Field verification of utilities locations was not performed during design.
   2. Services crossed or located nearby by new yard utilities may require relocation and possible shutdowns.
   3. Pipe alignments as indicated on the Drawings.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

APPENDIX A
"Method of Procedure" (MOP)
Instructions and Forms

Definition and Purpose

"Method of Procedure" (MOP) is a detailed document submitted by the Contractor to request process shutdown(s), utility tie-in(s), work in areas that may risk unanticipated outages, or flow diversions to accommodate site construction activities during a project. Such activities may include (but are not limited to) new tie-ins to utilities or structures, mechanical modifications to process piping or equipment, demolition, bulkhead installation, and cleaning processes.

The MOP provides a detailed plan to the Owner and Engineer that describes specific aspects of the work including purpose, time of execution, and anticipated impacts on treatment processes. The MOP also includes contingency measures and provisions for rapid closure in the event that shutdown or work progress difficulties are encountered. Information from relevant trades associated with the requested shutdown, diversion, or tie-in is also included.

The Owner should use the information within the MOP to define operational procedures and methods to safely and successfully assist the Contractor.

MOP Process Summary

WHO	STEP	TIMING
Contractor	1. Identify MOPs needed on MOP Log and Baseline Schedule.	No later than 7 days prior to Preconstruction Scheduling Meeting
Contractor, Owner, Engineer	2. Pre-MOP Meeting.	More than 28 days prior to work
Contractor	3. Submits MOP.	No later than 28 days prior to work
Owner	4. Reviews MOP.	
Owner	5. MOP finalized.	No later than 7 days prior to work
Contractor	6. Complete Readiness Checklist.	No later than 5 days prior to work
Contractor	7. Complete Safety Checklist.	Immediately prior to commencing work
Contractor	8. Complete Work.	
Contractor	9. Update MOP Log and Progress Schedules.	Monthly

MOP Process Detail

STEP 1. Identifies MOPs needed on MOP Log and Baseline Schedule.

Contractor submits a preliminary list of anticipated project MOPs on MOP Log. MOPs identified but not limited to those shutdowns, diversions, or tie-ins described in the Contract Documents. Incorporate MOPs as tasks in Baseline Schedule. Date scheduled MOPs to coincide with the appropriate construction activities.

STEP 2. Pre-MOP Meeting.

Contractor requests a Pre-MOP Meeting with the Owner and Engineer to discuss the nature of the shutdown, diversion, or tie-in, and to gather the information necessary to complete the MOP Form. The pre-MOP meeting may be waived by the Owner or Engineer if the work is deemed to be minor.

STEP 3. Submits MOP.

Contractor completes the MOP Form and submit 3 copies for approval to the Owner's Project Manager (OPM).

STEP 4. Reviews MOP.

OPM distributes MOP Form for review by the Owner's Construction Coordinator, O&M Representative, and Engineer's Project Representative. Review MOP Form for completeness, accuracy, compliance with both the construction schedule, constraints defined in contract documents, and to ensure that the requested work does not negatively impact plant operations or other concurrent project activities. Additional information may be requested to better understand the nature of and method for completing the Work.

STEP 5. MOP finalized.

Once the MOP is agreed to by all parties, the MOP will be finalized by signature. Copies are distributed to the Owner, Engineer, and Contractor.

STEP 6. Complete Readiness Checklist.

Contractor verifies everything is ready for the work.

STEP 7. Complete Safety Checklist.

Contractor ensures safety.

STEP 8. Complete work.

Contractor complete work.

STEP 9. Update MOP Log and Progress Schedules.

Contractor updates MOP Log weekly and distributes at the regularly scheduled construction progress meetings.

METHOD OF PROCEDURE (MOP) FORM

Owner: _____ **Date:** _____

Contractor: _____ **Carollo Project No.:** _____

Project Name: _____ **Submittal No.:** _____

Submittal Title: _____ **Spec/Dwg. Reference:** _____

MOP #	Task Title *(Provide <10 word title)*:	Submittal Date: *(No later than 28 days prior to work)*

SCHEDULE OF WORK ACTIVITY START: *(Date/Time)* END: (Date/Time)

REQUESTOR:

PRIMARY POINT OF CONTACT:	PHONE/PAGER:
SECONDARY POINT OF CONTACT:	PHONE/PAGER:
NOTIFY ☐ Control Room, Phone	☐ Security, Phone
BUILDING:	LOCATION OF WORK FLOOR/LEVEL:

DESCRIPTION OF WORK: *(Provide sufficient details on process isolation, work sequencing, and safety (i.e., control of significant hazards unique to the work) to demonstrate an understanding of the work and how it will be completed within the constraints, and its impact on the processes and facility.)*

Task Summary: _____

Processes Affected: _____

Trades Affected: _____

WORK PLAN:

Work Sequencing: _____

Process Isolation: _____

Spill Prevention Plan: _____

Contingency Plans: _____

CRITICAL EQUIPMENT/TOOLS: *(pumps and discharge hoses with correct fittings, blind flanges and pipe plugs, no-hub fittings, properly sized electrical service components, generators, portable lighting, chlorine for potable water pipe breaks, etc.)*

☐	Acoustic Ceiling/or Walls Access	☐	Excavation Permit	☐	Lock Out/Tag Out
☐	Chemical Use Approval	☐	Fire Sprinkler Impairment	☐	Life Safety Systems
☐	Confined Space Permit	☐	Flammable Materials	☐	Roof Protocol
☐	Critical Lift Plan	☐	Flush / Discharge	☐	Work After Dark
☐	Energized Electrical Work	☐	High Pressure Test	☐	
☐	Elect. Panel Schedules	☐	Hot Work/Open Flame	☐	

EXISTING SERVICE(S) AT RISK:

☐	Breathing Air	☐	Elect Normal	☐	Process Access	☐	Telephones
☐	Chemical Distribution	☐	Fire Protection	☐	Safety Showers	☐	UPS
☐	City Water	☐	HVAC	☐	SCADA	☐	VAX/DATA
☐	Communication	☐	Inert Gas	☐	Security	☐	
☐	Domestic Drain	☐	Instrument - Air	☐	Solvent Drain	☐	
☐	Elect-Bus Duct	☐	Life Safety System	☐	Specialty Gases	☐	

☐	Elect Emergency	☐	Natural Gas	☐	Storm Drain	☐	

REVIEWER'S INSTRUCTIONS / COMMENTS:

☐ PREJOB BRIEFING MUST BE COMPLETED PRIOR TO COMMENCING WORK:

	Full Name (printed)	Signature	Phone	Date
Submitted By				
System Owner				
Reviewer (if needed)				
Reviewer (if needed)				
Reviewer (if needed)				
Reviewer (if needed)				

READINESS CHECKLIST
(5 days prior to work)

Checklist provided as a guide but is not all inclusive.

1. Confirm all parts and materials are on site: _____
2. Review work plan: _____
3. Review contingency plan: _____

SAFETY CHECKLIST
(Just prior to commencing work)

Checklist provided as a guide but is not all inclusive.

1. Location awareness:
   a. Emergency exits: _____
   b. Emergency shower and eyewash: _____
   c. Telephones and phone numbers: _____
   d. Shut-off valve: _____
   e. Electrical disconnects: _____
2. Inspect work area:
   a. Take time to survey the area you are working in. Ensure that what you want to do will work. Do you have enough clearance? Is your footing secure? Do you have adequate lighting and ventilation? Are surrounding utilities out of the way for you to perform your work?
3. SDS (Safety Data Sheets):
   a. Understand the chemicals and substances in the area you are working in by reading the SDS.
4. Lockout/Tagout Procedure:
   a. Lockout/tagout energy sources before beginning work.
   b. Make sure all valves associated with the work are locked out and tagged out on each side of the penetration.
   c. Make sure the lines are depressurized.
5. Overhead work:
   a. Use appropriate personal protective equipment; i.e., safety harness, lifeline, etc.
   b. Select appropriate tie-off points; i.e., structurally adequate, not a pipe or conduit, etc.
   c. Spotter assigned and in position.
   d. Pipe rack access; i.e., check design capacity, protective decking or scaffolding in place, exposed valves or electrical switches identified and protected.
6. Safety equipment:
   a. Shepherd's hook.
   b. ARC flash protection.
   c. Fire extinguisher.
   d. Other: _____.
7. Accidents:
   a. Should accidents occur, do not shut off and do not attempt to correct the situation, unless you are absolutely positive that your action will correct the problem and not adversely affect other people or equipment.
8. Review process start-up documents:
   a. In the event the system is shutdown, the Control Center should have a working knowledge of the process start-up procedures in order to deal effectively with unforeseen events.
9. Evacuation procedures:
   a. Do not obstruct evacuation routes.
   b. Take time to survey the area for evacuation routes.

Method of Procedure (MOP) Log
Sample

MOP Number	Task Title	Date Requested	Date Approved	Date Work Planned	Work Completed (yes/no)
001					
002					
003					

SECTION 01292

SCHEDULE OF VALUES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for preparation, format, and submittal of Schedule of Values.

1.02 PREPARATION

A. Schedule of Values shall be a listing of all cost loaded, on-site construction activities from the progress schedule, listed in numerical order, showing that the sum total of all cost-loaded activities equal the Contract value.

B. When the schedule is changed or revised to include added or deleted work, the Schedule of Values shall also be revised such that the sum total of all cost-loaded activities continuously equal the current Contract value.
   1. Equate the aggregate of these costs to the Lump Sum Contract Price.

C. Prepare Schedule of Values identifying costs of Major Items of Work and other costs shown in sample included at end of this Section.

D. Divide the work into following Major Items of Work:
   1. Mobilization.
   2. Demobilization.
   3. Sheeting, shoring, and bracing.
   4. Effluent pump station (EPS) building.
   5. Headworks building raw sewage pump station.
   6. Maintenance building.
   7. All other costs required to complete all Work in the Contract Documents not covered by the other Line Items listed above.

1.03 SUBMITTALS

A. Submit preliminary schedule of values.

B. Submit corrected schedule of values within 10 days upon receipt of reviewed Schedule of Values, but no later than 10 days prior to anticipated submittal of first Application for Payment.

C. Upon request, support prices with data which will substantiate their correctness.

D. If activities are added or removed from the Progress Schedule revise the Schedule of Values and resubmit.

1.04 SAMPLE SCHEDULE OF VALUES

A. Following is an acceptable form for Schedule of Values:

(SAMPLE ONLY) SCHEDULE OF VALUES		
NO.	**DESCRIPTION OF ITEM**	**LUMP SUM COST**
1	Mobilization	
2.	Demobilization	
3.	Effluent pump station	
4.	Effluent pump station electrical building	
5.	Effluent pump station electrical building MCC	
6.	Effluent pump station electrical building VFDs	
7.	Headworks building raw sewage pump station	
8.	Headworks building VFDs	
9.	Maintenance building	
10.	New PLC-5, PLC-1 & PLC-3 panel mod. & instruments	
11.	All other costs required to complete all Work in the Contract Documents not covered by the other Line Items listed above.	
	TOTAL LUMP SUM BID	

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01294

APPLICATIONS FOR PAYMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Procedures for preparation and submittal of Applications for Payment.

1.02 FORMAT

A. Develop satisfactory spreadsheet-type form generated by downloading cost data from the Progress Schedule:
   1. Submit payment requests and attach spreadsheet with cost data related to Progress Schedule.

B. Fill in information required on form.

C. When Change Orders are executed, add Change Orders at end of listing of scheduled activities:
   1. Identify change order by number and description.
   2. Provide cost of change order in appropriate column.

D. After completing, submit Application for Payment.

E. Engineer will review application for accuracy. When accurate, Engineer will transmit application to Owner for processing of payment.

F. Execute application with signature of responsible officer of Contractor.

1.03 SUBSTANTIATING DATA

A. Provide Substantiating Data with cover letter identifying:
   1. Project.
   2. Application number and date.
   3. Cost flow summary.
   4. Updated schedule of values.
   5. Progress schedule.
   6. Detailed list of enclosures.
   7. For stored products with item number and identification on application, description of specific material, and proof of insurance coverage for offsite stored products.
   8. Submit “certified” payroll, if applicable.

1.04 SUBMITTALS

A. Submit 5 copies of Application for Payment and Substantiating Data with cover letter.

1.05 PAYMENT REQUESTS

A. Prepare progress payment requests on a monthly basis. Base requests on the breakdowns of costs for each scheduled activity and the percentage of completion for each activity.

B. Indicate total dollar amount of work planned for every month of the project. Equate sum of monthly amounts to Lump Sum Contract Price.

C. Generate Progress Payment request forms by downloading cost data from the schedule information to a spreadsheet type format.

D. Identify each activity on the Progress Schedule that has a cost associated with it, the cost for each activity, the estimated percent complete for each activity, and the value of work completed for both the payment period and job to date.

E. Prepare summary of cost information for each Major Item of Work listed in the Schedule of Values. Identify the value of work completed for both the payment period and job to date.

F. Payment period:
   1. Monthly Application for Payment period shall begin on the 1st day of each month, and end on the last day of each month.
   2. Submit Application for Payment to Engineer no later than the 5th day of each month for work completed the previous month.
   3. Engineer will finalize and submit recommendation for Application for Payment to Owner by the 15th day of each month to allow time for processing and approval.

1.06 COST SUMMARIES

A. Prepare Summary of Cost Information for each Major Item of Work listed in the Schedule of Values. Identify the Value of Work Completed for both the payment period and job to date.

B. Cash flow summary: Prepare cash flow summary, indicating total dollar amount of work planned for each month of the project. Equate sum of monthly amounts to Lump Sum contract price.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01312

PROJECT MEETINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for conducting conferences and meetings for the purposes of addressing issues related to the Work, reviewing and coordinating progress of the Work and other matters of common interest, and includes the following:
   1. Qualifications of Meeting Participants.
   2. Pre-construction Conference.
   3. Progress Meetings.
   4. Pre-Installation Meetings.
   5. Schedule Update Meetings.
   6. Quality Control Meetings.
   7. Pre-Shutdown Meetings.
   8. Pre-Process Start-up Meetings.
   9. Electrical and Instrumentation Coordination Meetings.
   10. Close-out meeting.
   11. Post Construction Meeting.

1.02 QUALIFICATIONS OF MEETING PARTICIPANTS

A. Representatives of entities participating in meetings shall be qualified and authorized to act on behalf of entity each represents.

1.03 PRE-CONSTRUCTION CONFERENCE

A. Upon issuance of Notice to Proceed, or earlier when mutually agreeable, Engineer will arrange pre-construction conference in place convenient for most invitees.

B. Pre-construction Conference invitees: Contractor's project manager and superintendent, Owner, Engineer, representatives of utilities, major subcontractors and others involved in performance of the Work, and others necessary to agenda.

C. Engineer will preside at conference.

D. Purpose of conference: To establish working understanding between parties and to discuss Construction Schedule, shop drawing and other submittals, cost breakdown of major lump sum items, processing of submittals and applications for payment, and other subjects pertinent to execution of the Work.

E. Agenda will include:
   1. Adequacy of distribution of Contract Documents.
   2. Distribution and discussion of list of major subcontractors and suppliers.
   3. Proposed progress schedules and critical construction sequencing.
   4. Major equipment deliveries and priorities.
   5. Project coordination.

6. Designation of responsible personnel.
7. Procedures and processing of:
    a. Field decisions.
    b. Proposal requests.
    c. Submittals.
    d. Change Orders.
    e. Request for Information/Interpretations.
    f. Applications for Payment.
    g. Record Documents.
8. Use of premises:
    a. Office, construction, and storage areas.
    b. Owner's requirements.
9. Construction facilities, controls, and construction aids.
10. Temporary utilities.
11. Safety and first aid procedures.
12. Security procedures.
13. Housekeeping procedures.

F. Engineer will record minutes of meeting and distribute copies of minutes within 7 days of meeting to participants and interested parties.

1.04 PROGRESS MEETINGS

A. Engineer will schedule and administer meetings throughout progress of the Work at maximum weekly intervals.

B. Engineer will make arrangements for meetings, prepare agenda with copies for participants and preside at meeting.

C. Attendance required: Owner, Engineer, Contractor, Contractor’s Project Manager, superintendent, quality control manager, project scheduler, major subcontractors and suppliers as appropriate to agenda topics for each meeting.

D. Additional invitees: Owner utility companies when the Work affects their interests, and others necessary to agenda.

E. Agenda:
1. Review minutes of previous meeting/minutes.
2. Safety and security.
3. Construction schedule summary.
4. Review of 6 weeks schedule.
5. Review of off-site fabrication and delivery schedules.
6. Review of submittals schedule and status of submittals.
7. Request for information (RFI’s) status.
8. MOP’s/shutdown coordination.
9. Change order management status.
10. Maintenance of quality standards (QA/QC).
11. Field observations, problems, and conflicts.
12. Commissioning and process start-up.
13. Partnering recognition status (optional).
14. General Items.
15. Action items.
16. Next meeting.

F. Engineer will record minutes and distribute copies within 5 calendar days after meeting to participants, with copies to Contractor, Owner, and those affected by decisions made.

1.05 PRE-INSTALLATION MEETINGS

A. When required in individual specification sections or requested by Engineer, convene pre-installation meeting at Project site before commencing work of specific section.

B. Require attendance of parties directly affecting, or affected by, Work of specific section.

C. Notify Engineer no later than 7 calendar days in advance of meeting date.

D. Prepare agenda and preside at meeting:
   1. Review conditions of installation, preparation, and installation procedures.
   2. Review coordination with related work.

E. Contractor will record minutes and distribute electronic copies within 7 calendar days after meeting to participants, with copies to Engineer, Owner, and those affected by decisions made.

1.06 SCHEDULE UPDATE MEETINGS

A. Engineer will schedule meetings throughout progress of the Work at maximum monthly intervals.

B. Engineer will make arrangements for meetings; Contractor will prepare agenda with copies for participants, and preside at meetings.

C. Attendance required: Owner, Engineer, Contractor, Contractor's Project Manager, General Superintendent, project scheduler, major subcontractors, and suppliers as appropriate to agenda topics for each meetings.

D. Additional invitees: Owner utility companies when the Work affects their interests and others necessary to the agenda.

E. Agenda:
   1. Review Monthly Schedule, (Actual Progress and Variance):
      a. "Activities Started/Completed" this period.
      b. "Activities Started/Completed" "Variance" Baseline vs. current.
      c. "Added/Deleted Activities".
      d. "Revised Activity Descriptions".
      e. Any significant Proposed Logic Changes.
   2. Review milestone "Substantial Completion" Schedule:
      a. "Critical" Activities - "Critical Area, Float and Vital Statistics".
   3. Review "Cumulative and Monthly Costs" graph.
   4. Review "Budgeted Cost" indicating the Current Project Budgeted Cost.

F. Contractor will record changes for update and distribute electronic copies within 7 calendar days after meeting to participants and interested parties.

1.07 QUALITY CONTROL MEETINGS

A. Contractor will schedule and administer meetings throughout progress of the Work at maximum weekly intervals.

B. Contractor will make arrangements for meetings, prepare agenda with copies for participants, and preside at meetings.

C. Attendance Required: Construction Manager and staff, Contractor's Quality Control Manager and staff.

D. Agenda:
   1. Review minutes of previous meetings.
   2. Review of Work progress and schedule.
   3. Review of out-of-compliance inspection or test results.
   4. Field observations, problems, and decisions.
   5. Review of offsite fabrication and delivery schedules.
   6. Planned progress during succeeding work period.
   7. Coordination of required inspections and tests.
   8. Review 6-week schedule report with upcoming inspections and special tests.
   9. Maintenance of quality and work standards.
   10. Other business relating to Work.

E. Contractor will record minutes and distribute electronic copies within 5 calendar days after meeting to participants, and those affected by decisions made.

1.08 PRE-SHUTDOWN MEETINGS

A. Follow Owner's standard Construction Method of Procedure (MOP). See Appendix A of Section 01140 - Work Restrictions for MOP format.

B. All short-term and longer-term shutdowns and other tie-ins that require an Owner approved MOP also require a pre-shutdown meeting at Project site prior to commencing shutdown for tie-in or modification of specific plant systems.

C. Require attendance of parties directly affecting, or affected by shutdown, including Engineer, specific work crews, Owner's construction, operations, and maintenance staff.

D. Notify Engineer no later than 7 calendar days in advance of meeting date.

E. Prepare agenda and preside at meeting:
   1. Review accepted MOP including conditions of shutdown, preparation, and installation procedures.
   2. Review timelines and sequences.
   3. Review responsibilities.
   4. Review dry run plan and schedule, as necessary.
   5. Review coordination with related work.

F. Contractor will record minutes and distribute copies within 5 calendar days after meeting and prior to scheduled shutdown to participants, with copies to Engineer, Owner, and those affected by decisions made.

1.09 COMMISSIONING COORDINATION MEETINGS

A. All processes and equipment that requires testing and process start-up also requires a pre-startup meeting at Project site before commencing process start-up of specific plant systems.

B. Require attendance of parties directly affecting, or affected by process start-up and testing, including Engineer, Commissioning Coordinator, specific work crews, Owner's construction operations, and maintenance staff.

C. Notify Engineer no later than 7 calendar days in advance of meeting date.

D. Prepare agenda:
   1. As specified in Section 01756 - Commissioning.
   2. Review accepted Construction Method of Procedure (MOP).
   3. Owner make final decision for GO or NO GO.

E. Preside at meeting.

F. Contractor will record minutes and distribute electronic copies within 5 calendar days after meeting and prior to scheduled process start-up to participants, with copies to Engineer, Owner, and those affected by decisions made:
   1. Follow Owner's standard Construction Method of Procedure (MOP). See Appendix A of Section 01140 - Work Restrictions for MOP format.

1.10 ELECTRICAL AND INSTRUMENTATION COORDINATION MEETINGS

A. Electrical Meetings:
   1. Pre-submittal review meeting as specified in Section 16050 - Common Work Results for Electrical.
   2. Electrical System Study Meetings (3 separate meetings) as specified in Section 16305 - Electrical System Studies.
   3. Other meetings as required and as otherwise specified.

B. Instrumentation and Control Meetings:
   1. Pre-Submittal Conference as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
   2. System Configuration Meetings (3 separate meetings) as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
   3. Graphics Meetings (2 separate meetings).
   4. Report Meetings (2 separate meetings).
   5. Other meetings as required and as otherwise specified.

1.11 CLOSE-OUT MEETING

A. Engineer will schedule close-out meeting.

B. Engineer will make arrangements for meeting, prepare agenda with copies for participants, and preside at meeting.

C. Attendance required: Owner, Engineer, Contractor, Contractor's Project Manager, and Superintendent.

D. Agenda:
   1. Review punch list completion.
   2. Transfer of record documents.
   3. Finalize payment.

E. Engineer will record minutes and within 5 calendar days after meeting distribute copies to participants.

1.12 POST CONSTRUCTION MEETING

A. Meet with and inspect the Work 11 months after date of Substantial Completion with Owner and Engineer.

B. Owner will arrange meeting at least 7 days before meeting.

C. Meet in Owner's office or other mutually agreed upon place.

D. Inspect the Work and draft list of items to be completed or corrected.

E. Review service and maintenance contracts and take appropriate corrective action when necessary.

F. Complete or correct defective work and extend correction period accordingly.

G. Require attendance of Contractor, Project Manager, or Superintendent, appropriate manufacturers and installers of major units of constructions, and affected subcontractors.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01321

SCHEDULES AND REPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Preparation, submittal, and maintenance of schedules and reports.

1.02 SUBMITTAL REQUIREMENTS

A. Submit preliminary and baseline schedule.

B. Submit preliminary and baseline schedule of values.

C. Submit preliminary and baseline schedule of submittals.

D. Submit, on a monthly basis, updated schedules as specified.

E. Submit final schedule update as specified.

F. Submit revised schedules and time impact analyses as specified.

G. Submit schedules in the media and number of copies as follows:
   1. Provide each submittal in PDF format and in other formats specified in this Section.
   2. 3 sets of the CPM network and/or bar chart (as specified by the Owner) on D-size sheets.
      a. Color-coding to be specified by the Owner.
   3. 3 sets of tabular reports listing all activities sorted numerically identifying duration, early start, late start, early finish, late finish, total float, and all predecessor/successor information.
   4. 2 sets of CPM Schedule data electronic files in a native backed-up file (.xer).

1.03 SCHEDULER

A. Designate, in writing and within 5 calendar days after Notice of Award, the person responsible for preparation, maintenance, updating, and revision of all schedules.

B. Qualifications of scheduler:
   1. Authority to act on behalf of Contractor.
   2. A minimum of 5 years verifiable experience in preparation of construction schedules for projects of similar value, size, and complexity.
   3. Knowledge of critical path method (CPM) scheduling utilizing Primavera P6 Professional or SureTrak or Microsoft Project software.

C. Owner reserves the right to disapprove scheduler when submitted by Contractor if not qualified.

D. Owner reserves the right to remove scheduler from the project if found to be unqualified.

1.04 SCHEDULING FORMAT AND SOFTWARE

A. Schedule format: Utilize CPM format.

B. Prepare computerized schedule utilizing Primavera P6 Professional or SureTrak or Microsoft Project software, most current version:
   1. Provide 1 licensed copy of the scheduling software to the engineer, registered in the Engineer's name, for the duration of the project.
   2. The provided copy of the software shall be a standalone version for installation on a standalone computer.

C. Contractor and Engineer must agree on the format.

1.05 PRECONSTRUCTION SCHEDULING MEETING

A. Engineer will conduct Preconstruction Scheduling Meeting with Contractor's Project Manager, General Superintendent, and scheduler within 7 calendar days after Notice to Proceed:
   1. This meeting is separate from the Preconstruction Conference Meeting and is intended to exclusively cover schedule issues.

B. At the meeting, review scheduling requirements:
   1. These include schedule preparation, reporting requirements, labor and equipment loading, updates, revisions, and schedule delay analysis.
   2. Present schedule methodology, planned sequence of operations, cost and resource loading methodology, and proposed activity coding structure.
   3. Naming convention: Name schedule files with the year, month and day of the data date, revision identifier, and a description of the schedule:
      a. Example 1: 2014_07_30 rev 1 draft baseline schedule.xer.
      b. Example 2: 2014_09_30 rev 2 sep final update.xer.

C. Filing: Post submitted files to Owner's construction document control system.

1.06 REVIEW AND ACCEPTANCE OF SCHEDULES

A. Engineer will review Baseline Schedule, Schedule Updates, Schedule Revisions and Time Impact Analyses to ascertain compliance with specified project constraints, compliance with milestone dates, reasonableness of durations and sequence, accurate inter-relationships, and completeness.

B. Engineer and Owner will issue written comments following completion of review of Baseline Schedule within 21 calendar days after receipt.

C. Written comments on review of Schedule Updates and Schedule Revisions and Time Impact Analyses will be returned to Contractor within 14 calendar days after receipt by Engineer.

D. Revise and resubmit schedule in accordance with Engineer's comments within 7 calendar days after receipt of such comments, or request joint meeting to resolve objections.

E. If Engineer requests a meeting, the Contractor and all major subcontractors must participate in the meeting with Engineer:
   1. Revise and resubmit schedule within 7 calendar days after meeting.

F. Use accepted schedule for planning, organizing, and directing the work and for reporting progress.

G. Engineer's submittal review response:
   1. When schedule reflects Owner's and Contractor's agreement of project approach and sequence, schedule will be accepted by Owner.
   2. Engineer's submittal review response for schedule submittal will be "Receipt Acknowledged - Filed for Record" including applicable comments.
   3. Acceptance of the schedules by the Owner is for general conformance with the Contract Documents and for Owner's planning information, and does not relieve the Contractor of sole responsibility for planning, coordinating, and executing the Work within the contract completion dates. Omissions and errors in the accepted schedules shall not excuse performance less than that required by the Contract Documents. Acceptance by the Owner in no way constitutes an evaluation or validation of the Contractor's plan, sequence or means, methods, and techniques of construction.

1.07 SCHEDULE UPDATES

A. Any update:
   1. Prepare update using most recent accepted version of schedule including:
      a. Actual start dates of activities that have been started.
      b. Actual finish dates of activities that have been completed.
      c. Percentage of completion of activities that have been started but not finished.
      d. Actual dates on which milestones were achieved.
      e. Update activities by inputting percent complete figures with actual dates.
      f. Use retained logic in preparing Schedule Updates.
      g. When necessary, input remaining durations for activities whose finish dates cannot be calculated accurately with a percent complete figure only.
      h. Revisions to the schedule may be included that have been previously approved as specified in this Section under Revisions to Schedule.

B. Monthly updates:
   1. Submit written narrative report in conjunction with each Schedule Update including descriptions of the following:
      a. Activities added to or deleted from the schedule are to adhere to cost and other resource loading requirements:
         1) Identify added activities in manner distinctly different from original activity designations.
      b. Changes in sequence or estimated duration of activities.
      c. Current or anticipated problems and delays affecting progress, impact of these problems and delays and measures taken to mitigate impact.
      d. Assumptions made and activities affected by incorporating change order work into the schedule.
   2. Submit updated schedule and materials specified under Submittal of Progress Schedules, 5 calendar days before the monthly schedule update meeting.

3. Since Monthly Schedule Update is the application for progress payment required as specified in Section 01294 - Applications for Payment, submittal and acceptance of the monthly Schedule Update is a condition precedent to the making of any progress payments.

C. Weekly progress meeting:
   1. Update the schedule prior to weekly progress meeting:
      a. Identify overall progress of each Major Item of Work in the Summary Schedule.
      b. If there are significant changes to the schedule, submit a written report at the weekly progress meeting.
   2. Should monthly Schedule Update show project completion earlier than current Contract completion date, show early completion time as schedule activity, identified as “Project Float”.
   3. Should monthly Schedule Update show project completion later than current Contract completion date, prepare and submit a Schedule Revision in accordance with the Revisions to Schedule.

1.08 REVISIONS TO SCHEDULE

A. Submit Revised Schedule within 5 days:
   1. When delay in completion of any activity or group of activities indicates an overrun of the Contract Time or milestone dates by 20 working days or 5 percent of the remaining duration, whichever is less.
   2. When delays in submittals, deliveries, or work stoppages are encountered making necessary the replanning or rescheduling of activities.
   3. When the schedule does not represent the actual progress of activities.
   4. When any change to the sequence of activities, the completion date for major portions of the work, or when changes occur which affect the critical path.
   5. When Contract modification necessitates schedule revision, submit schedule analysis of change order work with cost proposal.

B. Create a separate submittal for Schedule Revisions.
   1. Comply with schedule updates as specified in this Section.
   2. Do not submit with Schedule Updates.

C. Schedule Revisions will not be reflected in the schedule until after the revision is accepted by the Owner:
   1. This includes Schedule Revisions submitted for the purpose of mitigating a Contractor-caused project delay (Recovery Schedule).

1.09 ADJUSTMENT OF CONTRACT TIMES

A. Contract Time will be adjusted only for causes specified in Contract Documents.
   1. Non-excusable delay:
      a. Non-excusable delays include actions or inactions of the Contractor, or events for which the Contractor has assumed contractual responsibility (including actions or inactions of subcontractors, suppliers, or material manufacturers at any tier) that would independently delay the completion of the Work beyond the current Contract completion date).
      b. No time extensions will be granted for non-excusable delays.

2. Excusable delay:
    a. Events which are unforeseeable, outside the control of, and without the fault or negligence of either the Owner or the Contractor (or any party for whom either is responsible), which would independently delay the completion of the Work beyond the current Contract completion date.
    b. The Contractor is entitled to a time extension only.
    c. No other damages will be approved.
3. Compensable delay:
    a. Actions or inactions of the Owner, or events for which the Owner has assumed contractual responsibility, which would independently delay the completion of the Work beyond the current Contract completion date.
    b. The Contractor is entitled to a time extension and delay damages.
4. Concurrent delay:
    a. Concurrent delay is any combination of the above 3 types of delay occurring on the same calendar date.
    b. Exception to concurrent delay: Cases where the combination consists of 2 or more instances of the same type of delay occurring on the same calendar date. When one cause of delay is Owner-caused or caused by an event which is beyond the control and without the fault or negligence of either the Owner or the Contractor and the other Contractor-caused, the Contractor is entitled only to a time extension and no delay damages.

B. If the Contractor believes that the Owner has impacted its work, such that the project completion date will be delayed, the Contractor must submit proof demonstrating the delay to the critical path:
    1. This proof, in the form of a Time Impact Analysis, may entitle the Contractor to an adjustment of Contract Time.

C. Time Impact Analysis:
    1. Use the accepted schedule update that is current relative to the time frame of the delay event (change order, third party delay, or other Owner-caused delay). Represent the delay event in the schedule by:
        a. Inserting new activities associated with the delay event into the schedule.
        b. Revising activity logic.
        c. Revising activity durations.
    2. If the project schedule’s critical path and completion date are impacted as a result of adding this delay event to the schedule, a time extension equal to the magnitude of the impact may be warranted.
    3. The Time Impact Analysis submittal must include the following information:
        a. A fragment of the portion of the schedule affected by the delay event.
        b. A narrative explanation of the delay issue and how it impacted the schedule.
        c. A schedule file used to perform the Time Impact Analysis.

D. When a delay to the project as a whole can be avoided by revising preferential sequencing or logic, and the Contractor chooses not to implement the revisions, the Contractor will be entitled to a time extension and no compensation for extended overhead.

E. Indicate clearly that the Contractor has used, in full, all project float available for the work involved in the request, including any float that may exist between the Contractor's planned completion date and the Contract completion date.

1. Utilize the latest version of the Schedule Update accepted at the time of the alleged delay, and all other relevant information, to determine the adjustment of the Contract Time.

F. Adjustment of the Contract Times will be granted only when the Contract Float has been fully utilized and only when the revised date of completion of the Work has been pushed beyond the Contract completion date:
   1. Adjustment of the Contract Times will be made only for the number of days that the planned completion of the work has been extended.

G. Actual delays in activities which do not affect the critical path work or which do not move the Contractor's planned completion date beyond the Contract completion date will not be the basis for an adjustment to the Contract Time.

H. If completion of the project occurs within the specified Contract Time, the Contractor is not entitled to job-site or home office overhead beyond the Contractor's originally planned occupancy of the site.

I. Notify Engineer of a request for Contract Time adjustment:
   1. Submit request as specified with Contract Documents.
   2. In cases where the Contractor does not submit a request for Contract Time adjustment for a specific change order, delay, or Contractor request within the specified period of time, then it is mutually agreed that the particular change order, delay, or Contractor request has no time impact on the Contract completion date and no time extension is required.

J. The Engineer will, within 30 calendar days after receipt of a Contract Time adjustment, request any supporting evidence, review the facts, and advise the Contractor in writing:
   1. Include the new Progress Schedule data, if accepted by the Owner, in the next monthly Schedule Update.
   2. When the Owner has not yet made a final determination as to the adjustment of the Contract Time, and the parties are unable to agree as to the amount of the adjustment to be reflected in the Progress Schedule, reflect that amount of time adjustment in the Progress Schedule as the Engineer may accept as appropriate for such interim purpose.
   3. It is understood and agreed that any such interim acceptance by the Engineer shall not be binding and shall be made only for the purpose of continuing to schedule the Work, until such time as a final determination as to any adjustment of the Contract Time acceptable to the Engineer has been made.
   4. Revise the Progress Schedule prepared thereafter in accordance with the final decision.

1.10 SCHEDULE PREPARATION

A. Preparation and submittal of Progress Schedule represents Contractor's intention to execute the Work within specified time and constraints:
   1. Failure to conform to requirement may result in termination for cause.

B. Contractor's bid covers all costs associated with the execution of the Work in accordance with the Progress Schedule.

C. During preparation of the preliminary Progress Schedule, Engineer will facilitate Contractor's efforts by being available to answer questions regarding sequencing issues, scheduling constraints, interface points, and dependency relationships.

D. Prepare schedule utilizing Precedence Diagramming Method (PDM).

E. Prepare schedule utilizing activity durations in terms of working days:
   1. Do not exceed 15 working day duration on activities except concrete curing, submittal review, and equipment fabrication and deliveries.
   2. Where duration of continuous work exceeds 15 working days, subdivide activities by location, stationing, or other sub-element of the Work.
   3. Coordinate holidays to be observed with the Owner and incorporate them into the schedule as non-working days.

F. Failure to include an activity required for execution of the Work does not excuse Contractor from completing the Work and portions thereof within specified times and at price specified in Contract:
   1. Contract requirements are not waived by failure of Contractor to include required schedule constraints, sequences, or milestones in schedule.
   2. Contract requirements are not waived by Owner’s acceptance of the schedule. In event of conflict between accepted schedule and Contract requirements, terms of Contract govern at all times, unless requirements are waived in writing by the Owner.

G. Reference schedule to working days with beginning of Contract Time as Day "1".

H. Baseline Schedule and Project Completion:
   1. Should Contractor submit a Baseline Schedule showing project completion more than 20 working days prior to Contract completion date, Owner may issue Change Order, at no cost to Owner, revising time of performance of Work and Contract completion date to match Contractor’s schedule completion date.
   2. Adjust accordingly any Contract milestone dates.

I. Imposed dates, hidden logic prohibited: Do not use imposed dates or hidden logic in preparation of schedule.

J. Interim milestone dates, operational constraints:
   1. In event there are interim milestone dates and/or operational constraints set forth in Contract, show them on schedule.
   2. Do not use Zero Total Float constraint or Mandatory Finish Date on such Contract requirements.

K. Cost loading: All schedules:
   1. Only on-site construction activities.
   2. The sum total of all cost loaded activities equal to the current value of the Contract, including change orders, at all times.
   3. Owner acceptance of the Baseline Schedule creates the Schedule of Values required as specified in Section 01292 - Schedule of Values
   4. Provide updated Schedule of Values as the monthly Payment Application as specified in Section 01294 - Applications for Payment.
   5. Payments will not be made until updated Schedule of Values is accepted.

1.11 NETWORK DETAILS AND GRAPHICAL OUTPUT

A. Produce a clear, legible, and accurate calendar based, time scaled, and graphical network diagram:
   1. Group activities related to the same physical areas of the Work. Produce the network diagram based upon the early start of all activities.

B. Include for each activity, the description, activity number, estimated duration in working days, total float, and all activity relationship lines.

C. Illustrate order and interdependence of activities and sequence in which Work is planned to be accomplished:
   1. Incorporate the basic concept of the precedence diagram network method to show how the start of 1 activity is dependent upon the start or completion of preceding activities and its completion restricts the start of following activities.

D. Indicate the critical path for the project.

E. Delineate the specified contract duration and identify the planned completion of the Work as a milestone:
   1. Show the time period between the planned and Contract completion dates, if any, as an activity identified as project float unless a Change Order is issued to officially change the Contract completion date.

F. Identify system shutdown dates, system tie-in dates, specified interim completion or milestone dates and contract completion date as milestones.

G. Include, in addition to construction activities:
   1. Submission dates and review periods for major equipment submittals, shoring submittals, and indicator pile program:
      a. Shoring reviews: Allow 4-week review period for each shoring submittal.
      b. Pile indicator program: Allow 3-week review period for analysis of program.
   2. Any activity by the Owner or the Engineer that may affect progress or required completion dates.
   3. Equipment and long-lead material deliveries over 8 weeks.
   4. Approvals required by regulatory agencies or other third parties.

H. Produce network diagram on 22-inch by 34-inch sheets with grid coordinate system on the border of all sheets utilizing alpha and numeric designations.

I. Identify the execution of the following:
   1. Mobilization.
   2. All required submittals and submittal review times showing 30 calendar day duration for such activities and equal amount of time for re-submittal reviews.
   3. Equipment and materials procurement/fabrication/delivery.
   4. Excavation.
   5. Shoring design and submission of detailed shoring submittals. Identify submission as a milestone.
   6. Shoring review, shoring materials procurement, shoring installation, and shoring removal.
   7. Piles.
   8. Backfill and compaction.

9. Dewatering.
10. Grading, subbase, base, paving, and curb and gutters.
11. Fencing and landscaping.
12. Concrete, including installation of forms and reinforcement, placement of concrete, curing, stripping, finishing, and patching.
13. Masonry.
14. Metal fastenings, framing, structures, and fabrications.
15. Waterproofing and dampproofing, insulation, roofing and flashing, and sealants.
16. Doors and windows, including hardware and glazing.
17. Finishes including coating and painting, flooring, ceiling, and wall covering.
18. Process equipment, including identification of ordering lead-time, factory testing, and installation.
19. Pumps and drives, including identification of ordering lead time, factory testing, and installation.
20. Conveying equipment including hoists and cranes, conveyor systems, and materials handling equipment, including identification of ordering lead-time and installation.
21. Other mechanical equipment including fans and heating, ventilating, and air conditioning equipment.
22. Trenching, pipe laying, and trench backfill and compaction.
23. Piping, fittings, and appurtenances, including identification of ordering and fabrication lead time, layout, installation and testing.
24. Valves, gates, and operators, including identification of order lead-time, installation, and testing.
25. Plumbing specialties.
26. Electric transmission, service, and distribution equipment, including identification of ordering lead-time, and factory testing.
27. Other electrical work including lighting, heating and cooling, and special systems, including identification of ordering lead-time.
28. Instrumentation and controls, including identification of ordering lead-time.
29. Preliminary testing of equipment, instrumentation, and controls.
30. Commissioning Phase:
    a. Source Testing.
    b. Owner Training.
    c. Installation Testing.
    d. Functional Testing.
    e. Clean Water Facility Testing.
31. Process Start-up Phase:
    a. Process Start-up.
    b. Process Operational Period.
    c. Instrumentation and Controls Performance Testing.
32. Substantial completion.
33. Punch list work.
34. Demobilization.

1.12 WEATHER DAY ALLOWANCE

A. Definition:
    1. Weather conditions that prevent or inhibit the Contractor's performance of the Work and affect the Critical Path indicated on the Schedule shall be referred to as a Weather Day.

2. A Weather Day is defined as the Contractor being unable to perform at least 4 hours of work on the Critical Path.

B. Allowance:
   1. Include as a separate identifiable activity on the critical path, an activity labeled "Weather Days Allowance".

C. Actual weather day:
   1. Insert a weather delay activity in critical path to reflect actual weather day occurrences when weather days are experienced and accepted by Engineer.
   2. Reduce duration of Weather Days Allowance activity as weather delays are experienced and inserted into the Schedule. Remaining weather days in Weather Day Allowance at completion of project is considered float.
   3. The Contractor shall provide a written notice to the Engineer of the occurrence of a weather day within 2 days after the onset of such weather and shall describe in reasonable detail the type of weather encountered and the Work interfered with or interrupted:
      a. A schedule update will not suffice as a written notice.
      b. The Engineer will determine if the weather day constitutes a use of a portion of the Weather Day Allowance.
      c. After use of all the Weather Day Allowance, the Engineer will determine if the Contractor is entitled to an extension of the Contract Time due to weather conditions.
      d. Weather days are considered excusable delay as defined in this Section.

1.13 SCHEDULE OF SUBMITTALS

A. Schedule of Submittals shall include submittals required in the Contract Documents but not limited to Commissioning Plans, Training Plans, test procedures, operation and maintenance manuals, shop drawings, samples, record documents, and specifically required certificates, warranties, and service agreements.

B. Preliminary Schedule of Submittals:
   1. Due date: After Preliminary Schedule has been submitted and accepted by Owner.
   2. Format:
      a. Include submittals anticipated in the first 90 calendar days after Notice to Proceed using early start dates.
      b. Indicate week and month anticipated for each submittal.
      c. Indicate “Priority” submittals where review time can impact Contractor’s schedule:
         1) “Priority” indication will not alter review times specified in Section 01330 - Submittal Procedures.
         2) Engineer will endeavor to provide early review of “Priority” submittals where possible.
   3. Submittal of Preliminary Schedule of Submittals shall be a condition precedent to Owner making progress payments during the first 90 calendar days after Notice to Proceed.

C. Final Schedule of Submittals:
   1. Due date: After Baseline Schedule has been submitted and accepted by Owner.

2. Format:
    a. Include submittals using early start dates.
    b. Include all submittals, including those required in the Preliminary Schedule of Submittals.
    c. Indicate week and month anticipated for each submittal.
    d. Indicate “Priority” submittals where review time can impact Contractor’s schedule:
        1) “Priority” indication will not alter review times specified in Section 01330 - Submittal Procedures.
        2) Engineer will endeavor to provide early review of “Priority” submittals where possible.
3. Submittal of Final Schedule of Submittals shall be a condition precedent to Owner making progress payments after the first 90 calendar days after Notice to Proceed.

D. Provide updated Schedule of Submittals with updated schedules if schedule revisions change listing and timing of submittals.

1.14 BASELINE SCHEDULE AND BASELINE SCHEDULE OF VALUES

A. Due date: No more than 45 calendar days after Notice to Proceed.

B. Format:
1. Schedule: Show sequence and interdependence of all activities required for complete performance of all Work, beginning with date of Notice to Proceed and concluding with date of final completion of Contract.
2. Schedule of Values: As specified in Section 01292 - Schedule of Values.

1.15 SUMMARY SCHEDULE

A. Due date: At weekly progress meetings and after each Schedule Update or Schedule Revision.

B. Format:
1. Consolidate groups of activities associated with Major Items of Work shown on Baseline Schedule.
2. intended to give an overall indication of the project schedule without a large amount of detail.

1.16 COST FLOW SUMMARY

A. Due date: After Baseline Schedule has been submitted and accepted by the Owner, submit on a monthly basis as specified in Section 01294 - Applications for Payment.

B. Format:
1. Tabular and graphic report showing anticipated earnings each month of the Contract period.
2. Base tabulation on the summation of the cost-loaded activities each month.
3. Show planned amounts.
4. Show actual earned amounts and anticipated remaining earnings.
5. Spreadsheet format of all schedule activities showing cost and percentage completion during the current month for which payment is sought.

1.17 PROGRESS SCHEDULE AND UPDATED SCHEDULE OF VALUES

A. Due date: Submit on a monthly basis as specified in Section 01294 - Applications for Payment.

B. Format: Schedule of Values: As specified in Section 01292 - Schedule of Values.

1.18 WEEKLY SCHEDULE

A. Due date: At every weekly progress meeting.

B. Format:
   1. Contractor and Engineer must agree on the format.
   2. 6-Week Schedule showing the activities completed during the previous week and the Contractor's schedule of activities for following 5 weeks.
   3. Use the logic and conform to the status of the current progress schedule when producing a Weekly Schedule in CPM schedule or a bar chart format:
      a. In the event that the Weekly Schedule no longer conforms to the current schedule, Contractor may be required to revise the schedule as specified in this Section.
   4. The activity designations used in the Weekly Schedule must be consistent with those used in the Baseline Schedule and the monthly Schedule Updates.

1.19 MANPOWER SCHEDULE

A. Due date: With progress payments after Baseline Schedule has been submitted and accepted by Owner.

B. Format:
   1. Schedule histogram depicting total craft manpower and craft manpower for Contractor's own labor forces and those of each subcontractor.
   2. Submit electronically in Excel format, with 1 paper copy.

C. Progress payments after the first 90 calendar days after Notice to Proceed will not be made until manpower schedule is provided.

1.20 FINAL SCHEDULE

A. The final Schedule Update becomes the As-Built Schedule:
   1. The As-Built Schedule reflects the exact manner in which the project was constructed by reflecting actual start and completion dates for all activities accomplished on the project.
   2. Contractor's Project Manager and scheduler sign and certify the As-Built Schedule as being an accurate record of the way the project was actually constructed.

B. Retainage will not be released until final Schedule Update is provided.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01322

WEB BASED CONSTRUCTION DOCUMENT MANAGEMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for web-based construction document management.

1.02 REQUIREMENTS

A. Owner, Engineer, and Contractor shall utilize EADOC (EADOC is a registered trademark of EADOC LLC). For submission of all data and documents (unless specified otherwise in this Section) throughout the duration of the Contract:
   1. EADOC is a web-based electronic media site hosted by EADOC LLC.
   2. EADOC is available to all Contractor's personnel, subcontractor personnel, suppliers, consultants, Owner, and Engineer at no cost.
   3. The joint use of this system is to facilitate electronic exchange of information, automation of key processes, and overall management of Contract Documentation.
   4. EADOC shall be the primary means of project information submission and management.

1.03 USER ACCESS LIMITATIONS

A. Provide a list of Contractor's key EADOC personnel for the Engineer's acceptance. The Engineer reserves the right to perform a security check on all potential users. The Contractor will be allowed to add additional personnel and subcontractors to EADOC.

B. The Engineer will grant initial access to EADOC by creating user profiles to accepted Contractor personnel. User profiles will define levels of access into the system; determine assigned function based authorizations and user privileges. Subcontractors and suppliers will be given access to EADOC by and through the Contractor. Contractor is responsible for adding and removing users from the system after the initial setup by the Engineer.

1.04 JOINT OWNERSHIP OF DATA

A. Data entered in a collaborative mode (entered with the intent to share as determined by permissions and workflows within the EADOC system) by Engineer and Contractor will be jointly owned.

1.05 AUTOMATED SYSTEM NOTIFICATION AND AUDIT LOG TRACKING

A. Review comments made (or lack thereof) by Owner on Contractor submitted documentation shall not relieve Contractor from compliance with requirements of the Contract Documents. Contractor is responsible for managing, tracking, and documenting the Work to comply with the requirements of the Contract Documents. Owner's acceptance via automated system notifications or audit logs extends only to the face value of the submitted documentation and does not constitute validation of the Contractor's submitted information.

1.06 COMPUTER REQUIREMENTS

A. Contractor shall use computer hardware and software that meets the requirements of the EADOC system as recommended by EADOC LLC to access and utilize EADOC. As recommendations are modified by EADOC, Contractor will upgrade their system(s) to meet or exceed the recommendations. Upgrading of Contractor's computer systems will not be justification for a cost or time modification to the Contract.

B. Contractor shall ensure that connectivity to the EADOC system is accomplished through DSL, cable, T-1 or wireless communications systems. The minimum bandwidth requirements for using the system is 128 kb/s. It is recommended a faster connection be used when uploading pictures and files into the system.

C. EADOC supports the current and prior 2 major versions of Chrome, Mozilla's Firefox, Microsoft's Internet Explorer and Apple's Safari on a rolling basis:
   1. Each time a new version of one of these browsers is released, EADOC will begin supporting the update and stop supporting the fourth-oldest version.

1.07 CONTRACTOR RESPONSIBILITY

A. Contractor shall be responsible for the validity of their information placed in EADOC and for the abilities of their personnel.

B. Entry of information exchanged and transferred between the Contractor and its subcontractors and suppliers on EADOC shall be the responsibility of the Contractor.

C. Accepted users shall be knowledgeable in the use of computers, including Internet Browsers, email programs, cad drawing applications, and Adobe Portable Document Format (PDF) document distribution program.

D. Contractor shall utilize the existing forms in EADOC to the maximum extent possible. If a form does not exist in EADOC the Contractor must include a form of their own or provided by Engineer as an attachment to a submittal.

E. Adobe PDF documents will be created through electronic conversion rather than optically scanned whenever possible. Contractor is responsible for the training of their personnel in the use of EADOC (outside what is provided by Owner) and the other programs indicated above as needed.

1.08 TRAINING

A. The Owner has arranged and paid for web-based training on EADOC for the Contractor.

B. Contractor shall arrange and pay for the facilities and hardware/software required to facilitate Contractor's training.

PART 2 PRODUCTS

2.01 DESCRIPTION

A. EADOC project management application (no equal). Provided by EADOC LLC, www.EADOCsoftware.com.

PART 3 EXECUTION

3.01 EADOC UTILIZATION

A. EADOC shall be utilized in connection with all document and information management required by these Contract Documents.

3.02 SUBMITTALS

A. Use EADOC for submittals.

B. Content: As specified in Section 01330 - Submittal Procedures.

C. Format: As specified in Section 01330 - Submittal Procedures.

D. Submit Portable Document Format (PDF) documents to the EADOC submittal work flow process and forms:
   1. Consolidate electronic format submittals with multiples pages into a single file.

E. Hardcopy submittals:
   1. Contractor shall provide 3 hard copies of submittals within 14 days of the Submittal being closed.
   2. Hardcopy requirements as specified in Section 01330 - Submittal Procedures.

F. Samples:
   1. Contractor shall enter submittal data information into EADOC.
   2. Attach a copy of the submittal form(s) to the sample.

G. Record and Closeout Submittals:
   1. Operation and maintenance data as specified in Section 01782 - Operation and Maintenance Manuals.
   2. Extra materials, spare parts, etc.

3.03 REQUESTS FOR INFORMATION/INTERPRETATION (RFI)

A. Use EADOC for RFIs.

3.04 OFFICIAL CORRESPONDENCE

A. Use EADOC for memos, notices, change proposals, or any official correspondence.

3.05 INSPECTION REQUESTS

A. Use EADOC to request inspection for a portion of Work that is ready for inspection and prior to covering up the Work.

3.06 FINANCIAL SUBMITTALS

A. Use EADOC for financial submittals as specified in Section 01330 - Submittal Procedures.

3.07 OTHER

A. Use EADOC for daily reports, meeting agendas and minutes, and other construction documents.

END OF SECTION

SECTION 01330

SUBMITTAL PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements and procedures for submittals.

1.02 GENERAL INSTRUCTIONS

A. Contractor is responsible to determine and verify field measurements, field construction criteria, materials, dimensions, catalog numbers and similar data, and check and coordinate each item with other applicable approved shop drawings and Contract Document requirements.

B. Provide submittals:
   1. That are specified or reasonably required for construction, operation, and maintenance of the Work.
   2. That demonstrate compliance with the Contract Documents.

C. Where multiple submittals are required, provide a separate submittal for each specification section:
   1. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
      a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section.
      b. For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.

D. Prepare submittals in the English language. Do not include information in other languages.

E. Present measurements in customary American units (feet, inches, pounds, etc.).

F. Must be clear and legible, and of sufficient size for presentation of information.

G. Page size other than drawings:
   1. Minimum page size will be 8 1/2 inches by 11 inches:
   2. Maximum page size will be 11 inches by 17 inches.

H. Drawing sheet size:
   1. Maximum sheets size: 22-inch by 34-inch:
      a. Minimum plan scale: 1/8-inch equals 1 foot-0 inches.
      b. Minimum font size: 1/8 inch minimum.

2. 11-inch by 17-inch sheet:
    a. Minimum plan scale: 1/8-inch equals 1 foot-0 inches.
    b. Minimum font size: 1/8 inch minimum.

I. If submittal is more than 80 pages, additionally provide hardcopy.

J. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.

K. Provide submittal information from only 1 manufacturer for a specified product. Submittals with multiple manufacturers for 1 product will be rejected without review.

1.03 SUBMITTAL ORGANIZATION

A. Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.

B. For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is used.

C. Bookmarks:
1. Bookmarks shall match the table of contents.
2. Bookmark each section (tab) and heading.
3. Drawings: Bookmark at a minimum, each discipline, area designation, or appropriate division.
4. At file opening, display all levels of bookmarks as expanded.

D. Where applicable (i.e. except for drawings, figures, etc.) submittal content shall be electronically searchable utilizing the PDF file as submitted.

E. Thumbnails optimized for fast web viewing.

F. Sequentially number pages within the tabbed sections:
1. Submittals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.

G. Attachments:
1. Specification section: Include with each submittal a copy of the relevant specification section:
    a. Indicate in the left margin, next to each pertinent paragraph, either compliance with a check (√) or deviation with a consecutive number (1, 2, 3).
    b. Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
2. Drawings: Include with each submittal a copy of the relevant Drawing, including relevant addendum updates:
    a. Indicate either compliance with a check (√) or deviation with a consecutive number (1, 2, 3).
    b. Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
    c. Provide field dimensions and relationship to adjacent or critical features of the Work or materials.

H. Contractor: Prepare submittal information in sufficient detail to show compliance with specified requirements:
   1. Determine and verify quantities, field dimensions, product dimensions, specified design and performance criteria, materials, catalog numbers, and similar data.
   2. Coordinate submittal with other submittals and with the requirements of the Contract Documents.
   3. Check, verify, and revise submittals as necessary to bring them into conformance with Contract Documents and actual field conditions.

I. Contractor: Prepare “Or Equal” submittal information:
   1. Provide standard submittal requirements:
      a. In addition, provide in sufficient detail to show reason for variance from specified product and impacts.
   2. Provide reason the specified product is not being provided.
   3. Explain the benefits to the Owner for accepting the “Or Equal”.
   4. Itemized comparison of the proposed “Or Equal” with product specified including a list of significant variations:
      a. Design features.
      b. Design dimensions.
      c. Installation requirements.
      d. Operations and maintenance requirements.
      e. Availability of maintenance services and sources of replacement materials.
   5. Reference projects where the product has been successfully used:
      a. Name and address of project.
      b. Year of installation.
      c. Year placed in operation.
      d. Name of product installed.
      e. Point of contact: Name and phone number.
   6. Define impacts:
      a. Impacts to other contracts.
      b. Impacts to other work or products.
   7. Contractor represents the following:
      a. Contractor bears the burden of proof of the equivalency of the proposed “Or Equal”.
      b. Proposed “Or Equal” is equal or superior to the specified product.
      c. Contractor will provide the warranties or bonds that would be provided on the specified product on the proposed “Or Equal”, unless Owner requires a Special Warranty.
      d. Contractor will coordinate installation of accepted “Or Equal” into the Work and will be responsible for the costs to make changes as required to the Work.
      e. Contractor waives rights to claim additional costs caused by proposed “Or Equal” which may subsequently become apparent.

J. Contractor: Prepare substitution submittal information:
   1. Provide standard submittal requirements:
      a. In addition, provide in sufficient detail to show reason for variance from specified product and impacts.
   2. Provide reason the specified product is not being provided.
   3. Explain the benefits to the Owner for accepting the substitution.

4. Itemized comparison of the proposed substitution with product specified including a list of significant variations:
    a. Design features.
    b. Design dimensions.
    c. Installation requirements.
    d. Operations and maintenance requirements.
    e. Availability of maintenance services and sources of replacement materials.
5. Reference projects where the product has been successfully used:
    a. Name and address of project.
    b. Year of installation.
    c. Year placed in operation.
    d. Name of product installed.
    e. Point of contact: Name and phone number.
6. Define impacts:
    a. Impacts to Contract Price:
        1) Required license fees or royalties.
        2) Do not include costs under separate contracts.
        3) Do not include Engineer's costs for redesign or revision of Contract Documents.
    b. Impacts to Contract Time.
    c. Impacts to Contract Scope.
    d. Impacts to other contracts.
    e. Impacts to other work or products.
7. Contractor represents the following:
    a. Contractor shall pay associated costs for Engineer to evaluate the substitution.
    b. Contractor bears the burden of proof of the equivalency of the proposed substitution.
    c. Proposed substitution does not change the design intent and will have equal performance to the specified product.
    d. Proposed substitution is equal or superior to the specified product.
    e. Contractor will provide the warranties or bonds that would be provided on the specified product on the proposed substitution, unless Owner requires a Special Warranty.
    f. Contractor will coordinate installation of accepted substitution into the Work and will be responsible for the costs to make changes as required to the Work.
    g. Contractor waives rights to claim additional costs caused by proposed substitution which may subsequently become apparent.

1.04 SUBMITTAL METHOD AND FORMAT

A. Submittal identification numbering:
    1. Number each submittal using the format defined below:

	Spec Section Number	Dash	Initial Submittal - Sequential Number	Decimal Point	Subsequent Submittal Revisions Sequential Number
Example 1 Description	*Cast-In-Place Concrete*		*8th initial submittal*		
	03300	-	0008		
Example 2 Description	*Cast-In-Place Concrete*		*8th initial submittal*		*First revision to the 8th initial submittal*
	03300	-	0008	.	1

B. Submittals in electronic media format:
   1. General: Provide all information in PC-compatible format using Windows® operating system as utilized by the Owner and Engineer.
   2. Text: Provide text documents and manufacturer's literature in Portable Document Format (PDF).
   3. Graphics: Provide graphic submittals (drawings, diagrams, figures, etc.) utilizing Portable Document Format (PDF).
   4. Contractor using other software shall be required to provide to the Engineer conclusive evidence of 100-percent data transfer compatibility**.**

1.05 SUBMITTAL PROCEDURE

A. Engineer: Review submittal and provide response:
   1. Review description:
      a. Engineer will be entitled to rely upon the accuracy or completeness of designs, calculations, or certifications made by licensed professionals accompanying a particular submittal whether or not a stamp or seal is required by Contract Documents or Laws and Regulations.
      b. Engineer's review of submittals shall not release Contractor from Contractor's responsibility for performance of requirements of Contract Documents. Neither shall Engineer's review release Contractor from fulfilling purpose of installation nor from Contractor's liability to replace defective work.
      c. Engineer's review of shop drawings, samples, or test procedures will be only for conformance with design concepts and for compliance with information given in Contract Documents.
      d. Engineer's review does not extend to:
         1) Accuracy of dimensions, quantities, or performance of equipment and systems designed by Contractor.
         2) Contractor's means, methods, techniques, sequences, or procedures except when specified, indicated on the Drawings, or required by Contract Documents.
         3) Safety precautions or programs related to safety which shall remain the sole responsibility of the Contractor.
      e. Engineer can Approve or Not Approve any exception at their sole discretion.

2. Review timeframe:
    a. Except as may be provided in technical specifications, a submittal will be returned within 30 days.
    b. When a submittal cannot be returned within the specified period, Engineer will, within a reasonable time after receipt of the submittal, give notice of the date by which that submittal will be returned.
    c. Engineer's acceptance of progress schedule containing submittal review times less than those specified or agreed to in writing by Engineer will not constitute Engineer's acceptance of review times.
    d. Critical submittals:
        1) Contractor will notify Engineer in writing that timely review of a submittal is critical to the progress of Work.
3. Schedule delays:
    a. No adjustment of Contract Times or Contract Price will be allowed due to Engineer's review of submittals, unless all of the following criteria are met:
        1) Engineer has failed to review and return first submission within the agreed upon time frame.
        2) Contractor demonstrates that delay in progress of Work is directly attributable to Engineer's failure to return submittal within time indicated and accepted by Engineer.
4. Review response will be returned to Contractor with one of the following dispositions:
    a. Approved:
        1) No Exceptions:
            a) There are no notations or comments on the submittal and the Contractor may release the equipment for production.
        2) Make Corrections Noted - See Comments:
            a) The Contractor may proceed with the work, however, all notations and comments must be incorporated into the final product.
            b) Resubmittal not required.
        3) Make Corrections Noted - Confirm:
            a) The Contractor may proceed with the work, however, all notations and comments must be incorporated into the final product.
            b) Submit confirmation specifically addressing each notation or comment to the Engineer within 15 calendar days of the date of the Engineer's transmittal requiring the confirmation.
    b. Not approved:
        1) Correct and resubmit:
            a) Contractor may not proceed with the work described in the submittal.
            b) Contractor assumes responsibility for proceeding without approval.
            c) Resubmittal of complete submittal package is required within 30 calendar days of the date of the Engineer's submittal review response.
        2) Rejected - See Remarks:
            a) Contractor may not proceed with the work described in the submittal.

b) The submittal does not meet the intent of the Contract Documents. Resubmittal of complete submittal package is required with materials, equipment, methods, etc. that meet the requirements of the Contract Documents.

c. Receipt acknowledged - Filed for record:
   1) This is used in acknowledging receipt of informational submittals that address means and methods of construction such as schedules and work plans, conformance test reports, health and safety plans, etc.

d. Receipt acknowledged with comments - Resubmit:
   1) This is used in acknowledging receipt of informational submittals that address means and methods of construction such as schedules and work plans, conformance test reports, health and safety plans, etc. Feedback regarding missing information, conflicting information, or other information that makes it incomplete can be made with comments.

B. Contractor: Prepare resubmittal, if applicable:
   1. Clearly identify each correction or change made.
   2. Include a response in writing to each of the Engineer's comments or questions for submittal packages that are resubmitted in the order that the comments or questions were presented throughout the submittal and numbered consistent with the Engineer's numbering:
      a. Acceptable responses to Engineer's comments are listed below:
         1) "Incorporated" Engineer's comment or change is accepted and appropriate changes are made.
         2) "Response" Engineer's comment not incorporated. Explain why comment is not accepted or requested change is not made. Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
      b. Reviews and resubmittals:
         1) Contractor shall provide resubmittals which include responses to all submittal review comments separately and at a level of detail commensurate with each comment.
         2) Contractor responses shall indicate how the Contractor resolved the issue pertaining to each review comment. Responses such as "acknowledged" or "noted" are not acceptable.
         3) Resubmittals which do not comply with this requirement may be rejected and returned without review.
         4) Contractor shall be allowed no extensions of any kind to any part of their contract due to the rejection of non-compliant submittals.
         5) Submittal review comments not addressed by the Contractor in resubmittals shall continue to apply whether restated or not in subsequent reviews until adequately addressed by the Contractor to the satisfaction of the reviewing and approving authority.
      c. Any resubmittal that does not contain responses to the Engineer's previous comments shall be returned for Revision and Resubmittal. No further review by the Engineer will be performed until a response for previous comments has been received.
   3. Resubmittal timeframe:
      a. Contractor shall provide resubmittal within 15 days.
      b. When a resubmittal cannot be returned within the specified period, Contractor shall notify Engineer in writing.

4. Review costs:
    a. Costs incurred by Owner as a result of additional reviews of a particular submittal after the second time it has been reviewed shall be borne by Contractor.
    b. Reimbursement to Owner will be made by deducting such costs from Contractor's subsequent progress payments.

1.06 PRODUCT DATA

A. Edit submittals so that the submittal specifically applies to only the product furnished.

B. Neatly cross out all extraneous text, options, models, etc. that do not apply to the product being furnished, so that the information remaining is only applicable to the product being furnished.

1.07 SHOP DRAWINGS

A. Contractor to field verify elevation, coordinates, and pipe material for pipe tie-in to pipeline or structure prior to the preparation of shop drawings.

B. Indicate project designated equipment tag numbers for submittal of devices, equipment, and assemblies.

1.08 SAMPLES

A. Details:
    1. Submit labeled samples.
    2. Samples will not be returned.
    3. Provide number of sample submittals as below:
        a. Total: 3 minimum.
            1) Owner: 1.
            2) Engineer: 2.
            3) Contractor: None.

PART 1 PRODUCTS

Not Used.

PART 2 EXECUTION

Not Used.

APPENDIX B

CONTRACTOR SUBMITTAL TRANSMITTAL FORM

DOCUMENT 01330
CONTRACTOR SUBMITTAL TRANSMITTAL FORM

Owner:	Click here to enter text.	**Date:**	MM/DD/YYYY
Contractor:	Click here to enter text.	**Project No.:**	XXXXX.XX
Project Name:	Click here to enter text.	**Submittal Number:**	000
Submittal Title:	Click here to enter text.		
To:	Click here to enter text.		
From:	Click here to enter text.	Click here to enter text.	
	Click here to enter text.	Click here to enter text.	

Specification No. and Subject of Submittal / Equipment Supplier			
Spec ##:	Spec ##.	**Subject:**	Click here to enter text.
Authored By:	Click here to enter text.	**Date Submitted:**	XX/XX/XXXX

Submittal Certification
Check Either (A) or (B):
☐ (A) We have verified that the equipment or material contained in this submittal meets all the requirements specified in the project manual or shown on the contract drawings with no exceptions.
☐ (B) We have verified that the equipment or material contained in this submittal meets all the requirements specified in the project manual or shown on the contract drawings except for the deviations listed.
Certification Statement: By this submittal, I hereby represent that I have determined and verified all field measurements, field construction criteria, materials, dimensions, catalog numbers and similar data, and I have checked and coordinated each item with other applicable approved shop drawings and all Contract requirements.
General Contractor's Reviewer's Signature:
Printed Name:
In the event, Contractor believes the Submittal response does or will cause a change to the requirements of the Contract, Contractor shall immediately give written notice stating that Contractor considers the response to be a Change Order.
Firm: Click here to enter text. **Signature:** **Date Returned:** XX/XX/XXXX

PM/CM Office Use	
Date Received GC to PM/CM:	
Date Received PM/CM to Reviewer:	
Date Received Reviewer to PM/CM:	
Date Sent PM/CM to GC:	

END OF SECTION

SECTION 01354

HAZARDOUS MATERIAL PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Procedures required when encountering hazardous materials at the Work site.

1.02 REFERENCES

A. California Code of Regulations (CCR):
   1. Title 8: Industrial Relations.
   2. Title 22 Division 4.5: Environmental Health Standards for the Management of Hazardous Waste.

B. California Occupational Safety and Health Administration (Cal-OSHA).

C. Occupational Safety and Health Administration (OSHA).

D. United States Code of Federal Regulation (CFR):
   1. Title 29 - Labor:
      a. 1926.62 - Lead.
   2. Title 40 - Protection of Environment:
      a. 261 - Identification and Listing of Hazardous Waste.

1.03 SUBMITTALS

A. Submit laboratory reports, hazardous material removal plans, and certifications.

B. Submit the following work plan:
   1. Removal and Legal Disposal of Asbestos Cement Pipe Plan.
      a. Work plan shall include, but not be limited, to the following:
         1) Schedule of work.
         2) Security measures for work and disposal area.
         3) Staff training: Contractor shall provide at least one competent person who is capable of identifying asbestos hazards at the job site for the entire duration of the AC pipe removal and disposal operation.
         4) Trenching and removal of pipe procedure.

1.04 DEFINITIONS

A. Adequately Wet: Penetration of the pipe wall with liquid to prevent release of particulates.

B. Asbestos Cement Pipe: Also commonly referred to as AC Transite Pipe, AC pipe or ACP. Pipe that is generally composed of cement and asbestos fibers.

C. Competent Person: A trained worker who is capable of identifying existing and predictable asbestos hazards, perform exposure assessment and monitoring, is qualified to train other workers, and has the authority to take immediate corrective action to eliminate a hazardous exposure.

D. Non-friable Asbestos - Containing Material (NACM): Material containing more than 1 percent asbestos, that when dry, cannot be crumbled, pulverized, or reduced to powder by hand pressure.

E. Regulated Asbestos - Containing Material (RACM): Category II non-friable ACM that has a high probability of becoming or has become crumbled, pulverized, or reduced to powder in the course of work.

1.05 OPERATING DIGESTERS

A. Observe safety precautions in vicinity of operating digesters which contain digester gases, including methane, hydrogen sulfide, and carbon dioxide.

1.06 HAZARDOUS MATERIALS PROCEDURES

A. Hazardous materials are those defined by 40 CFR and State specific codes.

B. Forward to Engineer, copies of reports, permits, receipts, and other documentation related to remedial work.

C. Assume responsibility for worker health and safety, including health and safety of subcontractors and their workers:
   1. Instruct workers on recognition and reporting of materials that may be hazardous.

D. File requests for adjustments to Contract Times and Contract Price due to the finding of Hazardous Materials in the Work site in accordance with Contract Documents:
   1. Minimize delays by continuing performance of the Work in areas not affected by hazardous materials operations.

E. When hazardous materials have been found:
   1. Prepare and initiate implementation of plan of action.
   2. Notify immediately Owner, Engineer, and other affected persons.
   3. Notify such agencies as are required to be notified by laws and regulations with the times stipulated by such laws and regulations.
   4. Designate a Certified Industrial Hygienist to issue pertinent instructions and recommendations for protection of workers and other affected persons' health and safety.
   5. Identify and contact subcontractors and licensed personnel qualified to undertake storage, removal, transportation, disposal, and other remedial work required by, and in accordance with, laws and regulations.

1.07 LEAD PAINT REMOVAL AND DISPOSAL

A. Existing paint on the surfaces that may contain lead in concentrations which will require implementation of hazardous material compliance procedures as legislated by the following:
   1. CFR, Title 29 and Title 40.
   2. CCR, Title 8 and Title 22 Division 4.5.

B. Remove samples of paint from the structures identified herein and have samples tested by a certified testing laboratory to determine lead content in samples:
   1. Ensure that sufficient numbers of paint samples are removed and tested to provide adequate information regarding lead content in paint.
   2. Ensure that samples contain the total thickness of the paint to the substrate where removed.
   3. Ensure that each sample contains a sufficient quantity of paint to facilitate proper and adequate analyses by testing laboratory.
   4. Ensure that samples are adequately identified with location from which it was removed.

C. Laboratory testing of paint samples: In accordance with 40 CFR 261,
   1. Submit 10 copies of complete laboratory analyses of paint samples.

D. Submit a plan for the removal, containment, and disposal of lead-based paint and associated debris:
   1. Submit 10 copies of plan.

E. Prior to beginning work associated with the removal, containment, and disposal of lead-based paints, prepare and submit to the Engineer for his review 6 copies of the following:
   1. Listing of lead paint removal equipment to be used.
   2. Outline of procedures to be used to remove lead paint.
   3. Data and specifications describing chemical stripping materials to be used.
   4. Data and specifications describing abrasive blast materials and grit size to be used.
   5. Plan describing lead paint removal, hazardous waste debris containment, and hazardous waste disposal methods.
   6. Safety plan, consisting of a written plan of action covering operational requirements for safe removal of lead paint, safe handling and containment of waste and debris generated by the operation, and safe disposal of hazardous waste and non-hazardous waste materials, complying with the most stringent requirements of the following:
      a. Equipment and material manufacturer's safety sheets.
      b. 29 CFR 1926.62.

F. Carry out lead paint removal, containment, and disposal work in accordance with the following SSPC guidelines:
   1. SSPC-Guide 6.
      a. Open Abrasive Blast Cleaning with Expendable Abrasive.
      b. Open Abrasive Blast Cleaning with Recyclable Abrasive.
      c. Closed Abrasive Blast Cleaning with Recyclable Abrasive.
      d. Chemical Stripping.
   2. SSPC-Guide 7.

G. Assume responsibility for the proper utilization of the paint removal method selected. When abrasive blast cleaning is selected to remove lead-based paint, comply with all applicable federal, state, and local air quality, pollution, and environmental control regulations for blast cleaning. When chemical stripping is selected to remove the lead based paint, adhere to the chemical manufacturer's recommendations for the application of the product, the removal of the paint, and the containment of the debris.

H. Lead paint removal work shall be performed by a Contractor having prior experience in the removal method selected and shall provide at least 5 references of similar projects completed, 3 of which must have been completed within the past 12 months, documenting his experience.

I. Utilize a minimum of Class 3 containment and ventilation system as described in SSPC-Guide 6 during lead paint removal and containment procedures as required for the conditions.

J. Do not leave spent abrasive blast material, chemical stripping material, or lead paint debris uncontained on the project site overnight.

K. Test each container of paint debris, spent blast cleaning abrasive, chemical stripping debris, and other waste material generated by the operation to determine the waste material hazardous waste classification.

L. Assume responsibility for the disposal of lead paint waste and associated waste generated by the removal of the lead paint and the preparation of the surfaces for recoating. Dispose in accordance with applicable federal, state, and local requirements and regulations.

M. Accurately complete the Uniform Hazardous Waste Manifest included at the end of SSPC-Guide 7. Indicate on the Manifest that the Owner is the hazardous waste generator, and obtain the Owner's Environmental Protection Agency identification number for use in completing the Manifest.

1.08 ASBESTOS MATERIALS

A. It is the specific intent of these Contract Documents to exclude from the Work any and all products or materials containing asbestos. No products containing asbestos shall be incorporated in the Work.

B. Removal of existing ACM shall be performed by a firm that is registered by Cal-OSHA and certified by the State Contractors Licensing Board and shall be a Licensed Abatement Contractor in the state where the project is located.

C. Submit 10 copies of plan for the removal, containment, and disposal of ACM.

D. Submit 6 copies of abatement license of ACM removal contractor.

PART 2 PRODUCTS

2.01 ASBESTOS CEMENT PIPE (ACP)

A. The pipe to be removed from the ground has been in service for approximately 45 years:
   1. The manufacturer and exact composition of the pipe to be removed is unknown.
   2. ACP is generally manufactured using portland cement or pozzolan cement and asbestos fiber.
   3. Common pipe lengths: 3 feet 3 inches, 6 feet 6 inches, 9 feet 9 inches, and 13 feet 0 inches.

B. Pipe fittings. Separate from pipe brass, galvanized pipe, copper, cast iron, galvanized pipe or steel fittings and dispose of separately.

PART 3 EXECUTION

3.01 ASBESTOS MATERIALS

A. Notifications:
   1. Notify Cal-OSHA 24 hours prior to performing asbestos material removal operations.
   2. Contractor shall notify Owner 3 working days in advance of commencing asbestos material removal operations.

B. Work area:
   1. Establish a regulated work area, using at a minimum, construction warning tape to establish limits of work area for the asbestos material removal.
   2. On site stockpiling or storage of asbestos material designated for disposal shall not be allowed.

C. Safety:
   1. Conduct an Initial Exposure Assessment (IEA).
   2. Provide a hand/face wash station.

D. Worker qualifications:
   1. Asbestos removal shall be performed by employees trained in wet methods, vacuum cleaners with HEPA filters to collect debris and prompt cleanup in accordance with CCR, Title 8, § 1529, Section (g) Methods of Compliance, of “Asbestos”.

E. Legal disposal:
   1. Legal disposal of asbestos material is the Owner’s responsibility.
   2. Contractor shall transport the asbestos material to the location designated by the Owner and place into the location designated for this project.

3.02 EXCAVATION OF AC PIPE

A. Machine excavates to expose asbestos cement pipe.

B. Hand excavates areas under pipe where breaks are planned.

C. Pipe shall be pre-wetted prior to any breaks being made.

D. Pipe shall be snapped using mechanical snapping methods.

3.03 AC PIPE REMOVAL

A. All required pipe breaking operations shall require adequate pre-wetting with potable water.

B. The Contractor shall make every effort to minimize the number of pipe breaks. Wherever possible, the pipe should be removed by pulling the pipe out of the pipe joint collars.

C. Remove sections of AC pipe intact at joint collars by mechanical snapping methods between collars.

D. Wet and containerize waste materials as removed from the trench. Use lifting straps and methods that do not further damage the pipe.

E. Sections of AC pipe that become cut, have broken edges or have any friable surface shall be wet at exposed fractures and immediately wrapped:
   1. The pipe ends shall be sealed completely using a minimum 6-mil poly film wrap, which is securely fastened, taped to completely enclose the pipe and ACP appurtenances and shall have conspicuous, legible labeling that has the following or equivalent labeling: CAUTION: CONTAINS ASBESTOS FIBERS. BREATHING ASBESTOS DUST MAY CAUSE SERIOUS BODILY HARM.

F. AC Pipe sections shall not be left exposed in public view, either in trench or in disposal area.

G. All connecting parts of pipe, rubber gaskets, and pipe couplings shall be discarded with pipe.

H. AC pipe from this project only, shall be placed in the bin designated.

END OF SECTION

SECTION 01410

REGULATORY REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Regulatory authorities and codes.

1.02 APPLICABLE CODES

A. California Code of Regulations (CCR), California Building Standards Code, CCR Title 24:
   1. Building code:
      a. California Building Code (CBC), Title 24, Part 2 – 2019.
   2. Electrical code:
      a. California Electrical Code (CEC), Title 24, Part 3 – 2019.
   3. Mechanical code:
      a. California Mechanical Code (CMC), Title 24, Part 4 – 2019.
   4. Plumbing code:
      a. California Plumbing Code (CPC), Title 24, Part 5 –2019.
   5. Energy code:
      a. California Energy Code (CEC), Title 24, Part 6 –2019.
   6. Historical building code:
      a. California Historical Building Code (CHBC), Title 24, Part 8 –2019.
   7. Fire code:
      a. California Fire Code (CFC), Title 24, Part 9 – 2019.
   8. Existing building code:
      a. California Existing Building Code (CEBC), Title 24, Part 10 – 2019.
   9. Green building standards code:
      a. California Green Building Standards Code (CALGreen), Title 24, Part 11 – 2019.

PART 2 PRODUCTS

Not used

PART 3 EXECUTION

Not used

END OF SECTION

SECTION 01450

QUALITY CONTROL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Quality control and control of installation.
   2. Tolerances.
   3. References.
   4. Mock-up requirements.
   5. Authority and duties of Owner's representative or inspector.
   6. Sampling and testing.
   7. Testing and inspection services.
   8. Contractor's responsibilities.

1.02 QUALITY CONTROL AND CONTROL OF INSTALLATION

A. Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce Work of specified quality.

B. Comply with manufacturers' instructions, including each step in sequence.

C. When manufacturers' instructions conflict with Contract Documents, request clarification from Engineer before proceeding.

D. Comply with specified standards as minimum quality for the Work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

E. Perform Work by persons qualified to produce required and specified quality.

F. Verify field measurements are as indicated on Shop Drawings or as instructed by manufacturer.

G. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion, or disfigurement.

H. When specified, products will be tested and inspected either at point of origin or at Work site:
   1. Notify Engineer in writing well in advance of when products will be ready for testing and inspection at point of origin.
   2. Do not construe that satisfactory tests and inspections at point of origin is final acceptance of products. Satisfactory tests or inspections at point of origin do not preclude retesting or re-inspection at Work site.

I. Do not ship products which require testing and inspection at point of origin prior to testing and inspection.

1.03 TOLERANCES

A. Monitor fabrication and installation tolerance control of products to produce acceptable Work. Do not permit tolerances to accumulate.

B. Comply with manufacturers' tolerances. When Manufacturers' tolerances conflict with Contract Documents, request clarification from Engineer before proceeding.

C. Adjust products to appropriate dimensions; position before securing products in place.

1.04 REFERENCES

A. ASTM International (ASTM):
   1. E329 - Standard for Agencies Engaged in Construction Inspection, Testing or Special Inspection.

B. National Institute of Standards and Technology (NIST).

1.05 PRODUCT REQUIREMENTS

A. For products or workmanship specified by association, trade, or other consensus standards, comply with requirements of standard, except when more rigid requirements are specified or are required by applicable codes.

B. Conform to reference standard by date of issue current on date of Contract Documents, except where specific date is established by code.

C. Obtain copies of standards where required by product specification sections.

D. When specified reference standards conflict with Contract Documents, request clarification from Engineer before proceeding.

1.06 MOCK-UP REQUIREMENTS

A. Tests will be performed under provisions identified in this Section and identified in respective product specification sections.

B. Assemble and erect specified items with specified attachment and anchorage devices, flashings, seals, and finishes.

C. Accepted mock-ups shall be comparison standard for remaining Work.

D. Where mock-up has been accepted by Engineer and is specified in product specification sections to be removed; remove mock-up and clear area when directed to do so by Engineer.

1.07 AUTHORITY AND DUTIES OF OWNER'S REPRESENTATIVE OR INSPECTOR

A. Owner’s Project Representative employed or retained by Owner is authorized to inspect the Work.

B. Inspections may extend to entire or part of the Work and to preparation, fabrication, and manufacture of products for the Work.

C. Deficiencies or defects in the Work which have been observed will be called to Contractor's attention.

D. Inspector will not:
   1. Alter or waive provisions of Contract Documents.
   2. Inspect Contractor's means, methods, techniques, sequences, or procedures for construction.
   3. Accept portions of the Work, issue instructions contrary to intent of Contract Documents, or act as foreman for Contractor. Supervise, control, or direct Contractor's safety precautions or programs; or inspect for safety conditions on Work site, or of persons thereon, whether Contractor's employees or others.

E. Inspector will:
   1. Conduct on-site observations of the Work in progress to assist Engineer in determining when the Work is, in general, proceeding in accordance with Contract Documents.
   2. Report to Engineer whenever Inspector believes that Work is faulty, defective, does not conform to Contract Documents, or has been damaged; or whenever there is defective material or equipment; or whenever Inspector believes the Work should be uncovered for observation or requires special procedures.

1.08 SAMPLING AND TESTING

A. General:
   1. Prior to delivery and incorporation in the Work, submit listing of sources of materials, when specified in sections where materials are specified.
   2. When specified in sections where products are specified:
      a. Submit sufficient quantities of representative samples of character and quality required of materials to be used in the Work for testing or examination.
      b. Test materials in accordance with standards of national technical organizations.

B. Sampling:
   1. Furnish specimens of materials when requested.
   2. Do not use materials which are required to be tested until testing indicates satisfactory compliance with specified requirements.
   3. Specimens of materials will be taken for testing whenever necessary to determine quality of material.
   4. Assist Engineer in preparation of test specimens at site of work, such as soil samples and concrete test cylinders.

1.09 TESTING AND INSPECTION SERVICES

A. Contractor will employ and pay for specified services of an independent firm to perform Contractor quality control testing as required in the technical specifications for various work and materials.

B. Owner will employ and pay for specified services of an “Owner’s independent testing firm” certified to perform testing and inspection as required in the technical specifications for various work and materials or stipulated in Section 01455 - Regulatory Quality Assurance to confirm Contractor’s compliance with Contract Documents.

C. The Owner’s independent testing firm will perform tests, inspections and other services specified in individual specification sections and as required by Owner and requested by the Engineer.

D. The qualifications of laboratory that will perform the testing, contracted by the Owner or by the Contractor, shall be as follows:
   1. Has authorization to operate in the state where the project is located.
   2. Meets “Recommended Requirements for Independent Laboratory Qualification,” published by American Council of Independent Laboratories.
   3. Meets requirements of ASTM E329.
   4. Laboratory Staff: Maintain full time specialist on staff to review services.
   5. Testing Equipment: Calibrated at reasonable intervals with devices of accuracy traceable to NIST or accepted values of natural physical constants.
   6. Will submit copy of report of inspection of facilities made by Materials Reference Laboratory of NIST during most recent tour of inspection, with memorandum of remedies of deficiencies reported by inspection.

E. Testing, inspections and source quality control may occur on or off project site. Perform off-site testing inspections and source quality control as required by Engineer or Owner.

F. Contractor shall cooperate with Owner’s independent testing firm, furnish samples of materials, design mix, equipment, tools, storage, safe access, and assistance by incidental labor as requested:
   1. Notify Engineer and Owner’s independent testing firm 48 hours prior to expected time for operations requiring testing.
   2. Make arrangements with Owner’s independent testing firm and pay for additional samples and tests required for Contractor’s use.

G. Limitations of authority of testing Laboratory: Owner’s independent testing firm or Laboratory is not authorized to:
   1. Agency or laboratory may not release, revoke, alter, or enlarge on requirements of Contract Documents.
   2. Agency or laboratory may not approve or accept any portion of the Work.
   3. Agency or laboratory may not assume duties of Contractor.
   4. Agency or laboratory has no authority to stop the Work.

H. Testing and employment of an Owner’s independent testing firm or laboratory shall not relieve Contractor of obligation to perform Work in accordance with requirements of Contract Documents.

I. Re-testing or re-inspection required because of non-conformance to specified requirements shall be performed by same Owner’s independent testing firm on instructions by Engineer. Payment for re-testing or re-inspection will be charged to Contractor by deducting testing charges from Contract Sum/Price.

J. The Owner's independent testing firm responsibilities will include:
   1. Test samples of mixes submitted by Contractor.
   2. Provide qualified personnel at site. Cooperate with Engineer and Contractor in performance of services.
   3. Perform specified sampling and testing of products in accordance with specified standards.
   4. Ascertain compliance of materials and mixes with requirements of Contract Documents.
   5. Promptly notify Engineer and Contractor of observed irregularities or non-conformance of Work or products.
   6. Perform additional tests required by Engineer.
   7. Attend preconstruction meetings and progress meetings.

K. Owner's independent testing firm individual test reports: After each test, Owner's independent testing firm will promptly submit electronically and 3 hard copies of report to Engineer and to Contractor. Include the following:
   1. Date issued.
   2. Project title and number.
   3. Name of inspector.
   4. Date and time of sampling or inspection.
   5. Identification of product and specifications section.
   6. Location in Project.
   7. Type of inspection or test.
   8. Date of test.
   9. Certified test results stamped and signed by a registered Engineer in the State of where the project is located.
   10. Summary of conformance with Contract Documents.
   11. When requested by Engineer, the Owner's independent testing firm will provide interpretation of test results.

L. Owner's independent testing firm will provide monthly report of certification to identify all work performed for special inspections and other contract requirements on this project. The following certified monthly report at a minimum will include but not limited to:
   1. Results of testing.
   2. Testing logs.
   3. Outstanding deficiencies.
   4. Various statistical data.
   5. Testing curves (up to 4 types) as required by the Engineer.

1.10 CONTRACTOR'S RESPONSIBILITIES

A. Cooperate with Owner's independent testing firm or laboratory personnel and provide access to construction and manufacturing operations.

B. Secure and deliver to Owner's independent testing firm or laboratory adequate quantities of representative samples of materials proposed to be used and which require testing.

C. Provide to Owner's independent testing firm or laboratory and Engineer preliminary mix design proposed to be used for concrete, and other materials mixes which require control by testing laboratory.

D. Furnish electronically and 5 hard copies of product test reports.

E. Furnish incidental labor and facilities:
   1. To provide access to construction to be tested.
   2. To obtain and handle samples at Work site or at source of product to be tested.
   3. To facilitate inspections and tests.
   4. For storage and curing of test samples.

F. Notify Owner's independent testing firm or laboratory 48 hours in advance of when observations, inspections and testing is needed for laboratory to schedule and perform in accordance with their notice of response time.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01455

REGULATORY QUALITY ASSURANCE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: This Section describes project regulatory requirements for quality assurance that includes special inspections, special certification, and structural observation.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete.
   2. 530 – Building Code Requirements for Masonry Structures.
   3. 530.1 – Specification for Masonry Structures.

B. American Institute of Steel Construction (AISC):
   1. 360 – Specification for Structural Steel Buildings.

C. American Society of Civil Engineers (ASCE):
   1. 7 - Minimum Design Loads for Buildings and Other Structures.

D. American Welding Society (AWS):
   1. D1.3 - Structural Welding Code - Sheet Steel.
   2. D1.4 - Structural Welding Code - Reinforcing Steel.

E. ASTM International (ASTM):
   1. A706 – Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement.
   2. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   3. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
   4. C1611 Standard Test Method for Slump Flow of Self-Consolidating Concrete.

A. California Building Code (CBC) 2019.

1.03 DEFINITIONS

A. Special Certification: Certification for designated seismic systems that demonstrates compliance with performance requirements.

B. Special Inspection: Inspection of the materials, installation, fabrication, erection, or placement of components and connections requiring special expertise to ensure compliance with approved construction documents and referenced standards.

C. Special Inspection, Continuous: The full-time observation of work requiring special inspection by an approved special inspector who is present in the area where the work is being performed.

D. Special Inspection, Periodic: The part-time, or intermittent observation of work requiring special inspection by an approved special inspector who is present in the area where the work is being performed and at the completion of the work.

E. Structural Observation: The visual observation of the structural system by a registered design professional for general conformance to the approved construction documents at significant construction stages and at completion of the structural system.

1.04 DESCRIPTION

A. This Section describes special inspections, special certification and structural observation of structural assemblies and components to be performed in compliance with the building code specified in Section 01410 - Regulatory Requirements.

B. The special certification and special inspections specified in this Section are in addition to the requirements specified in Section 01450 - Quality Control, and by the individual Sections.

1.05 SUBMITTALS

A. Contractor shall submit special certifications for designated seismic systems.

B. Contractor shall schedule and coordinate the submittal of Special Inspection reports and test results prepared by others.

1.06 SPECIAL INSPECTION

A. Owner will employ 1 or more special inspectors who will provide special inspections during construction.

B. Special inspector(s) shall be qualified for inspection of the particular type of materials or operations requiring special inspection.

C. Testing laboratory: Testing that is required to satisfy the requirements of special inspection will be performed by the Owner's testing laboratory as specified in Section 01450 - Quality Control.

D. Duties of Special Inspector:
   1. General: Required duties of the special inspector(s) shall be as described in Chapter 17 of the building code specified in Section 01410 - Regulatory Requirements.
   2. Reporting: Special inspector(s) shall provide reports of each inspection to the Contractor. Contractor shall distribute copes of inspection reports to the Owner:
      a. Reports shall, at a minimum, include the following items:
         1) Date and time of inspection, and name(s) of individual(s) preforming the inspection.
         2) Structures and areas of the structure where work or testing was observed.

3) Discrepancies between the requirements of the Contract Documents and the work or testing observed.
4) Other areas of deficiency in the Work.

E. Special inspections shall not be construed as fulfilling the requirements for structural observation.

F. Owner or special inspector are responsible to select materials for special inspection:
1. It is not acceptable for Contractor to select materials for special inspection.

1.07 SPECIAL CERTIFICATION

A. Contractor shall be responsible for providing equipment that meets the special certification requirements of the building code specified in Section 01410 – Regulatory Requirements.

B. The following designated seismic systems shall be subject to the testing and qualification requirements of the regulatory building code, Section 1705.12.4 as specified in Section 01410 – Regulatory Requirements and shall require special certification as set forth in ASCE 7, Section 13.2:
1. Mechanical equipment that is assigned an importance factor of 1.50 as specified in Section 01612 - Seismic Design Criteria.
2. All electrical equipment.

C. Special certification requirements for designated seismic systems:
1. Submittals for mechanical and electrical equipment identified in this Section as designated seismic systems shall include certification that the equipment is seismically qualified. Certifications shall be subject to review and acceptance by Owner.
2. Certifications may be at least 1 of the following in accordance with ASCE 7, Section 13.2:
a. Analysis.
b. Testing.
c. Experience data.

1.08 STRUCTURAL OBSERVATION

A. Owner will employ 1 or more registered design professionals who will provide structural observation(s) during construction:
1. Registered design professional shall be a civil or structural engineer currently licensed as such in the state where the project is located and regularly engaged in structural design equivalent to or similar to those indicated on the Drawings.

B. Structural observations shall not be construed as fulfilling the requirements for special inspections.

PART 2 PRODUCTS

Not used

PART 3 EXECUTION

3.01 SPECIAL INSPECTIONS

A. The Owner will provide special inspection of following types of work as described in in Section 1705 of the building code as specified in Section 01410 - Regulatory Requirements wherever such work occurs unless otherwise specified:
   1. Appendix A, Concrete - Special Inspection Schedule.
   2. Appendix B, Masonry Special Inspection Schedule – "Level 2."
   3. Appendix C, Soils Verification and Inspection Schedule.
   4. Appendix D, Structural Steel - Special Inspection Schedule.
   5. Appendix E, Structural Steel Bolting - Special Inspection Schedule.
   6. Appendix F, Steel Construction (Steel Deck, Open Web Steel Joists and Joist Girders, and Cold Formed Steel Trusses) - Special Inspection Schedule.
   7. Appendix G: Deep Foundations, Driven - Special Inspection Schedule.

3.02 SPECIAL CERTIFICATION

A. Special inspector shall examine the designated seismic system(s) specified and determine whether the designated system components, including anchorage, are consistent with the evidence of compliance submitted for special certification.

3.03 STRUCTURAL OBSERVATION

A. The following work requires structural observation in accordance with Section 1704.5 of the building code specified in Section 01455 - Regulatory Requirements:
   1. All structures in all areas:
      a. Foundations.

B. Elevated slabs.

3.04 SCHEDULE

A. Contractor shall allow time necessary for special inspections and structural observation specified herein.

B. Sufficient notice shall be given so that the special inspections and structural observations can be performed. Contractor shall allow time for individuals performing special inspection and structural observation to travel to the site.

3.05 PROCEDURE

A. The special inspector will immediately notify the Engineer of any corrections required and follow notification with appropriate documentation.

B. Contractor shall not proceed until the work is satisfactory to the Engineer.

END OF SECTION

APPENDIX A

CONCRETE SPECIAL INSPECTION SCHEDULE
(Includes: cast-in-place, precast, prestressed, precast-prestressed, and shotcrete.)

Verification and Inspection	Reference Standard ACI 318-14 AWS D1.4-18 IBC 2018	Frequency of Inspection[1] (During Task Listed)	
		Continuous	Periodic
1. Inspect reinforcement, including prestressing tendons, and verify placement.	ACI 318: 20, 25.2, 25.3, 26.6.1-26.6.3 IBC: 1908.4		●
2. Reinforcing bar welding:			
a. Verify weldability of reinforcing bars other than ASTM A706;	AWS D1.4 ACI 318: 26.6.4		●
b. Inspect single-pass fillet welds, maximum 5/16"; and	AWS D1.4 ACI 318: 26.6.4		●
c. Inspect all other welds.	AWS D1.4 ACI 318: 26.6.4	●	
3. Inspect anchors cast in concrete.	ACI 318: 17.8.2		●
4. Inspect anchors post-installed in hardened concrete members.			
a. Adhesive anchors installed in horizontally or upwardly inclined orientations to resist sustained tension loads.	ACI 318: 17.8.2.4	●	
b. Mechanical anchors and adhesive anchors not defined in 4.a.	ACI 318: 17.8.2		●
5. Verify use of required design mix.	ACI 318: 19, 26.4.3, 26.4.4 IBC: 1904.1, 1904.2, 1908.2, 1908.3		●
6. Prior to concrete placement, fabricate specimens for strength tests, perform slump and air content tests, and determine the temperature of the concrete.	ASTM C172 ASTM C31 ACI 318: 26.5, 26.12 IBC: 1908.10	●	
7. Inspect concrete and shotcrete placement for proper application techniques.	ACI 318: 26.5 IBC: 1908.6, 1908.7, 1908.8	●	

Verification and Inspection	Reference Standard ACI 318-14 AWS D1.4-18 IBC 2018	Frequency of Inspection[1] (During Task Listed)	
		Continuous	Periodic
8. Verify maintenance of specified curing temperature and techniques.	ACI 318: 26.5.3-26.5.5 IBC: 1908.9		●
9. Inspect prestressed concrete for:			
a. Application of prestressing forces; and	ACI 318: 26.10	●	
b. Grouting of bonded prestressing tendons.	ACI 318: 26.10	●	
10. Inspect erection of precast concrete members.	ACI 318: 26.9		●
11. Verify in-situ concrete strength, prior to stressing of tendons in post-tensioned concrete and prior to removal of shores and forms from beams and structural slabs.	ACI 318: 26.11.2		●
12. Inspect formwork for shape, location and dimensions of the concrete member being formed.	ACI 318: 26.11.1.2.(b)		●

Notes:

(1) The "●" represents a required inspection activity for the project where it occurs.

APPENDIX B

MASONRY SPECIAL INSPECTION SCHEDULE - "LEVEL B"

MINIMUM TESTS

Verification of Slump flow and Visual Stability Index (VSI) as delivered to the project site as determined by ASTM C1611 for self-consolidating grout

Verification of f'_m in accordance with Specification Section 04220 - Concrete Unit Masonry prior to construction.

MINIMUM SPECIAL INSPECTION – LEVEL 2			
	Reference Standard	**Frequency of Inspection[1] (During Task Listed)**	
Verification and Inspection	**TMS 402 TMS 602**	**Continuous**	**Periodic**
1. Verify compliance with the approved submittals.	TMS 602: Art. 1.5		●
2. As masonry construction begins, verify that the following are in compliance:			
a. Proportions of site-prepared mortar.	TMS 602: Art. 2.1, 2.6A, 2.6C		●
b. Placement of masonry units and construction of mortar joints.	TMS 602: Art. 3.3B		●
c. Placement of reinforcement, connectors, and anchors.	TMS 402: Sec. 6.1, 6.3.1, 6.3.6, 6.3.7 TMS 602: Art. 3.2E, 3.4		●
d. Reinforcing bar couplers and terminators.		●	
3. Prior to grouting, verify that the following are in compliance:			
a. Placement of masonry units and construction of mortar joints	TMS 602: Art.3.3B		●
b. Grout space.	TMS 602: Art. 3.2D, 3.2F		●
c. Grade, type, and size of reinforcement and anchor bolts.	TMS 602: Art. 3.4, 3.6		●
d. Placement of reinforcement, connectors, and anchors.	TMS 402: Sec. 6.1, 6.3.1, 6.3.6, 6.3.7 TMS 602: Art. 3.2E, 3.4		●

MINIMUM SPECIAL INSPECTION – LEVEL 2			
Verification and Inspection	**Reference Standard TMS 402 TMS 602**	**Frequency of Inspection(1) (During Task Listed)**	
		Continuous	**Periodic**
e. Proportions of site-prepared grout.	TMS 602: Art. 2.6B, 2.4.G.1.b		●
4. Verify during construction:			
a. Size and location of structural elements:	TMS 602: Art. 3.3F		●
b. Type, size, and location of anchors, including details of anchorage of masonry to structural members, frames, or other construction.	TMS 402: Sec. 1.2.1(e), 6.2.1, 6.3.1		●
c. Welding of reinforcement.	TMS 402: Sec. 6.1.6.1.2	●	
d. Preparation, construction, and protection of masonry during cold weather (temperature below 40 degrees F) or hot weather (temperature above 90 degrees F).	TMS 602: Art. 1.8C, 1.8D		●
5. Observe preparation of grout specimens, mortar specimens, and/or prisms.	TMS 602: Art. 1.4 B.2.a.3, 1.4 B.2.b.3, 1.4 B.2.c.3, 1.4 B.3, 1.4 B.4		●
Notes: (1) The "●" represents a required inspection activity for the project where it occurs.			

APPENDIX C

SOILS VERIFICATION AND INSPECTION SCHEDULE

Verification and Inspection	Reference Standard CBC 2019	Frequency of Inspection[1] (During Task Listed)	
		Continuous	Periodic
1. Verify materials below shallow foundations are adequate to achieve the design bearing capacity.	CBC: T-1705.6		●
2. Verify excavations are extended to proper depth and have reached proper material.	CBC: T-1705.6		●
3. Perform classification and testing of fill and backfill materials.	CBC: T-1705.6		●
4. Verify use of proper materials, densities, and lift thicknesses during placement and compaction of fill and backfill.	CBC: T-1705.6	●	
5. Prior to placement of fill, observe subgrade and verify that site has been prepared properly.	CBC: T-1705.6		●

Notes:

(1) The "●" represents a required inspection activity for the project where it occurs.

APPENDIX D

STRUCTURAL STEEL SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Referenced Standard AISC 360-10	Frequency of Inspection[1] (During Task Listed)	
		Continuous	**Periodic**
Inspection Tasks Prior to Welding	AISC 360, Table N5.4-1		
1. Welding procedure specifications (WPSs) available.		●	
2. Manufacturer certifications for welding consumables available.		●	
3. Material identification (type/grade).			●
4. Welder identification system.			●
5. Fit-up groove welds (including joint geometry): • Joint preparation. • Dimensions (alignment, root opening, root face, bevel). • Cleanliness (condition of steel surfaces). • Tacking (tack weld quality and location). • Backing type and fit (if applicable).			●
5. Configuration and finish of access holes.			●
6. Fit-up of fillet welds: • Dimensions (alignment, gaps at root). • Cleanliness (condition of steel surfaces). • Tacking (tack weld quality and location).			●
7. Check welding equipment.			●
Inspection Tasks During Welding	AISC 360, Table N5.4-2		
8. Use of qualified welders.			●
9. Control and handling of welding consumables: • Packaging. • Exposure control.			●
10. No welding over cracked tack welds.			●

Verification and Inspection	Referenced Standard AISC 360-10	Frequency of Inspection[1] (During Task Listed) Continuous	 Periodic
11. Environmental conditions: • Wind speed within limits. • Precipitation and temperature.			●
12. WPS followed: • Settings on welding equipment. • Travel speed. • Selected welding materials. • Shielding gas type/flow rate. • Preheat applied. • Interpass temperature maintained (min/max). • Proper position (F, V, H, OH).			●
13. Welding techniques: • Interpass and final cleaning. • Each pass within profile limitations. • Each pass meets quality requirements.			●
Inspection Tasks After Welding	AISC 360, Table N5.4-3		
14. Welds cleaned.			●
15. Size, length, and location of welds.		●	
16. Welds meet visual acceptance criteria: • Crack prohibition. • Weld/base-metal fusion. • Crater cross section. • Weld profiles. • Weld size. • Undercut. • Porosity.		●	
17. Arc strikes.		●	
18. k-area.		●	
19. Backing removed and weld tabs removed (if required).		●	
20. Repair activities.		●	
21. Document acceptance or rejection of welded joint or member.		●	

Notes:

(1) The "●" represents a required inspection activity for the project where it occurs.

APPENDIX E

STRUCTURAL STEEL BOLTING SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Referenced Standard ASIC 360-10	Frequency of Inspection(1) (During Task Listed) Continuous	 Periodic
Inspection Tasks Prior to Bolting	AISC 360, Table N5.6-1		
1. Manufacturer's certifications available for fastener materials.		●	
2. Fasteners marked in accordance with ASTM requirements.			●
3. Proper fasteners selected for the joint detail (grade, type, bolt length if threads are to be excluded from shear plane).			●
4. Proper bolting procedure selected for joint detail.			●
5. Connecting elements, including the appropriate faying surface condition and hole preparation, if specified, meet applicable requirements.			●
6. Pre-installation verification testing by installation personnel observed and documented for fastener assemblies and methods used.			●
7. Proper storage provided for bolts, nuts, washers and other fastener components.			●
Inspection Tasks During Bolting	AISC 360, Table N5.6-2		
8. Fastener assemblies, of suitable condition, placed in all holes and washers (if required) are positioned as required.			●
9. Joint brought to the snug-tight condition prior to the pretensioning operation.			●
10. Fastener component not turned by the wrench prevented from rotating.			●
11. Fasteners are pretensioned in accordance with the RCSC Specification, progressing systematically from the most rigid point toward the free edges.			●
Inspection Tasks After Bolting	AISC 360, Table N5.6-3		
12. Document acceptance or rejection of bolted connections.		●	

Notes:

(1) The "●" represents a required inspection activity for the project where it occurs.

APPENDIX F

STEEL CONSTRUCTION – STEEL DECK; OPEN WEB STEEL JOISTS AND JOIST GIRDERS; AND COLD-FORMED STEEL TRUSSES SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Referenced Standard CBC 2019	Frequency of Inspection[1] (During Task Listed)	
		Continuous	Periodic
1. Cold-formed steel deck:			
a. Materials: Identification markings conform to ASTM standards specified in the approved construction documents.	Applicable ASTM material standards		●
b. Materials: Manufacturer's certified test reports.			●
c. Welding: Floor and roof deck welds.	AWS D1.3		●
2. Open web steel joints and joist girders:			
a. End connections – welded or bolted	SJI specs		●
b. Bridging – horizontal or diagonal	SJI specs		●
3. Cold-formed steel:			
a. Trusses: Inspect temporary and permanent installation restraints/bracing conform to approved truss submittal.	CBC 1705.2.4		●

Notes:

(1) The "●" represents a required inspection activity for the project where it occurs.

APPENDIX G
DEEP FOUNDATIONS, DRIVEN – SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Reference Standard IBC 2018	Frequency of Inspection[1] (During task listed)	
		Continuous	Periodic
1. Verify that element materials, sizes, and lengths comply with approved contract documents and approved shop drawings.	IBC 1705.7	●	
2. Determine capacities of test elements and conduct additional load tests, as required	IBC 1705.7		
3. Inspect driving operations and maintain complete and accurate records for each element.	IBC 1705.7	●	
4. Verify placement location and plumbness, confirm type and size of hammer, record number of blows per foot of penetration, determine required penetrations to achieve required/design capacity, record tip and butt elevations, and document any damage to foundation element.	IBC 1705.7	●	
5. Steel elements: perform additional special inspection as specified for structural steel.	IBC 1705.7	-	-
6. Concrete and concrete-filled elements: perform tests and additional special inspections as specified for concrete.	IBC 1705.7	-	-
7. Specialty elements: perform additional inspections as indicated on the approved shop drawings.	IBC 1705.7	-	-

Notes:

(1) The "●" represents a required inspection activity for the project where it occurs.

SECTION 01500

TEMPORARY FACILITIES AND CONTROLS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Furnishing, maintaining, and removing construction facilities and temporary controls, including temporary utilities, construction aids, barriers and enclosures, security, access roads, temporary controls, project sign, field offices and sheds, and removal after construction.

1.02 REFERENCE

A. American National Standards Institute (ANSI).

B. Occupational Safety and Health Administration (OSHA).

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

1.04 TEMPORARY UTILITIES

A. Temporary electrical power:
   1. Arrange with local utility to provide adequate temporary electrical service.
   2. Provide and maintain adequate jobsite power distribution facilities conforming to applicable Laws and Regulations.
   3. Provide, maintain, and pay for electric power for performance of the Work

B. Temporary electrical lighting:
   1. In work areas, provide temporary lighting sufficient to maintain lighting levels during working hours not less than lighting levels required by OSHA and state agency which administers OSHA regulations where Project is located.
   2. When available, permanent lighting facilities may be used in lieu of temporary facilities:
      a. Prior to Substantial Completion of the Work, replace bulbs, lamps, or tubes used by Contractor for lighting.

C. Temporary heating, cooling, and ventilating:
   1. Heat and ventilate work areas to protect the Work from damage by freezing, high temperatures, weather, and to provide safe environment for workers.
   2. Permanent heating system may be utilized when sufficiently completed to allow safe operation.

D. Temporary water:
   1. Pay for and construct facilities necessary to furnish potable water for human consumption and non-potable water for use during construction.
   2. Remove temporary piping and connections and restore affected portions of the facility to original condition before Substantial Completion**.**
   3. Pay for water used for construction prior to Substantial Completion. Owner will provide water for 7-day operational testing.
   4. Development of potable water supply:
      a. Potable water is not available at construction site.
      b. Provide potable water for human consumption during construction period.
      c. Furnish potable water that meets requirements of Laws and Regulations.
   5. Development of non-potable water supply:
      a. Post ample signs throughout the work area warning that plant water is not potable.
      b. Non-potable water is available from hydrants or hose valves within plant without cost. When combined demand of the Work and plant exceeds plant supply capacity, provide additional temporary supply capacity.

E. Temporary sanitary facilities:
   1. Provide suitable and adequate sanitary facilities that are in compliance with applicable Laws and Regulations.
   2. Existing facility use is not allowed.
   3. At completion of the Work, remove sanitary facilities and leave site in neat and sanitary condition.

F. Temporary fire protection:
   1. Provide fire protection required to protect the Work and ancillary facilities.

G. First aid: Post first aid facilities and information posters conforming to requirements of OSHA and other applicable Laws and Regulations in readily accessible locations.

H. Utilities in existing facilities: As specified in Section 01140 - Work Restrictions.

I. Temporary piping systems:
   1. Submit layout drawings showing proposed routing of piping, including proposed pipe support and pipe restraint locations.
   2. Submit product data for piping, fittings, appurtenances, restraints, supports, and other components of the temporary piping system.
   3. Submit information at least 28 days prior to when each temporary piping system is scheduled to be installed and allow 14 days for review and comment.

J. Temporary pumping systems:
   1. Submit pump data, performance curves, and other operating information as specified in Section 15050 - Common Work Results for Mechanical Equipment.
   2. Submit sketches showing layout of temporary pumping system, including pump quantity, configuration in wet well, and proposed piping layout specified in this Section.
   3. Submit piping headloss calculations based on proposed temporary piping system layout.

4. Submit information at least 28 days prior to when the temporary pumping system is scheduled to be installed and allow 14 days for review and comment.

1.05 CONSTRUCTION AIDS

A. Provide railings, kick plates, enclosures, safety devices, and controls required by Laws and Regulations and as required for adequate protection of life and property.

B. Use construction hoists, elevators, scaffolds, stages, shoring, and similar temporary facilities of ample size and capacity to adequately support and move loads.

C. Design temporary supports with adequate safety factor to ensure adequate load bearing capability:
   1. When requested, submit design calculations by professional registered engineer prior to application of loads.
   2. Submitted design calculations are for information and record purposes only.

D. Accident prevention:
   1. Exercise precautions throughout construction for protection of persons and property.
   2. Observe safety provisions of applicable Laws and Regulations.
   3. Guard machinery and equipment, and eliminate other hazards.
   4. Make reports required by authorities having jurisdiction, and permit safety inspections of the Work.
   5. Before commencing construction work, take necessary action to comply with provisions for safety and accident prevention.

E. Barricades:
   1. Place barriers at ends of excavations and along excavations to warn pedestrian and vehicular traffic of excavations.
   2. Provide barriers with flashing lights after dark.
   3. Keep barriers in place until excavations are entirely backfilled and compacted.
   4. Barricade excavations to prevent persons from entering excavated areas in streets, roadways, parking lots, treatment plants, or other public or private areas.

F. Warning devices and barricades: Adequately identify and guard hazardous areas and conditions by visual warning devices and, where necessary, physical barriers:
   1. Provide devices in accordance with minimum requirements of OSHA and State agency which administers OSHA regulations where Project is located.

G. Hazards in public right-of-way:
   1. Comply with local jurisdiction standards and requirements for right-of-way barricades and other safety devices.
   2. Mark at reasonable intervals, trenches, and other continuous excavations in public right-of-way, running parallel to general flow of traffic, with traffic cones, barricades, or other suitable visual markers during daylight hours:
      a. During hours of darkness, provide markers with torches, flashers, or other adequate lights.

3. At intersections or for pits and similar excavations, where traffic may reasonably be expected to approach head on, protect excavations by continuous barricades:
    a. During hours of darkness, provide warning lights at close intervals.

H. Hazards in protected areas: Mark or guard excavations in areas from which public is excluded, in manner appropriate for hazard.

I. Above grade protection: On multi-level structures, provide safety protection that meets requirements of OSHA and State agency which administers OSHA regulations where Project is located.

J. Protect existing structures, trees, shrubs, and other items to be preserved on Project site from injury, damage, or destruction by vehicles, equipment, worker or other agents with substantial barricades or other devices commensurate with hazards.

K. Fences:
1. Enclose site of the Work with fence adequate to protect the Work against acts of theft, violence, and vandalism.
2. Enclose temporary offices and storage areas with fence adequate to protect temporary facilities against acts of theft, violence, and vandalism.
3. When entire or part of site is to be permanently fenced, permanent fence may be built to serve for both permanent and temporary protection of the work site, provided that damaged or defaced fencing is replaced prior to Substantial Completion.
4. Protect temporary and permanent openings and close openings in existing fences to prevent intrusion by unauthorized persons:
    a. Bear responsibility for protection of plant and material on site of the Work when openings in existing fences are not closed.
5. During night hours, weekends, holidays, and other times when no work is performed at site, provide temporary closures or enlist services of security guards to protect temporary openings.
6. Fence temporary openings when openings are no longer necessary.

1.06 SECURITY

A. Make adequate provision for protection of the work area against fire, theft, and vandalism, and for protection of public against exposure to injury.

1.07 ACCESS ROADS

A. General:
1. Build and maintain access roads to and on site of the Work to provide for delivery of material and for access to existing and operating plant facilities on site.
2. Build and maintain dust free roads which are suitable for travel at 20 miles per hour.

B. Off-site access roads:
1. Build and maintain graded earth roads.
2. Build roads only in public right-of-way or easements obtained by Owner.

3. Obtain rights-of-way or easements when electing to build along other alignment.

C. On-site access roads:
   1. Maintain access roads to storage areas and other areas to which frequent access is required.
   2. Maintain similar roads to existing facilities on site of the Work to provide access for maintenance and operation.
   3. Protect buried vulnerable utilities under temporary roads with steel plates, wood planking, or bridges.
   4. Maintain on-site access roads free of mud.
   5. Provide controls to prevent vehicles leaving the site from tracking mud off the site onto the public right-of-way.

1.08 TEMPORARY CONTROLS

A. Dust control:
   1. Prevent dust nuisance caused by operations, unpaved roads, excavation, backfilling, demolition, or other activities.
   2. Control dust by sprinkling with water, use of dust palliatives, modification of operations, or other means acceptable to agencies having jurisdiction.

B. Noise control:
   1. Comply with noise and work hours regulations by local jurisdiction.
   2. In or near inhabited areas, particularly residential, perform operations in manner to minimize noise.
   3. In residential areas, take special measures to suppress noise during night hours.

C. Mud control:
   1. Prevent mud nuisance caused by construction operations, unpaved roads, excavation, backfilling, demolition, or other activities.

1.09 PROJECT SIGN

A. Provide and maintain Project identification sign consisting of painted 8-foot wide by 4-foot high exterior grade plywood and minimum 10-foot long, 4 by 4 lumber posts, set in ground at least 3 feet, with exhibit lettering by professional sign painter using no more than 5 sign colors:
   1. List at least the title of the Project, and names of the Owner, Engineer, and Contractor.
   2. Identify Contractor’s and Engineer’s names in upper right-hand corner underneath the bid number.

B. Provide project sign as directed by the Owner.

C. Erect Project identification sign where directed.

1.10 CONTRACTOR FIELD OFFICES AND SHEDS

A. Maintain on Project Site weather tight space in which to keep copies of Contract Documents, progress schedule, shop drawings, and other relevant documents.

B. Provide field office with adequate space to examine documents, and provide lighting and telephone service in that space.

1.11 REMOVAL

A. Remove temporary facilities and controls before inspection for Substantial Completion or when directed.

B. Clean and repair damage caused by installation or use of temporary facilities.

C. Remove underground installations to minimum depth of 24 inches and grade to match surrounding conditions.

D. Restore existing facilities used during construction to specified or original condition.

1.12 TEMPORARY PROCESS PIPING SYSTEMS

A. Provide piping, appurtenances, and other materials as required to provide temporary piping systems as specified in this Section, as indicated on the Drawings, and as needed to perform the Work.

B. Provide field route piping as needed and as field conditions dictate, unless otherwise indicated on the Drawings, and determine appropriate lengths of piping and quantity/type of pipe fittings needed to construct temporary piping system. Do not block access points such as stairs, doors, and walkways to existing facilities unless approved in writing by the Owner.

C. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
   1. When piping is buried, use concrete thrust block or mechanical restraints.
   2. When piping is exposed or under water, use mechanical or structural restraints.
   3. Determine thrust forces by multiplying the nominal cross sectional area of the piping by the operating pressure of the piping.

D. Install temporary piping systems in a manner that will not damage existing or new facilities.

E. Piping material, including gaskets: Suitable for the process fluid requiring temporary piping, unless indicated otherwise.

F. After temporary piping system is no longer required:
   1. Remove temporary piping system.
   2. Clean and repair damage caused by installation or use of temporary piping system.
   3. Restore existing facilities to original condition.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01600

PRODUCT REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for tangible materials, raw or manufactured, that become part of the project.

1.02 REFERENCES

A. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

1.03 DEFINITIONS

A. Certificates: Describe certificates that document affirmations by the Contractor or other entity that the work is in accordance with the Contract Documents.

B. Extra stock materials: Describe extra stock materials to be provided for the Owner's use in facility operation and maintenance.

C. Manufacturer's instructions:
   1. Stipulations, directions, and/or recommendations issued in printed form by the manufacturer of the product addressing handling, installation, erection, and/or application of the product.

D. Products:
   1. Raw materials, finished goods, equipment, systems, and shop fabrications.

E. Product data:
   1. Public information about the product which is found in the manufacturer's catalogs or on their web site including catalog pages, data sheets, bulletins, and brochures.

F. Samples:
   1. As defined in the General Conditions and Supplementary Conditions.
   2. Full-size actual products or pieces of products intended to illustrate the products to be incorporated into the project. Sample submittals are often necessary for such characteristics as colors, textures, and other appearance issues.

G. Schedules:
   1. Product parts and materials lists.

H. Shop drawings:
   1. As defined in the General Conditions and Supplementary Conditions.

2. Shop drawings are prepared specifically for the project to illustrate details, dimensions, and other data necessary for satisfactory fabrication or construction that are not shown in the contract documents. Shop drawings could include graphic line-type drawings, single-line diagrams, or schedules and lists of products and their application.

I. Spare parts:
   1. Duplicate parts necessary to replace a damaged or worn part of the product.
   2. Consumables such as operating fluids.

J. Special tools:
   1. Special wrenches, gauges, circuit setters, and other similar devices required for the proper operation or maintenance of a system that would not normally be in the Owner's tool kit and that have been specifically made for use on a product for assembly, disassembly, repair, or maintenance.

K. Source Quality Control:
   1. Testing and inspections at the location of fabrication or assembly.
   2. Includes Factory Acceptance Testing (FAT), Factory Testing, and Source Testing.
   3. Test reports including the following information:
      a. Test description.
      b. List of equipment used.
      c. Name of the person conducting the test.
      d. Date and time the test was conducted.
      e. Ambient temperature and weather conditions.
      f. Raw data collected.
      g. Calculated results.
      h. Clear statement if the test passed or failed the requirements stated in Contract Documents.
      i. Signature of the person responsible for the test.

L. Submittals:
   1. As defined in the General Conditions and Supplementary Conditions.
   2. Samples, product data, shop drawings, and others that demonstrate how Contractor intends to conform to the Contract Documents.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Products in contact with drinking water:
   1. Provide certification for by an independent ANSI accredited third party.
      a. In accordance with NSF 61.
      b. Weighted average lead content of less than 0.25 percent in accordance with NSF 372.
      c. In accordance with California Health and Safety Code, Section 116875.

1.05 GENERAL REQUIREMENTS

A. Comply with specified requirements.

B. Provide products by same manufacturer when products are of similar nature, unless otherwise specified.

C. Provide like parts of duplicate units that are interchangeable.

D. Provide equipment or product that has not been in service prior to delivery, except as required by tests.

E. Provide manufacturer’s standard products when available.

F. Provide products produced by manufacturers regularly engaged in the production of these products.

G. Provide products that bear approvals and labels as specified.

1.06 QUALITY CONTROL

A. Manufacturer to provide permanent quality control department and laboratory facility capable of performing inspections and testing as required by the Contract Documents.
   1. Material testing, inspection procedures, and manufacturing process are subject to inspection by Engineer.
   2. Contractor shall notify Engineer in writing of the manufacturing start date not less than 14 days prior to the start of manufacturer of project pipe.
   3. Perform manufacturer’s tests and inspections required by the referenced standards and as specified in this Section including the following:
      a. Provide the Manufacturer's Certificate of Source Testing.
      b. Calibration within last 12 months for equipment such as scales, measuring devices and calibration tools used in the manufacturing of pipe as required by ISO 9001.
         1) Each device used in the manufacturer of pipe is required to have a tag recording date of last calibration.
         2) Provide calibration certificate.
         3) Devices are subject to inspection by Engineer.

PART 2 PRODUCTS

2.01 GENERAL

A. Material requirements:
   1. Materials: Provide corrosion resistance suitable for project conditions as specified in Section 01610 - Project Design Criteria.
   2. Dissimilar metals: Separate contacting surfaces with dielectric material.

B. Edge grinding:
   1. Sharp projections of cut or sheared edges of ferrous metals which are not to be welded shall be ground to a radius required to ensure satisfactory paint adherence.

C. Aluminum in contact with concrete or masonry: Apply epoxy mastic.

D. Provide new pipe manufactured for the project, not from manufacturer's inventory, under the following conditions:
   1. Pipe 24-inch diameter and larger.
   2. Pipe material subject to UV degradation manufactured more than 6 months prior to delivery to the project.
   3. Pipe with coating material subject to UV degradation manufactured more than 6 months prior to delivery to the project.
   4. Ductile iron pipe with cement-mortar lining manufactured more than 6 months prior to delivery to the project.
   5. Steel pipe 6-inch diameter and larger.

E. Mark each length of pipe in accordance with applicable standards.

2.02 PRODUCT SELECTION

A. When products are specified by standard or specification designations of technical societies, organizations, or associations only, provide products that meet or exceed reference standard and Specifications.

B. When products are specified with names of manufacturers but no model numbers or catalog designations, provide:
   1. Products by one of named manufacturers that meet or exceed Specifications.
   2. Engineer deemed "or equal" evidenced by an approved shop drawing or other written communication.

C. When products are specified with names of manufacturers and model numbers or catalog designations, provide:
   1. Products with model numbers or catalog designations by one of named manufacturers.
   2. Engineer deemed "or equal" evidenced by an approved shop drawing or other written communication.

D. When products are specified with names of manufacturers, but with brand or trade names, model numbers, or catalog designations by one manufacturer only, provide:
   1. Products specified by brand or trade name, model number, or catalog designation.
   2. Products by one of named manufacturers proven, in accordance with requirements for an "or equal", to meet or exceed quality, appearance and performance of specified brand or trade name, model number, or catalog designation.
   3. Engineer deemed "or equal" evidenced by an approved shop drawing or other written communication.

E. When Products are specified with only one manufacturer followed by "or Equal," provide:
   1. Products meeting or exceeding Specifications by specified manufacturer.
   2. Engineer deemed "or equal" evidenced by an approved shop drawing or other written communication.

2.03 SHIPMENT

A. Requirements prior to shipment of equipment:
   1. Engineer approved shop drawings.

2. Engineer approved Manufacturer's Certificate of Source Testing when required by specifications.
3. Draft operations and maintenance manuals, as specified in Section 01782 - Operation and Maintenance Manuals, when required by specifications.

B. Prepare products for shipment by:
1. Tagging or marking products to agree with delivery schedule or shop drawings.
2. Including complete packing lists and bills of material with each shipment.
3. Packaging products to facilitate handling and protection against damage during transit, handling, and storage.
4. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

C. Transport products by methods that avoid product damage.

D. Deliver products in undamaged condition in manufacturer's unopened containers or packaging.

2.04 SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. Provide spare parts and maintenance products as required by Technical Sections.

B. Provide one set of special tools required to install or service the equipment.

C. Box, tag, and clearly mark items.

D. Contractor is responsible for spare parts, maintenance products, and special tools until acceptance by Owner.

E. Immediately store products not to be incorporated into the work in accordance with the manufacturer's instructions.

F. Add product to the Spare Parts, Maintenance Products, and Special Tools Inventory List - form as given in Appendix B.

G. Store spare parts, maintenance products, and special tools in enclosed, weather-proof, and lighted facility during the construction period:
1. Protect parts subject to deterioration, such as ferrous metal items and electrical components with appropriate lubricants, desiccants, or hermetic sealing.

H. With Owner's written request for advanced delivery of spare parts, maintenance products, and special tools.
1. Deliver requested items and deduct them from the inventory list.
2. Provide transmittal documentation.

I. Provide spare parts and special tools inventory list, see Appendix B:
1. Equipment tag number.
2. Equipment manufacturer.
3. Subassembly component, if appropriate.
4. Quantity.
5. Storage location.

J. Store large items individually:
   1. Weight: Greater than 50 pounds.
   2. Size: Greater than 24 inches wide by 18 inches high by 36 inches long.
   3. Clearly labeled:
      a. Equipment tag number.
      b. Equipment manufacturer.
      c. Subassembly component, if appropriate.

K. Store in spare parts box smaller items:
   1. Weight: Less than 50 pounds.
   2. Size: Less than 24 inches wide by 18 inches high by 36 inches long.
   3. Clearly labeled:
      a. Equipment tag number.
      b. Equipment manufacturer.
      c. Subassembly component, if appropriate.

L. Spare parts and special tools box:
   1. Box material: Waterproof, corrosion resistant.
   2. Hinged cover:
      a. Locking hasp.
   3. Spare parts inventory list taped to underside of cover.
   4. Clearly labeled:
      a. The words “Spare Parts and/or Special Tools”.
      b. Equipment tag number.
      c. Equipment manufacturer.
      d. Subassembly component, if appropriate.

PART 3 EXECUTION

3.01 DELIVERY AND HANDLING

A. Handle equipment in accordance with manufacturer's instructions.

B. Provide construction equipment and personnel to handle products by methods to prevent soiling or damage.

C. Upon delivery, promptly inspect shipments:
   1. Verify compliance with Contract Documents, correct quantities, and undamaged condition of products.
   2. Acceptance of shipment does not constitute final acceptance of equipment.

3.02 STORAGE AND PROTECTION

A. Immediately store and protect products and materials until installed in Work.

B. Furnish covered, weather-protected storage structures providing a clean, dry, noncorrosive environment for mechanical equipment, valves, architectural items, electrical and instrumentation equipment and special equipment to be incorporated into this project:
   1. Storage of equipment shall be in strict accordance with the “instructions for storage” of each equipment supplier and manufacturer including connection of heaters, placing of storage lubricants in equipment, rotating equipment, etc.

2. The Contractor shall furnish a copy of the manufacturer's instructions for storage to the Engineer prior to storage of equipment and materials.
3. Maintain products within temperature and humidity ranges required or recommended by manufacturer.

C. Store products with seals and legible labels intact.

D. Protect painted or coated surfaces against impact, abrasion, discoloration, and damage:
1. Repaint or recoat damaged painted or coated surfaces.

E. Exterior storage of fabricated products:
1. Place on aboveground supports that allow for drainage.
2. Cover products subject to deterioration with impervious sheet covering.
3. Provide ventilation to prevent condensation under covering.

F. Store moisture sensitive products in watertight enclosures.

G. Store loose granular materials on solid surfaces in well-drained area:
1. Prevent materials mixing with foreign matter.
2. Provide access for inspection.

H. If approved by the Engineer, provide offsite storage location within 20 miles of the project site:
1. Provide proof of insurance coverage for products stored offsite.

I. Payment will not be made for equipment and materials improperly stored or stored without providing Engineer with the manufacturer's instructions for storage.

J. Provide an equipment log and stored products log with monthly pay applications:
1. Data includes as a minimum: The storage location, equipment or product identification, date stored, date of inspection/maintenance, date removed from storage, copy of manufacturer's recommended storage guidelines, description of inspection/maintenance activities performed, and signature of party performing inspection/maintenance.

3.03 PROTECTION AFTER INSTALLATION

A. Provide substantial coverings as necessary to protect installed products from damage from traffic and subsequent construction operations:
1. Remove covering when no longer needed.
2. Replace corroded, damaged, or deteriorated equipment, product, or parts before acceptance of the project.

B. Update equipment log on a monthly basis with description of maintenance activities performed in accordance with the manufacturer's recommendation and industry standards and signature of party performing maintenance.

3.04 ATTACHMENTS

A. Appendix A - Spare Parts, Maintenance Products, and Special Tools Inventory List.

END OF SECTION

APPENDIX A
SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS INVENTORY LIST

Owner: _____ **Date:** _____

Contractor: _____ **Project No.:** _____

Project Name: _____

Inventory List				
Spec Number: _____		Spec Title _____		
Equipment Tag No.: _____		Equipment Manufacturer: _____		
Quantity	**Subassembly Component**	**Description**	**Manufacturer's Part Number**	**Storage Location**

SECTION 01610

PROJECT DESIGN CRITERIA

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Project design criteria such as temperature and site elevation.

1.02 PROJECT DESIGN CRITERIA

A. Equipment and materials for the project are to be suitable for performance in wastewater treatment plant environment and under following conditions:
   1. Design temperatures are:
      a. Outdoor temperatures: 25 to 110 degrees Celsius.
   2. Design groundwater elevation: +4.00.
   3. Moisture conditions: Defined in individual equipment sections.
   4. Marine environment with coastal fog and sea salt spray**.**

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01612

SEISMIC DESIGN CRITERIA

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Seismic design criteria for the following:
   1. Anchorage of mechanical and electrical equipment.
   2. Seismic design and design of anchorage for small tanks fabricated off site and shipped to the Project site.
   3. Other structures or items as specified or indicated on the Drawings.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. 7-16 - Minimum Design Loads for Buildings and Other Structures.

1.03 SYSTEM DESCRIPTION

A. Design in accordance with the requirements of the building code as specified in Section 01410 - Regulatory Requirements.

B. Risk Category:

Table 1: Risk Category	
Structure/Area	**Risk Category**
All	III

C. Design spectral acceleration at short period, S_{DS}: 0.976g.

D. Design of non-structural components and their connections to structures:
   1. Component amplification factor, a_p: In accordance with ASCE 7, Tables 13.5-1 and 13.6-1.
   2. Component response modification factor, R_p: In accordance with ASCE 7, Tables 13.5-1 and 13.6-1.
   3. Component importance factor, I_p:

Table 2: Component Importance Factor, I_p		
Rick Category	**Description**	**Ip**
All	Equipment and as specified in Division **16** - Electrical.	1.5
II or III	Equipment and components as specified in Divisions 6-15.	1.0

E. Seismic Design Category (SDC):
   1. Seismic Design Category (SDC) for certification of mechanical and electrical equipment as required by ASCE 7:
      a. All areas: Seismic Design Category D.

F. Design requirements: Anchorage of equipment to structures:
   1. Do not use friction to resist sliding due to seismic forces. Do not design or provide connections that use friction to resist seismic loads. Resist seismic forces through direct tension and/or direct bearing in shear on anchors and fasteners.
   2. Do not use more than 60 percent of the weight of the mechanical and electrical equipment for designing anchors for resisting overturning due to seismic forces.
   3. Do not use more than 60 percent of the weight of the tank for resisting overturning due to seismic forces.
   4. Anchoring and fastening to concrete and masonry:
      a. Use only cast-in anchors (anchor bolts, anchor rods, or welded studs) specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry, for anchoring at connections that resist seismic forces:
         1) Do not use, sleeve anchors, screw anchors, powder actuated fasteners, or other types of post-installed mechanical anchors unless indicated on the Drawings or accepted in writing by the Engineer.
      b. Anchors provided under the following Specifications shall hold a current Evaluation Service report allowing use in Seismic Design Categories indicated for this Work:
         1) Post-installed mechanical anchors specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
         2) Post-installed adhesive bonded anchors specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.
         3) Post-installed adhesive bonded anchors specified in Section 04055 - Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry.
   5. Anchor bolt holes in equipment support frames:
      a. Do not exceed bolt diameter by more than 25 percent, up to a maximum diameter equal to that of the bolt plus 1/4 inch.

1.04 SUBMITTALS

A. Shop drawings and calculations: Complete shop drawings and seismic calculations for anchorage to structures.

B. Calculations shall be signed and sealed by a civil or structural engineer licensed in the state where the Project is located.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01614

WIND DESIGN CRITERIA

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Wind design criteria.

1.02 SYSTEM DESCRIPTION

A. Design requirements:
   1. Building code criteria: Design for wind in accordance with building code as specified in Section 01410 - Regulatory Requirements:
      a. Risk category: III.
      b. Basic Wind speed, V: 99 miles per hour.
      c. Exposure category: C.
      d. Topographic factor, K_{zt}: 1.0
   2. Resist wind forces through direct bearing on anchors and fasteners. Do not design or provide connections that use friction to resist wind loads.
   3. Anchoring and fastening to concrete and masonry:
      a. Provide anchors specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All-Thread Rods and 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
      b. Do not use flush shells, sleeve anchors, flush shells, screw anchors, powder actuated fasteners, or other types of post-installed mechanical anchors unless indicated on the Drawings or accepted in writing by the Engineer.

1.03 SUBMITTALS

A. Shop drawings and calculations: Complete shop drawings and wind design calculations.

B. Calculations shall be signed and stamped by a civil or structural engineer licensed in the state where the Project is located.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01722

FIELD ENGINEERING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Field engineering to establish lines and grades for the Work.

1.02 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Qualifications of the professional land surveyor or registered civil engineer in the state where project is located that will be performing the field engineering.

C. Pre-Excavation Report.

1.03 PRE-EXCAVATION REPORT

A. Prior to the start of the Work, create a report confirming the verification of the following data:
   1. Site elevation.
   2. Existing structures including but not limited to buildings, manholes (sanitary, storm, electrical, and other), drainage inlets:
      a. Location coordinates.
      b. Top of wall elevation and coordinates.
      c. Floor elevations.
      d. Invert elevations.
   3. Existing utilities. Concealed Existing Utilities.
   4. Proposed building corners, tank, and equipment locations.
   5. Verify existing electrical, instrumentation, and phone utilities.

B. Incorporate information from Pre-Excavation Report into the record drawings.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 SURVEY REFERENCE POINTS

A. Basic reference line, a beginning point on basic reference line, and a benchmark will be provided by Owner.

B. From these reference points, establish other control and reference points as required to properly lay out the Work.

C. Locate and protect control points prior to starting site work, and preserve permanent reference points during construction:
   1. Make no changes or relocations without prior written notice.
   2. Replace Project control point, when lost or destroyed, in accordance with original survey control.

D. Set monuments for principal control points and protect them from being disturbed and displaced:
   1. Re-establish disturbed monuments.
   2. When disturbed, postpone parts of the Work that are governed by disturbed monuments until such monuments are re-established.

3.02 PROJECT SITE SURVEY REQUIREMENTS

A. Establish minimum of 2 permanent benchmarks on site referenced to data established by survey control points.

B. Record permanent benchmark locations with horizontal and vertical data on Project Record Documents.

C. Perform verifications and checking in accordance with standard surveying practice.

D. Maintain complete, accurate log of control points and survey.

E. Affix civil engineer's or professional land surveyor's signature and registration number to Record Drawings to certify accuracy of information shown.

3.03 CONSTRUCTION STAKES, LINES, AND GRADES

A. Execute the Work in accordance with the lines and grades indicated.

B. Make distances and measurements on horizontal planes, except elevations and structural dimensions.

3.04 QUALITY CONTROL

A. Accuracy of stakes, alignments, and grades may be checked randomly by Engineer:
   1. Notice of when checking will be conducted will be given.
   2. When notice of checking is given, postpone parts of the Work affected by stakes, alignments, or grades to be checked until checked.
   3. Engineer's check does not substitute or complement required field quality control procedures.

3.05 RECORD DOCUMENTS

A. Prepare and submit Record Documents as specified in Section 01770 - Closeout Procedures.

B. Provide certified site survey including buildings, benchmarks, and appurtenances sealed and signed by professional land surveyor or registered civil engineer:
   1. File with permitting agency, as required.

END OF SECTION

SECTION 01738

SELECTIVE ALTERATIONS AND DEMOLITION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cutting or modifying of existing and new work.
   2. Partial demolition of structures.
   3. In-place abandonment of pipe.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. A10.6 - Safety and Health Program Requirements for Demolition Operations.

B. International Concrete Repair Institute (ICRI):
   1. Guideline No. 310.2R - Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.
   2. Guideline No. 310.3R - Guide for the Preparation of Concrete Surfaces for Repair Using Hydrodemolition Methods.

1.03 DEFINITIONS

A. Chipping hammer: A hand-operated electrical or pneumatic demolition device for removal of hardened concrete or masonry materials having a weight of less than 15 pounds and an impact frequency of greater than 2,000 blows/minute.

B. Concrete breaker: A hand-operated electrical or pneumatic demolition device for removal of hardened concrete or masonry materials having a weight greater or impact frequency less than the limits defined for a chipping hammer.

C. Coring equipment: Non-impact rotary drill with diamond cutting edges.

D. Heavy abrasive blast: Cleaning procedure by which various abrasives materials, or steel shot, are forcibly propelled by high pressure against a surface to remove loose material and produce a concrete surface roughened to ICRI Surface Profile CSP-7, or higher, as specified in ICRI 301.3R.

1.04 DESCRIPTION OF WORK

A. The work includes partial demolition, cutting, and modifying of existing facilities, utilities, and/or structures.

B. These facilities may be occupied and/or operational. Satisfactory completion of the work will require that the Contractor plan activities carefully to work around unavoidable obstacles and to maintain overall stability of structures and structural elements. It will further require restoration of existing facilities, utilities, and structures that are to remain in place and that are damaged by demolition or removal operations.

1.05 SUBMITTALS

A. General:
   1. Submit specified in Section 01330 - Submittal Procedures.

B. Shop drawings: Include:
   1. The location of all embedded items shall be documented using diagrams and/or other media that clearly show dimensions and locations of existing structural elements, existing embedded items and any new embedded items and their relationship to each other.

C. Submittals for information only:
   1. Permits and notices authorizing demolition.
   2. Certificates of severance of utility services.
   3. Permit for transport and disposal of debris.
   4. Selective Demolition Plan.
   5. Pipe Abandonment Plan.

D. Quality assurance submittals:
   1. Qualifications of non-destructive testing agency/agencies.

E. Project record documents.

F. Drawings and/or other media documenting locations of service lines and capped utilities.

1.06 QUALITY ASSURANCE

A. Qualifications:
   1. Assign relocation, removal, cutting, coring, and patching to trades and workers qualified to perform the Work in manner that causes the least damage and that provides means of returning surfaces to an appearance at least equal to that of the surrounding areas unaffected by the Work.
   2. Non-destructive testing agencies: Minimum of 5 years' experience performing non-destructive testing for location of steel reinforcement in existing concrete under conditions similar to that required for this Work.

1.07 SEQUENCING

A. Perform Work in sequences and within times specified in Section 01140 - Work Restrictions.

B. If the facility or utility to be modified cannot be removed from service, perform the Work while the facility is in operation using procedures and equipment that do not jeopardize operation or materially reduce the efficiency of that facility.

C. Coordinate the Work with operation of the facility:
   1. Do not begin alterations of designated portions of the Work until specific permission for activities in each area has been granted by Owner in writing.
   2. Complete Work as quickly and with as little delay as possible.

D. Operational functions of the facility that are required to be performed to facilitate the Work will be performed by facility personnel only.

E. Owner will cooperate in every way practicable to assist in expediting the Work.

F. When necessary for the proper operation or maintenance of portions of the facility, reschedule operations so the Work will not conflict with required operations or maintenance.

1.08 REGULATORY REQUIREMENTS

A. Dispose of debris in accordance with governing regulatory agencies.

B. Comply with applicable air pollution control regulations.

C. Obtain permits for building demolition, transportation of debris to disposal site and dust control.

1.09 PROJECT CONDITIONS

A. Do not interfere with use of adjacent structures and elements of the facility not subject to the Work described in this Section. Maintain free and safe passage to and from such facilities.

B. Provide, erect, and maintain barricades, lighting, guardrails, and protective devices as required to protect building occupants, general public, workers, and adjoining property:
   1. Do not close or obstruct roadways without permits.
   2. Conduct operations with minimum interference to public or private roadways.

C. Prevent movement, settlement, or collapse of structures**,** adjacent services, sidewalks, driveways and trees:
   1. Provide and place bracing or shoring.
   2. Cease operations and notify Engineer immediately when safety of structures appears to be endangered. Take precautions to properly support structure. Do not resume operations until safety is restored.
   3. Assume liability for movement, settlement, or collapse. Promptly repair damage.

D. Arrange and pay for capping and plugging utility services. Disconnect and stub off:
   1. Notify affected utility company in advance and obtain approval before starting demolition.
   2. Place markers to indicate location of disconnected services.

E. Unknown conditions:
   1. The drawings may not represent all conditions at the site and adjoining areas. Compare actual conditions with drawings before commencement of Work.

2. Existing utilities and drainage systems below grade are located from existing documents and from surface facilities such as manholes, valve boxes, area drains, and other surface fixtures.
3. If existing active services encountered are not indicated or otherwise made known to the Contractor and interfere with the permanent facilities under construction, notify the Engineer in writing, requesting instructions on their disposition. Take immediate steps to ensure that the service provided is not interrupted, and do not proceed with the Work until written instructions are received from the Engineer.

PART 2 EXECUTION

2.01 EXAMINATION

A. Prior to beginning selective demolition operations, perform a thorough inspection of the facility and site, and report to the Engineer defects and structural damage to or deterioration of existing construction to remain.

B. Examine areas affected by the Work and verify the following conditions prior to commencing demolition:
   1. Disconnection of utilities as required.
   2. That utilities serving occupied or active portions of surrounding facilities will not be disturbed, except as otherwise indicated.

C. If unsatisfactory conditions exist, notify the Engineer, and do not begin demolition operations until such conditions have been corrected.

2.02 PREPARATION

A. Selective Demolition Plan:
   1. Prepare and submit a comprehensive selective demolition plan for the Work including the following elements, at a minimum:
      a. Proposed sequence, methods, temporary support, and equipment for demolition, removal, and disposal of portions of structure(s).
      b. Provisions and procedures for salvage and delivery to Owner of salvaged items, if required.
   2. Plan shall be signed and sealed by a Professional Engineer registered in the state where Project is located.
   3. Submit plan a minimum 4 weeks before demolition is scheduled to begin.

B. Protection:
   1. Erect weatherproof closures to protect the interior of facilities and elements or equipment that are not designed for exposure to the weather. Provide temporary heat, cooling, and humidity control as necessary to prevent damage to existing and new construction. Maintain existing exiting paths and/or provide new paths in compliance with Building Code requirements.
   2. Erect and maintain dustproof partitions as required to prevent spread of dust, to other parts of building. Maintain negative pressure in the area where the Work is being performed to prevent the accidental spread of dust and to minimize the spread of fumes related to the Work.
   3. Upon completion of Work, remove weatherproof closures and dustproof partitions, and repair damaged surfaces to match adjacent surfaces.

4. Provide and maintain protective devices to prevent injury from falling objects.
5. Locate guardrails in stairwells and around open shafts to protect workers. Post clearly visible warning signs.
6. Cause as little inconvenience to adjacent building areas as possible.
7. Protect landscaping, benchmarks**,** and existing construction to remain from damage or displacement.
8. Carefully remove designated materials and equipment to be salvaged by Owner or reinstalled.
9. Store and protect materials and equipment to be reinstalled.

C. Layout:
1. The limits of selective demolition are indicated on the Drawings. Confine demolition operations within the limits indicated on the Drawings.
2. Lay out demolition and removal work at the site and coordinate with related Work for which demolition and removal is required. Clearly mark the extent of structural elements to be removed on the actual surfaces that will be removed.
3. Arrange for Engineer's inspection of the lay out extents.
4. Do not begin demolition/removal operations until the lay out markings have been reviewed by the Engineer.

2.03 DEMOLITION

A. General:
1. Perform demolition work in accordance with ANSI A10.6.
2. Demolish designated portions of structures and appurtenances in orderly and careful manner in accordance with the Selective Demolition Plan.
3. Conduct demolition and removal work in a manner that will minimize dust and flying particles:
   a. Use water or dust palliative when necessary to prevent airborne dust.
   b. Provide and maintain hoses and connections to water main or hydrant.
4. Demolish concrete and masonry in small sections. Perform demolition with small tools as much as possible. Blasting with explosive charges is not permitted.
5. Remove materials carefully, to the extent indicated and as required:
   a. Provide neat and orderly junctions between existing and new materials.
   b. Use methods that terminate surfaces in straight lines at natural points of division.
6. Do not remove anything beyond the limits of Work indicated without prior written authorization of the Engineer. If in doubt about whether to remove an item, obtain written authorization of the Engineer prior to proceeding.
7. Perform work so as to provide the least interference and most protection to existing facilities to remain.
8. Assume possession of demolished materials, unless otherwise indicated on the Drawings or specified:
   a. Remove demolished materials from site at least daily and dispose of in accordance with Laws and Regulations.
   b. Do not burn materials on site.

B. Pump out buried tanks. Remove tanks and service piping from site**.**

C. Immediately upon discovery, remove and dispose of contaminated, vermin-infested, or dangerous materials using safe means that will not endanger health of workers and public.

D. Remove trees and shrubs within marked areas; clear undergrowth and dead plant material as specified in Section 02300 - Earthwork.

E. Backfill open pits and holes caused by demolition as specified in Section 02300 - Earthwork.

F. Rough grade areas affected by demolition.

G. Remove demolished materials, tools, and equipment upon completion of demolition.

2.04 RESTORATION

A. General:
   1. Repair damage caused by demolition to conditions equal to those that existing prior to beginning of demolition:
      a. Patch and replace portions of existing finished surfaces that are damaged, lifted, and discolored with matching material. Refinish patched portion surfaces in a manner which produces uniform color and texture to entire surface.
      b. When existing finish cannot be matched, refinish entire surface to nearest change of plane where angle of change exceeds 45 degrees.
   2. The cost of repairs shall be at the Contractor’s expense at no increase in the Contract Price.

2.05 FIELD QUALITY CONTROL

A. Do not proceed with demolition without Engineer's inspection of lay out.

B. Do not deviate from the submitted demolition plan without notifying the Engineer prior to Work.

END OF SECTION

SECTION 01756

COMMISSIONING
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PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for each Commissioning phase of, the Project equipment/system and/or facility.

1.02 DEFINITIONS

A. Clean Water Facility Testing - Testing of complete facility utilizing clean water for purposes of confirming extended equipment/system operation prior to Process Start-up Phase.

B. Commissioning - The process of planning, testing, and process start-up of the installation for compliance with contract requirements and demonstrating, through documented verification, that the project has successfully met the Contractual requirements. It includes training the Owner's staff to operate the facility.

C. Commissioning Phases - The work activities of facility commissioning are grouped into the phases defined in the table below.

Commissioning		
Planning Phase	**Testing and Training Phase**	**Process Start-Up Phase**
Owner Training Plan and Schedule	Source Testing	Process Start-up
Commissioning Schedule	Owner Training	Process Operational Period
Subsystem Testing Plan	Installation Testing	PCIS Optimization and Fine-Tuning
Clean Water Facility Testing Plan	Functional Testing	
	Clean Water Facility Testing	
	Closeout Documentation	

D. Component - A basic building block of equipment, subsystems, and systems that requires installation or functional testing but does not have an electrical connection or internal electronics. (Examples: filter effluent piping and manual isolation valves).

E. Device - A basic building block of equipment, subsystems, and systems that requires installation or functional testing and does have an electrical connection or internal electronics. (Examples: filter level transmitter or water pump pressure transmitter).

F. Equipment - An assembly of component(s) and devices(s) that requires installation or functional testing. (Examples: Pump, motor, VFD, Ozone Generator, UV Disinfection System, etc.).

G. Facility - A grouping of process areas, systems, subsystems, equipment, components, and devices (Examples: treatment plant, pump station, etc.).

H. Functional Testing - Testing performed on a completed subsystem to demonstrate that equipment/system meets manufacturers' calibration and adjustment requirements and other requirements as specified. Functional testing includes operating equipment/system manually in local, manually in remote (or remote manual), and automatically in remote (in remote auto).

I. Installation Testing - Testing to demonstrate that subsystem component (piping, power, networks, devices, etc.) is ready and meets the project requirements in advance of functional testing. Installation testing also includes manufacturers' certification of installation and other requirements as specified to prepare equipment/system for Functional Testing. Also referred to as Field Acceptance Testing.

J. Manufacturer's Certificate of Source Testing - When applicable, the form is used during Source Testing for the manufacturer to confirm that the applicable source tests have been performed and results conform to the Contract Documents. The form is provided at the end of this Section.

K. Manufacturer's Certificate of Installation and Functionality Compliance - The form is used during Installation Testing and Functional Testing. It is submitted at the end of Functional Testing to confirm that the equipment/system is installed in conformance with the Contract Documents and that it meets the Functional Testing requirements defined in the Contract Documents. The form is provided at the end of this Section.

L. PCIS Optimization and Fine-Tuning - Test and adjust the entire process control system under standard operating conditions.

M. Process Area - A grouping of systems, subsystems, equipment, components, and devices that divide a facility into functional areas. (Examples: Filter Process Area or Chemical Area).

N. Process Operational Period - A period of time after completion of the process start-up set aside for final Operational Testing to verify facility performance meets the Contract Document requirements. This period may specifically limit other construction activities.

O. Process Start-up Phase - Operating the facility to verify performance meets the Contract Document requirements.

P. Process Start-Up - Activities conducted after the testing and training phase that are necessary to place systems or process areas into operational service.

Q. Product - A system, subsystem or component.

R. Subsystem - A building block of systems made up from a grouping of components, devices, and equipment that perform a definable function. (Examples: Filter No. 1 Backwash Subsystem, Sedimentation Basin No. 1 Hoseless Sludge Removal Subsystem).

S. System - A grouping of subsystems, equipment, components, and devices that perform a definable function. (Examples: Filter No. 1, Sedimentation Basin).

1.03 SUBMITTALS

A. Qualifications:
   1. Commissioning Coordinator's qualifications.
   2. Manufacturer's representative's qualifications.

B. Schedules:
   1. Owner Training Plan Schedule.
   2. Commissioning Schedule.

C. Certificates:
   1. Manufacturer's Certificate of Source Testing.
   2. Manufacturer's Certificate of Installation and Functionality Compliance.

D. Reports:
   1. Test reports.

E. Plans:
   1. Owner Training Plan.
   2. Source Test Plan.
   3. Installation and Functional Testing Plan:
      a. Subsystem Testing Plans.
   4. Clean Water Facility Testing Plan.
   5. Process Start-Up Plan:
      a. Process Start-Up.
      b. Process Operational Period.
      c. PCIS Optimization and Fine-Tuning.
   6. Final Operational Testing Plan.

F. Documentation:
   1. Preliminary documentation.
   2. Final documentation.
   3. Closeout documentation.

1.04 COMMISSIONING COORDINATOR (CC)

A. Designate and provide a CC for this project:
   1. Submit summary of the CC's qualifications within 30 days of NTP:
      a. Include description of previous experience as a CC on similar projects for the designated CC with a list of references including phone numbers for review and Owner approval.
   2. The CC must have minimum of 10 years of experience in similar construction projects.

B. CC responsibilities include the following:
   1. Lead efforts relating to Commissioning.
   2. Be thoroughly familiar with commissioning requirements in the Contract Documents.
   3. Be regularly engaged and experienced in all aspects of commissioning.
   4. Provide technical instruction for commissioning.

5. Provide primary interface with Engineer and Owner for efforts relating to Commissioning of Project facilities.
6. Coordinate training efforts.

1.05 SERVICES OF MANUFACTURER'S REPRESENTATIVES

A. Qualification of manufacturer's representative as specified in the Contract Documents technical sections include the following:
   1. Authorized representative of the manufacturer, factory trained and experienced in the technical applications, installation, operation, and maintenance of respective equipment/system with full authority by the equipment/system manufacturer to issue the certifications required of the manufacturer.
   2. Competent, experienced technical representative of equipment/system manufacturer for assembly, installation, testing guidance, and training.
   3. Additional qualifications may be specified in the individual sections.
   4. Submit qualifications of the manufacturer's representative no later than 30 days in advance of required observations.
   5. Representative subject to approval by Owner and Engineer.
   6. No substitute representatives will be allowed until written approval by Owner and Engineer has been obtained.

B. Completion of manufacturer on-site services: Engineer approval required.

C. Manufacturer is responsible for determining the time required to perform the specified services:
   1. Minimum times specified in the Contract Documents are estimates.
   2. No additional costs associated with performing the required services will be approved.
   3. Manufacturer required to schedule services in accordance with the Contractor's project schedule up to and including making multiple trips to project site when there are separate milestones associated with installation of each occurrence of manufacturer's equipment.

D. Manufacturer's on-site services as specified in the Contract Documents include the following:
   1. Assistance during Commissioning Phase and Process Start-Up Phase.
   2. Provide copies of manufacturer's representatives field notes and data to Engineer.
   3. Other requirements as specified in the Contract Documents.

1.06 PLANNING PHASE

A. Overview of Planning Phase:
   1. Define approach and timing for Commissioning.

B. Owner training plan and schedule:
   1. Training outcomes:
      a. Owner's operations, maintenance, and engineering staff have the information needed to safely operate, maintain, and repair the equipment/systems provided in the Contract Documents.

2. Training objectives:
    a. To instruct personnel in the operation and maintenance of the equipment/system. Instruction shall include step-by-step troubleshooting procedures with all necessary test equipment/system.
    b. To instruct personnel in the removal, inspection, and cleaning of equipment/system as needed.
    c. Training tailored to the skills and job classifications of the staff attending the classes (e.g., plant superintendent, treatment plant operator, maintenance technician, electrician, etc.).
    d. Provide supporting documentation, such as vendor operation and maintenance manuals.
3. Training schedule:
    a. Schedule Owner's staff training within the constraints of their workloads. Those who will participate in this training have existing full-time work assignments, and training is an additional assigned work task, therefore, scheduling is imperative. Owner staff work schedules regularly shift, as treatment facilities are typically operated on an around-the-clock basis.
4. Training plan:
    a. Coordinate and arrange for manufacturer's representatives to provide both classroom-based learning and field (hands-on) training, based on training module content and stated learning objectives.
    b. Conduct classroom training at location designated by Owner.
    c. Scope and sequence:
        1) Plan and schedule training in the correct sequence to provide prerequisite knowledge and skills to trainees:
            a) Describe recommended procedures to check/test equipment/system following a corrective maintenance repair.
5. Training scheduling coordination:
    a. CC is responsible for the following:
        1) Coordinate schedule for training periods with the Owner's personnel and manufacturer's representatives (instructors).
    b. Complete Owner training no sooner than 15 calendar days prior to start of process start-up of each system.
6. Meetings:
    a. CC is responsible for setting commissioning coordination meeting dates and times, as well as preparing the agendas and meeting minutes.
    b. CC shall meet with Engineer and Owner's designated training coordinator to develop list of personnel to be trained and to establish expected training outcomes and objectives at least 60 calendar days prior to commissioning of equipment/system.
    c. CC shall conduct commissioning progress meetings throughout construction, to plan, scope, coordinate, and schedule future activities, resolve problems, etc:
        1) Frequency: Monthly minimum. Increase frequency as needed based on complexity and quantity of commissioning activities.
7. Submittals:
    a. Submit Training Plan Schedule 30 calendar days before the first scheduled training session, including but not limited to lesson plans, participant materials, instructor's resumes, and training delivery schedules.

b. Submit training documentation including the following:
1) Training plan:
a) Training modules.
b) Scope and sequence statement.
c) Contact information for manufacturer's instructors including name, phone, and e-mail address.
d) Instructor qualifications.
2) Training program schedule:
a) Format: Bar chart:
(1) Additionally include in the Project Progress Schedule.
b) Contents:
(1) Training modules and classes.

8. Training sessions:
a. Provide training sessions for equipment/system as specified in the individual equipment/system section.

C. Commissioning Schedule:
1. Commissioning overview:
a. Comply with Commissioning Roles and Responsibilities Matrix specified at the end of this Section.
2. Submittal due date:
a. Submit Commissioning Schedule not less than 30 calendar days prior to planned initial commissioning of each subsystem or system.
3. Schedule requirements:
a. Schedule durations and float for commissioning activities to ensure Work does not fall behind schedule due to complications or delays during commissioning.
b. Time-scaled network diagram detailing the work to take place in the period between 60 calendar days prior to planned initial commissioning of equipment and systems, and prior to the date of Substantial Completion, together with supporting narrative.
c. Provide detailed schedule of commissioning activities including durations and sequencing requirements:
1) Identify the following activities:
a) Testing and Training Phase:
(1) Source Testing.
(2) Owner Training.
(3) Installation Testing.
(4) Functional Testing.
(5) Clean Water Facility Testing.
(6) Closeout Documentation.
b) Process Start-Up Phase:
(1) Process Start-Up.
(2) Process Operational Period.
(3) PCIS Optimization and Fine-Tuning.
d. Schedule manufacturer's services to avoid conflict with other on-site testing or other manufacturers' on-site services.
e. Verify that conditions necessary to allow successful testing to have been met before scheduling services.

D. Installation and Functional Testing Plan:
1. Submit Installation and Functional Testing Plan.

2. Subsystem testing plans:
    a. Submit separate testing plans for each individual subsystem and system that include the following:
        1) Approach to testing including procedures, schedule, and recirculation requirements.
        2) Test objective: Demonstrate subsystem meets the design requirements as specified in the technical sections.
        3) Test descriptions, forms, temporary systems (pumps, piping, etc.), shutdown requirements for existing systems, test forms, test logs, witness forms, and checklists to be used to control and document the required tests.
        4) Test forms: Include, but not limited to, the following information:
            a) Tag and name of equipment/system to be tested.
            b) Test date.
            c) Names of persons conducting the test.
            d) Names of persons witnessing the test, where applicable.
            e) Test data.
            f) Applicable project requirements.
            g) Check offs for each completed test or test step.
            h) Place for signature of person conducting tests and for the witnessing person, as applicable.
        5) Define start-up sequencing of unit processes:
            a) Include testing of alarms, interlocks, permissives, control circuits, capacities, speeds, flows, pressures, vibrations, sound levels, and other parameters.
            b) Provide detailed test procedures setting forth step-by-step descriptions of the procedures for systematic testing of equipment/system.
            c) Demonstrate proper rotation, alignment, speed, flow, pressure, vibration, sound level, adjustments, and calibration:
                (1) Perform initial checks in the presence of and with the assistance of the manufacturer's representative.
            d) Demonstrate proper operation of each control loop function including mechanical, electrical, alarms, local and remote controls, instrumentation, and other equipment/system functions:
                (1) Generate signals with test equipment/system to simulate operating conditions in each control mode.
    b. Engineer approval of test plan is required prior to performing test:
        1) Revise and update test plans based on review comments, actual progress, or to accommodate changes in the sequence of activities.
        2) Submit test reports for each phase of testing for each equipment/system.
        3) Engineer approval of preceding test reports is required prior to start of next test.
        4) Tests will be rescheduled if test plan is not approved by the required deadline:
            a) Contractor is responsible for any resulting delay.
    c. Contractor is responsible to reproduce and distribute final test procedures:
        1) Provide 3 copies for Engineer.
    d. Tests may commence only after Engineer has received approved test plan copies.

e. Submittals:
    1) Submit test plans not less than 15\ calendar days prior to planned installation testing of subsystem or system.
    2) Completed Manufacturer's Certificate of Installation and Functionality Compliance.
    3) Test procedures and forms: Provide signed-off copy of test forms and test reports upon completion of the test.
    4) Test reports:
        a) Submit preliminary copies within 1 day after testing completion.
        b) Submit final copies and report within 14 days after testing completion.

E. Clean Water Facility Testing Plan:
    1. Submit a Clean Water Facility Testing Plan equivalent to the requirements of the subsystem test plans a minimum of 30 calendar days prior to Clean Water Facility Testing.

1.07 TESTING AND TRAINING PHASE

A. Overview of Testing and Training Phase:
    1. General:
        a. Include specified Source Testing, Owner Training, Installation Testing, Functional Testing, Clean Water Facility Testing, and Closeout Documentation required by this Section and the technical sections.
    2. Contractor responsibilities:
        a. Furnish labor, , tools, equipment, instruments, and services required for and incidental to completing commissioning activities in accordance with the approved Commissioning Plans.
        b. Prior to testing, verify equipment protective devices and safety devices have been installed, calibrated, and tested.
        c. Acceptable tests: Demonstrate the equipment/system performance meets the requirements stated in the Contract Documents:
            1) When the equipment/system fails to meet the specified requirements, perform additional, more detailed, testing to determine the cause, correct, repair, or replace the causative components and repeat the testing that revealed the deficiency.

B. Source testing:
    1. Also referred to as factory testing or factory acceptance testing (FAT).
    2. Test components, devices, and equipment/system for proper performance at point of manufacture or assembly as specified in the technical sections.
    3. Notify the Engineer in writing when the equipment/system is ready for source inspection and testing.
    4. Source Test Plan:
        a. As specified in this Section and other technical sections.
        b. Source testing requirements as specified in technical sections:
            1) Non-witnessed: Provide Manufacturer's Certificate of Source Testing.
            2) Witnessed: 1 Owner's representative and 1 Engineer's representative present during testing, unless otherwise specified, and provide Manufacturer's Certificate of Source Testing.

c. Prepared by Contractor as a result of discussions and planning emerging from regularly conducted commissioning meetings for source tests as specified in the Contract Documents.
d. Provide the following items for each Source Test:
    1) Purpose and goals of the test.
    2) Identification of each item of equipment/system, including system designation, location, tag number, control loop identifier, etc.
    3) Description of the pass/fail criteria that will be used.
    4) Listing of pertinent reference documents (Contract Documents and industry standards or sections applicable to the testing).
    5) Complete description, including drawings or photographs, of test stands and/or test apparatus.
    6) Credentials of test personnel.
    7) Descriptions of test equipment to be used, product information, and all appropriate calibration records for the test equipment.
    8) Test set-up procedures.
    9) Detailed step-by-step test procedures:
        a) The level of detail shall be sufficient for any witness with a rudimentary technical aptitude to be able to follow the steps and develop confidence that the tests were being performed as planned.
        b) All steps are significant, and all steps shall be included in the procedures.
    10) Sample data logs and data recording forms.
    11) Sample computations or analyses with the results in the same format as the final report to demonstrate how data collected will be used to generate final results:
        a) Complete disclosure of the calculation methodologies.
        b) Include a sample for each type of computation required for the test and analysis of the results.
    12) Detailed outline of the Source Test report.
    13) Sample test reports.
e. Submit Source Test Plan and forms as specified in the technical sections:
    1) Submit a copy of the Source Test Plan at least 21 days before any scheduled test date.
    2) Engineer approval of Source Test Plan required prior to beginning source testing.
    3) Schedule the testing after approval of the Source Test Plan submittal.
f. Indicate the desired dates for source inspection and testing:
    1) Notify the Engineer of the scheduled tests a minimum of 15 days before the date of the test.

5. Test results:
    a. Prepare and submit test results with collected data attached.
6. Contractor is responsible for costs associated with Owner's and Engineer’s representatives when witnessing is specified:
    a. Include costs for at least the following:
        1) Transportation:
            a) Travel on commercial airline to and from site including related fees.
            b) Rental car to and from airport, hotel, and test site including related fees.

2) Hotel/Meals:
a) Hotel costs at a facility with an American Automobile Association 3-star rating or higher equivalent for single occupancy room per person per day.
b) Meal allowance based on government per diem guidelines per location.
3) Witness labor costs:
a) The greater of $200 per hour or $1,600 per day.
b. If Source Test is not ready when the witnesses arrive or if the Source Test fails, the witnesses will return home with Contractor responsible for costs associated with the trip including costs described above.
1) Contractor is responsible for rescheduling the Source Test and witnesses' costs associated with the second trip including costs described above.
7. Contractor is responsible for witnesses' costs associated with retests including costs described above.

C. Owner training:
1. Training instruction format:
a. The training for operations and maintenance personnel shall be provided as one entity.
b. Instructors shall apply adult education best practices, emphasizing learner participation and activity.
c. Training delivery may include problem solving, question/answer, hands-on instruction, practice, evaluation/feedback tools, and lecture.
d. Visual aids and hands-on practice sessions must support training objectives.
e. Lecturing should be less than 30 percent of class time.
f. Conduct hands-on instruction according to the following descriptions:
1) Present hands-on demonstrations of at least the following tasks:
a) Proper start-up, shutdown, and normal and alternative operating strategies.
b) Common corrective maintenance repairs for each group.
c) Recommended procedures to check/test equipment/system following a corrective maintenance repair.
d) Preventative maintenance points.
e) Calibration, if applicable.
2) Use tools and equipment provided by manufacturer to conduct the demonstrations:
a) Submit requests for supplemental assistance and facilities with the Contractor's proposed lesson plans.
3) Contractor remains responsible for equipment disassembly or assembly during hands-on training situations involving equipment disassembly or assembly by Owner's personnel.
2. Class agenda:
a. Include the following information in the agenda:
1) Instructor name.
2) Listing of subjects to be discussed.
3) Time estimated for each subject.
4) Allocation of time for Owner staff to ask questions and discuss the subject matter.
5) List of documentation to be used or provided to support training.

b. Owner may request that particular subjects be emphasized and the agenda be adjusted to accommodate these requests.
c. Distribute copies of the agenda to each student at the beginning of each training class.

3. Number of students:
   a. Estimated maximum class size: 10 persons:
      1) Owner will determine the actual number of students.
      2) Engineer will provide an estimated headcount 1 week prior to the class, so that the instructor can provide the correct number of training aids for students.
4. Instructor qualifications:
   a. Provide instructors completely knowledgeable in the equipment/system for which they are training.
   b. Provide instructors experienced in conducting classes.
   c. Provide instructor's technical preparation and instructional technology skills and experience.
   d. Sales representatives are not qualified instructors unless they possess the detailed operating and maintenance knowledge required for proper class instruction.
   e. If, in the opinion of the Owner, an appropriately knowledgeable person did not provide the scheduled training, such training shall be rescheduled and repeated with a suitable instructor.
5. Training aids:
   a. Instructors are encouraged to use audio-visual devices, P&IDs, models, charts, etc. to increase the transfer of knowledge.
   b. Instructors shall provide such equipment (televisions, video recorder/player, computer, projectors, screens, easels, etc.), models, charts, etc. for each class.
   c. Instructor is responsible for confirming with Engineer and Owner in advance of each class that the classroom will be appropriate for the types of audiovisual equipment to be employed.
6. Classroom documentation:
   a. Trainees will keep training materials and documentation after the session.
   b. Operations and maintenance manuals, as specified in technical sections:
      1) Provide the quantity final Engineer-approved operations and maintenance manuals as specified in Section 01782 - Operation and Maintenance Manuals for use during the classroom instruction.
      2) Owner reserves the right to delay training for a particular equipment item if the operations and maintenance manuals for that equipment are incomplete, inaccurate, or otherwise unsuitable for use by the Owner's staff.
      3) No contract extensions or extra costs will be allowed for training delays due to operations and maintenance manual submittal delays.
   c. Provide supplemental documentation handouts to support instruction.
   d. Digitally record audio and video of each training session:
      1) Include classroom and field instruction with question and answering periods.
      2) Engineer approval required for producer of video materials from one of the following options:
         a) Qualified, professional video production company.
         b) Contractor demonstrates satisfactory skill.

3) Record in digital format and recording shall become property of the Owner:
    a) Provide audio quality that is not degraded during the recording of the field sessions due to background noise, space, distance or other factors.
4) Video files shall be file format and delivery medium as directed and approved by Owner.
5) Provide 2 complete sets of video materials fully indexed and cataloged with printed labels stating session content and dates recorded.
6) The Contractor shall provide a written release from all claims to the recorded training material produced, if required.

e. Training modules:
    1) Provide a training module for each equipment category.
    2) Divide each training module's instructional content into discrete lesson plans.

f. Lesson plans:
    1) Provide performance-based learning objectives.
    2) State learning objectives in terms of what the trainees will be able to do at the end of the lesson.
    3) Define student conditions of performance and criteria for evaluating instructional success.
    4) Instruction lesson plan outlines for each trade.
        a) Provide specific components and procedures.
    5) Minimum requirements:
        a) Hands-on demonstrations planned for the instructions.
        b) Cross-reference training aids.
        c) Planned training strategies such as whiteboard work, instructor questions, and discussion points or other planned classroom or field strategies.
        d) Attach handouts cross-referenced by section or topic in the lesson plan.
        e) Indicate duration of outlined training segments.
    6) Provide maintenance instruction lesson plans including mechanical, HVAC, instrumentation, and electrical aspects:
        a) Equipment operation:
            (1) Describe equipment's operating (process) function and system theory.
            (2) Describe equipment's fundamental operating principles and dynamics.
            (3) Identify equipment's mechanical, electrical, and electronic components and features.
            (4) Identify support equipment associated with the operation of subject equipment.
            (5) Detail the relationship of each piece of equipment or component to the subsystems, systems, and process.
            (6) Cite hazards associated with the operations, exposure to chemicals associated with the component, or the waste stream handled by the component.
            (7) Specify appropriate safety precautions, equipment, and procedures to eliminate, reduce, or overcome hazards.

b) Detailed component description:
(1) Define Preventative Maintenance (PM) inspection procedures required on equipment in operation, spot potential trouble symptoms (anticipate breakdowns), and forecast maintenance requirements (predictive maintenance):
(a) Review preventive maintenance frequency and task analysis table.
(2) Identify each component function and describe in detail.
(3) Where applicable, group relative components into subsystems.
(4) Identify and describe in detail equipment safety features, permissive and controls interlocks.

7) Provide the following information in equipment troubleshooting lesson plans:
a) Define recommended systematic troubleshooting procedures as they relate to specific craft problems.
b) Provide component specific troubleshooting checklists as they relate to specific craft problems.

8) Provide the following information in equipment Corrective Maintenance (CM) troubleshooting lesson:
a) Describe recommended equipment preparation requirements as they relate to specific craft problems.
b) Identify and describe the use of any special tools required for maintenance of the equipment as they relate to specific craft problems.
c) Describe component removal/installation and disassembly/assembly procedures for specific craft repairs.
d) Perform at least 2 hands-on demonstrations of common corrective maintenance repairs:
(1) Additional demonstrations may be required by the Owner.
e) Describe recommended measuring instruments and procedures, and provide instruction on interpreting alignment measurements, as appropriate.

7. Class logistics:
a. Delivery time minimum: 2 hours.
b. Delivery time maximum: 4 hours:
1) Longer time requires Engineer approval.
c. Class agenda:
1) Refreshment break: One 10-minute break.
2) Meal break: One 45-minute break, unless otherwise specified.
3) Schedule refreshment breaks and meal breaks to meet the class needs and Owner work rules.
d. Schedule specific sessions:
1) Minimum of 30 days in advance to allow Owner staffing arrangements to take place.
2) At the times requested by the Owner, within the period 7 a.m. to 7 p.m. Monday through Friday:
a) Times scheduled will be at Owner’s discretion.
3) Owner approval and confirmation required for session schedules.

4) Provide minimum of 3 sessions for each class unless otherwise noted:
a) The purpose of having multiple sessions on each class is to accommodate the attendance of as many Owner personnel working different shifts as possible.

8. Distribute Training Evaluation Form following each training session:
   a. Training Evaluation Form is included in this Section.
   b. Return completed Training Evaluation Forms to Owner's designated training coordinator immediately after session is completed.
   c. Revise training sessions judged "Unsatisfactory" by a majority of attendees:
      1) Conduct training sessions again until a satisfactory rating is achieved at no additional cost to Owner.
9. Submittals:
   a. Prior to the training session:
      1) Instructor qualifications: Due 30 calendar days prior to initial training session.
      2) Training course materials: Due 14 calendar days prior to initial training session:
         a) Training agenda, lesson plan, presentation, and handouts.
         b) Other audio-visual aids utilized during each training course.
         c) Format: 2 electronic copies and 3 hard copies organized in notebooks.
   b. Post training session:
      1) Training course materials: Due 14 calendar days after class completion.
         a) Video recordings.
         b) Class attendance sheet.
         c) Training agenda, final lesson plan, presentation, and handouts.
         d) Other audio-visual aids utilized during each training course.
         e) Provide materials for all sessions of the class in a single transmittal.
         f) Format: 2 electronic copies and 3 hard copies organized in notebooks.

D. Installation Testing:
   1. Perform subsystem testing according to approved Subsystem Testing Plans.
   2. Initiate the Manufacturer's Certificate of Installation and Functionality Compliance for all equipment:
      a. Manufacturer's Certificate of Installation and Functionality Compliance form is included in this Section.
      b. Manufacturer's Certificate of Installation and Functionality Compliance certifies the equipment meets the following requirements:
         1) Has been properly installed, adjusted, aligned, and lubricated.
         2) Is free of any stresses imposed by connecting piping or anchor bolts.
         3) Is able to be operated as necessary for Functional Testing.
      c. Form shall be submitted after completion of Functional Testing, as specified in this Section.
   3. Coordinate Installation Testing with restrictions and requirements as specified in Section 01140 - Work Restrictions.
   4. Perform coating holiday testing as specified in Section 09960 - High- Performance Coatings.

5. Perform pressure and leakage testing as specified in individual component Sections and Section 15956 - Piping Systems Testing.
6. Perform mechanical equipment Installation Testing: As specified below and in individual equipment sections, such as Section 15050 - Common Work Results for Mechanical Equipment, Section 15954 - Testing, Adjusting, and Balancing for HVAC, and Section 15958 - Mechanical Equipment Testing:
    a. Remove rust preventatives and oils applied to protect equipment during construction.
    b. Flush lubrication systems and dispose of flushing oils:
        1) Recharge lubrication system with lubricant recommended by manufacturer.
    c. Flush fuel system and provide fuel for testing and start-up.
    d. Install and adjust packing, mechanical seals, O-rings, and other seals. Replace defective seals.
    e. Remove temporary supports, bracing, or other foreign objects installed to prevent damage during shipment, storage, and erection.
    f. Check rotating machinery for correct direction of rotation and for freedom of moving parts before connecting driver.
    g. Perform cold alignment and hot alignment to manufacturer's tolerances.
    h. Adjust V-belt tension and variable pitch sheaves.
    i. Inspect hand and motorized valves for proper adjustment:
        1) Tighten packing glands to ensure no leakage, but permit valve stems to rotate without galling.
        2) Verify valve seats are positioned for proper flow direction.
    j. Tighten leaking flanges or replace flange gasket:
        1) Inspect screwed joints for leakage.
    k. Install gratings, safety chains, handrails, shaft guards, and sidewalks prior to operational testing.

7. Electrical devices and subsystems Installation Testing: As specified below, in Section 16950 - Field Electrical Acceptance Tests, and the technical sections:
    a. Complete requirements as specified in Section 16305 - Electrical System Studies.
8. Instrumentation devices and subsystems Installation Testing: As specified below, in Section 17950 - Testing, Calibration, and Commissioning, and technical sections.

E. Functional Testing:
1. Prerequisite: Successful completion with Engineer approval of Installation Testing.
2. Perform subsystem testing according to approved Subsystem Testing Plan:
    a. Heating, ventilating, and air conditioning systems:
        1) As specified in Section 15954 - Testing, Adjusting, and Balancing for HVAC, and technical sections.
3. Notify the Engineer 5 days prior to when the Work is ready for Functional Testing:
    a. Perform testing in the presence of the Engineer.
4. Determine Functional Testing durations with Owner’s input:
    a. Durations will vary depending on the availability of water for testing.
    b. Target minimum Functional Test duration: 8 hours:
        1) Identify equipment/system that cannot be tested for a minimum of 8 hours as specified in technical sections.

5. Perform Functional Testing as specified in technical sections:
    a. Perform Functional Testing in addition to the other tests specified in the technical sections.
    b. Perform Functional Testing to demonstrate that the component equipment functions as an entire system in accordance with the design requirements.
    c. Perform Functional Testing to demonstrate that the unit process has operated in a manner necessary to demonstrate equipment/system functions manually in local, manually in remote (or remote manual), and automatically in remote (in remote auto).
    d. Repair or replace parts that operate improperly and retest.
    e. Submit testing reports as specified in the technical sections to the Owner and Engineer for approval of Functional Testing reports.
6. Provide completed Manufacturer's Certificate of Installation and Functionality Compliance forms for all equipment:
    a. Manufacturer's Certificate of Installation and Functionality Compliance form is included in this Section.
    b. Manufacturer's Certificate of Installation and Functionality Compliance certifies the equipment/system meets the following requirements:
        1) Is suitable for satisfactory full-time operation under full-load conditions.
        2) Operates within the allowable limits for vibration and noise.
        3) Electrical and instrumentation requirements:
            a) Electrical equipment, instrumentation, and control panels are properly installed, calibrated, and functioning.
            b) Electrical Installation Testing is complete, and test results have been approved by the Engineer:
                (1) Noted deficiencies have been corrected.
                (2) Relays, circuit breakers, and other protective devices are set.
            c) Control logic for start-up, shutdown, sequencing, interlocks, control, and emergency shutdown has been tested and is properly functioning.
            d) Motor control is calibrated and tested.

F. Clean Water Facility Testing:
1. Utilize plant water.
2. Prerequisite: Successful completion with Engineer approval of Functional
3. Test facility with recirculating water supply at the design flow for the largest single process or system train to ensure proper complete facility (equipment/system) hydraulic performance.
4. Perform testing in the presence of the Engineer unless such presence is expressly waived in writing.
5. The purpose of Clean Water Facility Testing is to confirm extended equipment/system operation prior to process start-up:
    a. Testing shall occur for a minimum of 7 days with all systems operational to the extent possible.
6. Reset to condition prior to testing:
    a. Remove, clean, and replace permanent and temporary filters and strainers in pipeline systems.
    b. Replace HVAC filters, dewater and clean sumps.
    c. Dewater process units, where directed by the Engineer.

G. Closeout documentation submittals:
    1. Provide records generated during Commissioning Phase of Project including but not limited to:
        a. Training documentation.
        b. Manufacturer’s Certificate of Source Testing.
        c. Manufacturer’s Certificate of Installation and Functionality Compliance.
        d. Daily logs of equipment/system testing identifying tests conducted and outcome.
        e. Test forms and documentation.
        f. Functional Testing results.
        g. Logs of time spent by manufacturer's representatives performing services on the job site.
        h. Equipment lubrication records.
        i. Electrical phase, voltage, and amperage measurements.
        j. Insulation resistance measurements.
        k. Bearing temperature measurements.
        l. Data sheets of control loop testing including testing and calibration of instrumentation devices and setpoints.
        m. Provide: 2 electronic copies and 3 hard copies organized in notebooks.
        n. Due date: Within 14 calendar days of Substantial Completion.

1.08 PROCESS START-UP PHASE

A. Overview of Process Start-Up Phase:
    1. Operating the facility to verify performance meets the Contract Document requirements.

B. Process Start-Up:
    1. Prerequisite: Successful completion with Engineer approval of Clean Water Facility Testing.
    2. Perform process start-up in the presence of the Engineer.
    3. Pre-start-up activities and submittals:
        a. Commissioning Documentation and Data Review.
        b. Start-Up Go/No-Go Decision Criteria.
        c. Building and Fire Inspection Compliance Check.
        d. Process Start-Up Sequence Review.
        e. Process Start-Up plan for review by Engineer not less than 30 calendar days prior to planned commencement of process start-up activities:
            1) Include the following:
                a) Pre-start-up activities.
                b) Process Start-Up.
                c) Process Operational Period.
                d) PCIS Optimization and Fine-Tuning.
        f. Description of Temporary Testing Arrangement, if applicable.
        g. Final Process Start-Up Forms and Documentations.
        h. Final Operational Testing Plan.
    4. Control loop tuning:
        a. Perform control loop tuning during system testing with water to the extent possible.

5. Process area start-ups:
    a. Process start-up individual process areas comprised of multiple interdependent systems where possible and beneficial to reduce complexity and risk of complete facility testing.
    b. Process area test flows may be limited by upstream and downstream process constraints (i.e., tank and basin volumes) and/or localized recirculation capabilities.
6. Facility-wide process start-up:
    a. Upon approved completion of pre-start-up activities, perform entire facility process start-up:
        1) Complete control loop tuning during this phase of process start-up.
        2) Continue process start-up operations until facility meets or exceeds the Contract requirements.
    b. HVAC systems start-up and testing:
        1) Test complete HVAC system for the facility.
    c. Ancillary systems start-up and testing:
        1) Test complete security system, phone system, fire alarm system, etc. for the facility.
    d. Remaining equipment/system tests:
        1) Conduct remaining specified equipment/system performance tests that could not be performed during the Testing and Training Phase due to inter-system and/or treatment process dependencies.

C. Process Operational Period:
1. Prerequisite: Successful completion with Engineer approval of Process Start-Up.
2. Prior to beginning the Process Operational Period:
    a. Conformance with treatment standards is required prior to Operational Testing, if applicable:
        1) Biological processes require time to build up the necessary population of organisms to meet treatment standards, as specified in Section 01140 - Work Restrictions.
    b. Correct any outstanding punch list items prior to the Operational Testing.
3. Duration: 7 calendar days.
4. Engineer will be present for process operational period unless such presence is expressly waived in writing.
5. Prove facility conformance with Contract Document requirements.
6. Contractor to provide:
    a. Specified start-up materials and operating supplies.
    b. Necessary craft of labor assistance, in the event of an emergency equipment failure requiring immediate attention (emergency is defined as a failure of function which precludes the further operation of a critical segment of or the whole of the Work) with a response time of not more than 4 hours from the time of notification.
    c. Manufacturer’s authorized representative to supervise placing equipment/systems in operation and provide guidance during Operational Testing per applicable section.
    d. Necessary manufacturer’s representatives and operating supplies for retesting systems that fail to pass the initial Operational Testing due to deficiencies in products of workmanship at no additional cost to the Owner.

e. List of 24-hour “on-call” representative supervisory persons who will monitor the Operational Testing and serve as liaison for the Engineer and Owner.

7. Owner will provide:
   a. Operations personnel for duration of test.
8. Contractor’s CC shall oversee Process Operational Period:
   a. Owner staff will operate the completed Project construction.
   b. Entire system shall continuously meet performance requirements and shall operate without fault, failure, or defect for a continuous period.
   c. Individual equipment/system failures that are corrected within 24 hours and do not prevent the entire project from continuously satisfying the established operational requirements shall not require the consecutive day test to be restarted unless the failure recurs.
   d. Restart the consecutive test period for any of the following conditions:
      1) Any failure of the complete Project construction to meet operational requirements.
      2) When malfunctions or deficiencies cause shutdown or partial operation of the facility, or results in failure of the complete Project construction to meet operational requirements.
      3) Any individual equipment/system failure that meets any of the following conditions:
         a) Requires more than 24 hours to correct.
         b) Recurs within the 24-hour correction period requiring further correction.
      4) Immediately correct defects in material, workmanship, or equipment/system which became evident during Operational Testing.
9. Permitting approval of Process Operational Period results required for Substantial Completion.

D. PCIS Optimization and Fine-Tunin:
   1. Prerequisite: Successful completion with Engineer approval of Process Operational Period.
   2. Test PCIS system for additional 60 days.
   3. Permitting approval of PCIS Optimization and Fine-Tuning results required for Substantial Completion.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION

MANUFACTURER'S CERTIFICATE OF SOURCE TESTING

OWNER _____ EQPT/SYSTEM _____
PROJECT NAME _____ EQPT TAG NO. _____
PROJECT NO. _____ EQPT SERIAL NO. _____
SPECIFICATION NO. _____
SPECIFICATION TITLE _____

Comments: _____

_____

_____

_____

_____

I hereby certify Source Testing has been performed on the above-referenced equipment/system as defined in the Contract Documents, and results conform to the Contract Document requirements. Testing data is attached.

Date of Execution: _____, 20____

Manufacturer: _____

Manufacturer's Authorized Representative Name *(print)*: _____

_____
(Authorized Signature)

If applicable, Witness Name *(print)*: _____

_____
(Witness Signature)

MANUFACTURER'S CERTIFICATE OF INSTALLATION AND FUNCTIONALITY COMPLIANCE

OWNER _____ EQPT/SYSTEM _____
PROJECT NAME _____ EQPT TAG NO. _____
PROJECT NO. _____ EQPT SERIAL NO. _____
SPECIFICATION NO. _____
SPECIFICATION TITLE _____

I hereby certify the installation and function of the above-referenced equipment/system as defined in the Contract Documents. The above-referenced equipment/system has been: (Check Applicable)

- ☐ Installed in accordance with manufacturer's recommendations.
- ☐ Inspected, checked, and adjusted.
- ☐ Serviced with proper initial lubricants.
- ☐ Electrical/instrumentation and mechanical connections meet quality and safety standards.
- ☐ All applicable safety equipment has been properly installed.
- ☐ Functionally tested.
- ☐ System has been performance tested, and meets or exceeds specified performance requirements.

NOTES:
Attach test results with collected data and test report.

Attach written certification report prepared by and signed by the electrical and/or instrumentation subcontractor.

Comments: _____

_____

I, the undersigned manufacturer's representative, hereby certify that I am (i) a duly authorized representative of the manufacturer, (ii) empowered by the manufacturer to inspect, approve, and operate this equipment/system, and (iii) authorized to make recommendations required to ensure that the equipment/system furnished by the manufacturer is complete and operational, except as may be otherwise indicated herein. I further certify that all information contained herein is true and accurate.

Date: _____

Manufacturer: _____

Manufacturer's Authorized Representative Name *(print)*: _____

By Manufacturer's Authorized Representative: _____
(Authorized Signature)

TRAINING EVALUATION FORM

EQUIPMENT/SYSTEM ITEM: _____

VENDOR/MANUFACTURER: _____

DATE: _____ NAME OF REPRESENTATIVE: _____

1.	Was representative prepared?	Acceptable	Unacceptable	or	N/A
2.	Was an overview description presented?	Acceptable	Unacceptable	or	N/A
3.	Were specific details presented for system components?	Acceptable	Unacceptable	or	N/A
4.	Were alarm and shutdown conditions clearly presented?	Acceptable	Unacceptable	or	N/A
5.	Were step-by-step procedures for starting, stopping, and troubleshooting presented?	Acceptable	Unacceptable	or	N/A
6.	Were routine/preventative maintenance items clearly identified?	Acceptable	Unacceptable	or	N/A
7.	Was the lubrication schedule (if any) discussed?	Acceptable	Unacceptable	or	N/A
8.	Was the representative able to answer all questions?	Acceptable	Unacceptable	or	N/A
9.	Did the representative agree to research and answer unanswered questions?	Acceptable	Unacceptable	or	N/A
10.	Comments: _____				

_____

_____

_____

11. Overall Rating: Satisfactory Unsatisfactory

Note:

Sessions judged “Unsatisfactory” by a majority of attendees shall be revised and conducted again until a satisfactory rating is achieved.

COMMISSIONING ROLES AND RESPONSIBILITIES MATRIX

NO.	TASK	OWNER	CONTRACTOR	ENGINEER
Testing and Training Phase				
Source Testing				
1	Source Testing	No Action	Lead	Witness, Review
Installation Testing				
2	Electrical Conductor Testing	No Action	Lead	Witness
3	Electrical Field Acceptance Tests	No Action	Lead	Witness
4	Instrument Field Calibration	No Action	Lead	Witness
5	Network Installation Testing	Witness	Lead	Witness
6	Loop Testing	Witness	Lead	Witness
7	Pressure Testing	No Action	Lead	Witness
8	Leak Testing	No Action	Lead	Witness
9	Holiday Testing	No Action	Lead	Witness
10	HVAC Testing	No Action	Lead	Witness
11	Motor Electrical Testing	No Action	Lead	Witness
Functional Testing				
12	Network Operational Testing	Witness	Lead	Review
13	Preliminary Run Testing Local/Manual Control	Witness	Lead	Review
14	PCIS Functional Demonstration Testing - Local/Auto Control Testing - Remote/Manual Contact Testing - Alarm Testing - Control Loop Testing	No Action	Lead	Review
15	Subsystem Start-Up and Testing	Witness	Lead	Review
16	Equipment/System Start-Up and Testing	Witness	Lead	Review
17	HVAC Start-Up and Testing	Witness	Lead	Review
18	Corrosion Control Start-Up and Testing	Witness	Lead	Review
19	Wide Area Network Communications Testing	Support	Lead	Witness
20	Manufacturer's Certificate of Installation and Functionality Compliance	No Action	Lead	Witness, Review
Clean Water Facility Testing				
21	Test Water Management Plan Finalization	Support	Lead	Review
22	Clean Water Facility Testing	Witness	Lead	Witness, Review
Process Start-Up Phase				
Process Start-Up				
23	Commissioning Documentation and Data Review	Review	Support	Lead
24	Start-Up Go/No-Go Decision Criteria	Lead	Support	Review
25	Building and Fire Inspection Compliance Check	No Action	Lead	Witness

NO.	TASK	OWNER	CONTRACTOR	ENGINEER
Testing and Training Phase				
26	HVAC Functionality Check	No Action	Lead	Witness
27	Start-Up Sequence Review	Support	Lead	Review
28	Temporary Testing Arrangement Finalization	Support	Lead	Support
29	Start-Up Forms Finalization	Support	Lead	Support
30	Operation Testing Plan Finalization	Review	Support	Lead
31	Test Water Management Plan Finalization	Support	Lead	Review
32	System Testing	Support	Lead	Witness
33	Control Loop Tuning	Support	Lead	Witness
34	Process Area Start-Ups	Support	Lead	Witness
35	Facility-Wide Start-Up	Support	Lead	Witness
36	Process Control Systems Testing	Support	Lead	Witness
38	HVAC Final Testing, Adjust, and Balancing	Witness	Lead	Witness, Review
Process Operational Period				
39	Operational Testing	Support	Lead	Witness, Review
40	Final Testing Reports	Support	Lead	Review
41	Water Quality Testing and Documentation	Support	Lead	Review
PCIS Optimization and Fine-Tuning				
42	As specified in Section 17950 - Testing, Calibration, and Commissioning	Support	Lead	Review

Legend:
Lead: Primarily responsible for organization, coordination, and execution of task work product or result.
Support: Assist the lead with organization, coordination, and execution of task work product or result.
Witness: Observe and document completion of task work product or result.
Review: As necessary to accept task work product result.
No Action: Limited or no involvement.

SECTION 01770

CLOSEOUT PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Contract closeout requirements.

1.02 REFERENCES

A. American Water Works Association (AWWA).

1.03 FINAL CLEANING

A. Perform final cleaning prior to inspections for Substantial Completion.

B. Employ skilled workers who are experienced in cleaning operations.

C. Use cleaning materials which are recommended by manufacturers of surfaces to be cleaned.

D. Prevent scratching, discoloring, and otherwise damaging surfaces being cleaned.

E. Clean roofs, gutters, downspouts, and drainage systems.

F. Broom clean exterior paved surfaces and rake clean other surfaces of site work:
   1. Police yards and grounds to keep clean.

G. Remove dust, cobwebs, and traces of insects and dirt.

H. Clean grease, mastic, adhesives, dust, dirt, stains, fingerprints, paint, blemishes, sealants, plaster, concrete, and other foreign materials from sight-exposed surfaces, and fixtures and equipment.

I. Remove non-permanent protection and labels.

J. Polish waxed woodwork and finish hardware.

K. Wash tile.

L. Wax and buff hard floors, as applicable.

M. Wash and polish glass, inside and outside.

N. Wash and shine mirrors.

O. Polish glossy surfaces to clear shine.

P. Vacuum carpeted and soft surfaces.

Q. Clean permanent filters and replace disposable filters when heating, ventilation, and air conditioning units were operated during construction.

R. Clean ducts, blowers, and coils when units were operated without filters during construction.

S. Clean light fixtures and replace burned-out or dim lamps.

T. Probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

1.04 WASTE DISPOSAL

A. Arrange for and dispose of surplus materials, waste products, and debris off-site:
   1. Prior to making disposal on private property, obtain written permission from Owner of such property.

B. Do not fill ditches, washes, or drainage ways which may create drainage problems**.**

C. Do not create unsightly or unsanitary nuisances during disposal operations.

D. Maintain disposal site in safe condition and good appearance.

E. Complete leveling and cleanup prior to Final Completion of the Work.

1.05 TOUCH-UP AND REPAIR

A. Touch-up or repair finished surfaces on structures, equipment, fixtures, and installations that have been damaged prior to inspection for Substantial Completion.

B. Refinish or replace entire surfaces which cannot be touched-up or repaired satisfactorily.

1.06 FINAL CLEANING AND DISINFECTION OF SYSTEMS OF PLANT FACILITIES

A. Clean pipes before facility goes on stream.

B. Wash, wherever practicable, or broom sweep.

C. Disinfect tanks and piping intended to carry potable water as follows or in accordance with AWWA Standards.

D. Provide ample sampling outlets in pipe for testing.

E. Fill pipe and other plant facilities with chlorine solution of sufficient strength to retain residual of not less than 10 parts per million at end of 24 hours.

F. After disinfection, rinse entire potable water system with potable water sufficient to reduce chlorine residual to not more than 0.6 parts per million throughout system before system is put into service.

1.07 FINAL CLEANING AND DISINFECTION OF SYSTEMS OF POTABLE WATER MAINS

A. Clean interior of pipe and fittings.

B. When pipe contains dirt that cannot be removed by flushing, swab pipe interiors with solution containing not less than 500 parts per million of chlorine until clean.

C. Flush 12-inch in diameter and smaller pipe as thoroughly as available water sources will permit.

D. Fill pipe with chlorine solution of sufficient strength to provide 10 parts per million chlorine residual at end of 24 hours.

E. Flush pipes with potable water until chlorine residual is less than 0.6 parts per million before pipe are put into service.

1.08 SPARE PARTS

A. Owner may request advanced delivery of spare parts, maintenance products, and special tools:
   1. Deduct the delivered items from the inventory list and provide transmittal documentation.

B. Prior to Substantial Completion, arrange to deliver spare parts, maintenance products, and special tools to Owner at a location on site chosen by the Owner:
   1. Provide itemized list of spare parts and special tools that matches the identification tag attached to each item.
   2. Owner and Engineer will review the inventory and the itemized list to confirm it is complete and in good condition prior to signing for acceptance.

1.09 CLOSEOUT DOCUMENTS

A. Submit following Closeout Submittals before Substantial Completion:
   1. Punch list of items to be completed or corrected with the request for issuance of Substantial Completion.
   2. Evidence of Compliance with Requirements of Governing Authorities.
   3. Project Record Documents.
   4. Approved Operation and Maintenance Manuals.
   5. Approved Warranties and Bonds.
   6. Keys and Keying Schedule.
   7. Completed contract requirements for commissioning and process start-up.

B. Submit following Closeout Submittals before final completion of the Work and at least 7 days prior to submitting Application for Final Payment:
   1. Punch list of items have been completed and Engineer and Owner are satisfied that all deficiencies are corrected.
   2. Evidence of Payment and Release of Liens or Stop Payment Notices as outlined in Conditions of the Contract.
   3. Release of claims as outlined in Conditions of the Contract.
   4. Submit certification of insurance for products and completed operations, as specified in the General Conditions.

5. Final statement of accounting.
6. Submit Final (As-Built) Schedule as specified in Section 01321 - Schedules and Reports.

1.10 EVIDENCE OF COMPLIANCE WITH REQUIREMENTS OF GOVERNING AUTHORITIES

A. Submit the following:
   1. Certificate of Occupancy.
   2. Certificates of Inspection:
      a. Mechanical:
         1) Form U-1 "Manufacturer's Data Report for Unfired Pressure Vessels" for each pressure vessel furnished and installed.
      b. Electrical.
      c. As required in other specification sections.

1.11 PROJECT RECORD DOCUMENTS

A. Maintain at Project site, available to Owner and Engineer, 1 copy of the Contract Documents, shop drawings, and other submittals in good order:
   1. Mark and record field changes and detailed information contained in submittals and change orders.
   2. Record actual depths, horizontal and vertical location of underground pipes, duct banks, and other buried utilities. Reference dimensions to permanent surface features.
   3. Identify specific details of pipe connections, location of existing buried features located during excavation, and the final locations of piping, equipment, electrical conduits, manholes, and pull boxes.
   4. Identify location of spare conduits including beginning, ending, and routing through pull boxes and manholes. Record spare conductors, including number and size, within spare conduits and filled conduits.
   5. Provide schedules, lists, layout drawings, and wiring diagrams.
   6. Make annotations in electronic format or hard copy format with erasable colored pencil conforming to the following color code:

Additions:	Red
Deletions:	Green
Comments	Blue
Dimensions:	Graphite

B. Maintain documents separate from those used for construction:
   1. Label documents "RECORD DOCUMENTS."

C. Keep documents current:
   1. Record required information at the time the material and equipment is installed and before permanently concealing.
   2. Engineer will review Record Documents weekly to ascertain that changes have been recorded.

D. Affix civil engineer's or professional land surveyor's signature and registration number to Record Drawings to certify accuracy of information shown.

E. Deliver Record Documents with transmittal letter containing date, Project title, Contractor's name and address, list of documents, and signature of Contractor.

F. Record Documents will be reviewed monthly to determine the percent complete for the monthly pay application.

G. Updated Record Documents are a condition for Engineer’s recommendation for progress payment.

H. Final Schedule Submittal as specified in Section 01321- Schedules and Reports.

1.12 MAINTENANCE SERVICE

A. Maintenance service as specified in technical specifications.

1.13 SUBSTANTIAL COMPLETION

A. Obtain Certificate of Substantial Completion.

1.14 FINAL COMPLETION

A. When Contractor considers the Work is complete, submit written certification that:
   1. Work has been completed in accordance with the Contract Document:
   2. Punch list items have been completed or corrected.
   3. Work is ready for final inspection.

B. Engineer will make an inspection to verify the status of completion with reasonable promptness.

C. Should the Engineer consider that the Work is incomplete or defective:
   1. Engineer will promptly notify the Contractor in writing, listing the incomplete or defective work.
   2. Contractor shall take immediate steps to remedy the stated deficiencies and send a second written certification to the Engineer that the Work is complete.
   3. Engineer shall re-inspect the Work.

1.15 FINAL ADJUSTMENT OF ACCOUNTS

A. Submit a final statement of accounting to the Engineer at least 7 days prior to final Application for Payment.

B. Statement shall reflect all adjustments to the Contract amount.
   1. The original Contract amount.
   2. Additions and deductions resulting from:
      a. Change Orders.
      b. Units installed and unit prices.
      c. Set-offs for uncorrected or incomplete Work.
      d. Set-offs for liquidated damages.
      e. Set-offs for reinspection payments.
      f. Extended engineering and/or inspection services and inspection overtime.
      g. Excessive shop drawings review cost by the Engineer.
      h. Other adjustments.
   3. Total Contract amount, as adjusted.

4. Previous payments.
5. Remaining payment due.

C. Engineer will prepare a final Change Order reflecting approved adjustments to the Contract amount which were not previously made by Change Orders.

1.16 FINAL APPLICATION FOR PAYMENT

A. Contractor shall submit the final Application for Payment reflecting the agreed upon information provided in the final statement of accounting.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01782

OPERATION AND MAINTENANCE MANUALS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Preparation and submittal of Operation and Maintenance (O&M) Manuals.

1.02 GENERAL

A. Submit O&M Manuals as specified in technical sections.

B. Make approved manuals available at project site for use by construction personnel and Owner.

1.03 SUBMITTALS

A. Draft O&M Manuals:
   1. Submit prior to shipment of equipment or system to site.
   2. Shipment will be considered incomplete without the draft O&M manuals.
   3. Quantity:
      a. Hard copy: 4 sets.
      b. Electronic: 2 USB flash drive.

B. Final O&M Manuals:
   1. Make additions and revisions in accordance with Owner's and Engineer's review comments on draft manuals.
   2. Submit approved O&M Manuals at least 30 days prior to Functional Testing and at least 60 days prior to Owner Training.
   3. Quantity:
      a. Hard copy: 4 sets.
      b. Electronic: 2 USB flash drive.

1.04 PREPARATION

A. General requirements:
   1. Provide dimensions in English units.
   2. Assemble material, where possible, in the same order within each volume.
   3. Reduce drawings and diagrams to 8 1/2 by 11-inch size, if possible unless otherwise specified.
   4. Complete forms on computer, handwriting not acceptable.
   5. Delete items or options not provided in the supplied equipment or system.
   6. Provide package control system annotated ladder logic for PLC, if applicable.

B. Hard copy requirements:
   1. Binders: 3-ring with rigid covers:
      a. Break into separate binders as needed to accommodate large size.
   2. Utilize numbered tab sheets to organize information.

3. Provide original and clear text on reproducible non-colored paper, 8 1/2 by 11-inch size, 24 pound paper.
4. Drawings larger than 8 1/2 by 11 inch:
    a. Fold drawings separately and place in envelope bound into the manual.
    b. Label each drawing envelope on the outside regarding contents.

C. Electronic requirements:
1. File format:
    a. Entire manual in PDF format:
        1) Include text and drawing information.
        2) Provide a single PDF file even if the hard copy version is broken into separate binders due to being large.
        3) Create PDF from the native format of the document (Microsoft Word, graphics programs, drawing programs, etc.):
            a) If material is not available in native format and only available in paper format, remove smudges, fingerprints, and other extraneous marks before scanning to PDF format.
            b) Hard copy record drawing requirements:
                (1) Provide a single multipage PDF file of each set of the scanned drawings.
                (2) Page 1 shall be the cover of the drawing set.
            c) At file opening, display the entire cover:
                (1) Scan drawings at 200 to 300 dots per inch (DPI), black and white, Group IV Compression, unless otherwise specified.
                (2) Scan drawings with photos in the background at 400 dots per inch (DPI), black and white, Group IV Compression.
        4) Pagination and appearance to match hard copy.
        5) Searchable.
        6) Scanned images are not acceptable.
        7) Bookmarks:
            a) Bookmarks shall match the table of contents.
            b) Bookmark each section (tab) and heading.
            c) Drawings: Bookmark at a minimum, each discipline, area designation, or appropriate division.
            d) At file opening, display all levels of bookmarks as expanded.
        8) Thumbnails optimized for fast web viewing.
    b. Drawing requirements:
        1) Provide additional copy of drawings in most current version of MicroStation and AutoCAD format.
        2) Drawings shall have a white background.
        3) Drawing shapes shall not degrade when closely zoomed.
        4) Screening effects intended to de-emphasize detail in a drawing must be preserved.
        5) Delete items or options not provided in the supplied equipment or system.
2. Media:
    a. USB flash drive.
    b. Secure File Transfer Protocol (SFTP).
3. Label media with the following information:
    a. O&M Manual.
    b. Equipment name.
    c. Specification Section Number.

d. Equipment tag number.
e. Owner's name.
f. Project number and name.
g. Date.

4. If multiple submittals are made together, each submittal must have its own subdirectory that is named and numbered based on the submittal number.

1.05 CONTENTS

A. Label the spines:
1. Equipment name.
2. Tag number.
3. Project name.
4. Owner name.

B. Cover page:
1. O&M Manual.
2. Equipment name.
3. Specification Section Number.
4. Equipment tag number.
5. Owner's name.
6. Project number and name.
7. Date.

C. Table of Contents: General description of information provided within each tab section.

D. Equipment Summary Form: Completed form as specified in Appendix A of this Section.

E. Electric Motor Technical Data Form: Completed form as specified in Appendix C of this Section.

F. Description of system and components.

G. Description of equipment function, normal operating characteristics, and limiting conditions.

H. Manufacturer's product data sheets:
1. Where printed material covers more than 1 specific model, indicate the model number, calibrated range, and other special features.
2. Equipment with bearings:
a. Include manufacturer and model number of every bearing.
b. Include calculated ball pass frequencies of the installed equipment for both the inner and outer raceways.

I. Assembly, installation, alignment, adjustment, and checking instructions.

J. Storage instructions.

K. Control diagrams:
1. Internal and connection wiring, including logic diagrams, wiring diagrams for control panels, ladder logic for computer based systems, and connections

between existing systems and new additions, and adjustments such as calibrations and set points for relays, and control or alarm contact settings.
2. Complete set of 11-inch by 17-inch drawings of the control system.
3. Complete set of control schematics.

L. Programming: Copies of Contractor furnished programming.

M. Start-up procedures: Recommendations for installation, adjustment, calibration, and troubleshooting.

N. Operating procedures:
1. Step-by-step instructions including but not limited to the following:
   a. Safety precautions and applicable Safety Data Sheets.
   b. Guidelines.
   c. Manual keyboard entries.
   d. Entry codes.
   e. System responses.
   f. Other information as needed for safe system operation and maintenance.
2. Modes:
   a. Startup.
   b. Routine and normal operation.
   c. Regulation and control.
   d. Shutdown under specified modes of operation.
   e. Emergency operating shutdown.

O. Preventative maintenance procedures:
1. Recommended steps and schedules for maintaining equipment.
2. Troubleshooting.

P. Lubrication information: Required lubricants and lubrication schedules.

Q. Overhaul instructions: Directions for disassembly, inspection, repair and reassembly of the equipment; safety precautions; and recommended tolerances, critical bolt torques, and special tools that are required.

R. Parts list:
1. Complete parts list for equipment including but not limited to the following information:
2. Catalog data: Generic title and identification number of each component part of equipment.
3. Include bearing manufacturer, model and ball or roller pass frequencies for every bearing.
4. Availability.
5. Service locations.

S. Spare parts list: Recommended number of parts to be stored at the site and special storage precautions.

T. Engineering data:
1. Drawings: Complete set of 11-inch by 17-inch equipment drawings.
2. Exploded view or plan and section views with detailed callouts.
3. Outline, cross-section, and assembly drawings.

4. System drawings: Provide interconnection and wiring diagrams, plan views, panel layouts, bill of materials, etc.
5. Packaged equipment system drawings: Provide instrumentation loop drawing, control schematic diagrams, interconnection and wiring diagrams, plan views, panel layouts, bill of materials, etc.
6. System drawings and data sheets: Include drawings and data furnished by the Engineer and the Supplier; provide "as installed" version.
7. Provide electrical and instrumentation schematic record drawings.

U. Test data and performance curves, when applicable.

V. Manufacturer's technical reference manuals.

W. Source (factory) Test results: Provide copies of Source Tests reports as specified in technical sections.

X. Functional Test results: After Functional Tests are completed, insert Functional Test reports as specified in technical sections.

1.06 ARCHIVAL DOCUMENTATION

A. Typically does not require updating to remain valid and should be stored in a format that preserves the document and limits one's ability to make changes.

B. Types of archival documents include the following:
1. Record drawings.
2. Reports.
3. Specifications.
4. Shop drawings.
5. Vendor Equipment O&M Manuals.
6. Photos.
7. Demonstration and training videos.
8. Other.

1.07 LIVING DOCUMENTATION

A. Requires periodic updates to remain valid and should be stored in formats that are easy to update.

B. Types of living documents include the following:
1. Facility O&M Manuals.
2. Standard Operating Procedures.
3. Other.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

APPENDIX A
EQUIPMENT SUMMARY FORM

1. EQUIPMENT ITEM _____

2. MANUFACTURER _____

3. EQUIPMENT IDENTIFICATION NUMBER(S) _____
(maps equipment number)

4. LOCATION OF EQUIPMENT _____

5. WEIGHT OF INDIVIDUAL COMPONENTS (OVER 100 POUNDS) _____

_____

_____

_____

NAMEPLATE DATA -
- Horsepower _____
- Amperage _____
- Voltage _____
- Service Factor (S.F.) _____
- Speed _____
- ENC Type _____
- Capacity _____
- Other _____

7. MANUFACTURER'S LOCAL REPRESENTATIVE

Name _____

Address _____

Telephone Number _____

8. MAINTENANCE REQUIREMENTS:

Maintenance Operation	Frequency	Lubricant (if applicable)	Comments
(List each operation required. Refer to specific information in Manufacturer's Manual, if applicable)	(List required frequency of each maintenance operation)	(Refer by symbol to lubricant list as required)	

9. LUBRICANT LIST:

Reference Symbol	Conoco Phillips	Exxon/Mobil	BP/Amoco	Other (List)

(Symbols used in Item 7 above)	(List equivalent lubricants, as distributed by each manufacturer for the specific use recommended)			

10. SPARE PARTS (recommendations)_____

_____

11. COMMENTS_____

12. GENERAL INFORMATION:

Date Accepted*: _____

Expected Life*: _____

Project Name & Number: _____

Design Engineer: _____

13. WARRANTY:

Start Date: _____

Expiration Date: _____

Prorated: _____

APPENDIX B
ELECTRIC MOTOR TECHNICAL DATA

Technical Data for Each Motor:

Application: _____

Manufacturer: _____

Frame No.: _____ Type: _____

Code Letter: _____ Design Letter: _____

Rating:

Horsepower: _____Voltage: _____ Phase: _____

Cycles: _____Full Load rpm: _____

(wound rotor secondary)

Volts: _____ Amperes: _____

Full Load Current: _____ amperes

Locked Rotor Current: _____ amperes

Locked Rotor or Starting Torque (percent of full load): _____ percent

Full Load Torque: _____ ft-lb

Breakdown Torque: _____ percent

Efficiency:		Power Factor:	
Full Load:	_____ percent	Full Load	_____ percent
3/4 Load:	_____ percent	3/4 Load:	_____ percent
1/2 Load:	_____ percent	1/2 Load:	_____ percent

Insulation:

Type: _____

Class: _____

Temperature Rise: _____ Above Ambient: _____

Enclosure: _____

Net Weight: _____ lbs

Wk^2: _____ lbs/sq ft

Type of Bearings: _____

Service Factor: _____

Noise Level in Decibels: _____

Heaters: _____ kW, _____ Phase, _____ volts

Altitude: _____

SECTION 02050

SOILS AND AGGREGATES FOR EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Material requirements for soils and aggregates.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C117 - Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
   2. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   3. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   4. C535 - Standard Test Method for Resistance to Degradation of Larger-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   5. D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
   6. D2844 - Standard Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils.
   7. D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   8. D4829 - Standard Test Method for Expansion Index of Soils.
   9. D5821 - Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.

B. California State Transportation Agency, Department of Transportation (CALTRANS):
   1. Standard Specifications.
   2. California Test Methods (CTM):
      a. California Test 205 - Method of Test for Determining Crushed Particles.
      b. California Test 211 - Method of Test for Abrasion of Coarse Aggregate by Use of the Los Angeles Abrasion Testing Machine.
      c. California Test 217 - Method of Test for Sand Equivalent.
      d. California Test 229 - Method of Test for Durability Index.
      e. California Test 301 - Method of Test for Determining the Resistance "R" Value of Treated and Untreated Bases, Subbases, and Basement Soils by the Stabilometer.

1.03 SUBMITTALS

A. Product data:
   1. Material source.
   2. Gradation.
   3. Testing data.

B. Quality control for aggregate base course:
   1. Test reports: Reports for tests required by Sections of Standard Specifications.
   2. Certificates of Compliance: Certificates as required by Sections of Standard Specifications.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection: Protect from segregation and excessive moisture during delivery, storage, and handling.

B. Comply with Standard Specification storage requirements, if applicable.

PART 2 PRODUCTS

2.01 MATERIALS - GENERAL

A. Provide material having maximum particle size not exceeding 4 inches and that is free of trash, lumber, debris, leaves, grass, roots, stumps, and other organic matter.

B. Materials derived from processing demolished or removed asphalt concrete are not acceptable.

C. Comply with soil and aggregate material requirements in the Standard Specifications, unless specified otherwise.

2.02 NATIVE MATERIAL

A. Native soil-select:
   1. Sound earthen material.
   2. Sum of plasticity index when tested in accordance with ASTM D4318 and the percent of material by weight passing a Number 200 sieve shall not exceed 23 when tested in accordance with ASTM C136.
   3. Organic content to not be greater than 3 percent by volume.
   4. Corrosion resistance requirements:
      a. Resistivity minimum (wet aggregates): 5,000 ohm-cm.
      b. pH: 5.0 to 12.0.
      c. Chlorides maximum: 100 parts per million.
      d. Sulfates maximum: 200 parts per million.

2.03 AGGREGATE BASE COURSE

A. Material requirements:
   1. Class 2, 3/4-inch maximum aggregate size, free from organic matter and other deleterious substances, and of such nature that aggregate can be compacted readily under watering and rolling to form a firm, stable base.
   2. Aggregate base course for structures:
      a. Consist of crushed or fragmented particles.
      b. Coarse aggregate material retained in Number 4 sieve shall consist of material of which at least 25 percent by weight shall be crushed particles when tested in accordance with California Test 205.
   3. Aggregate shall not be treated with lime, cement, or other chemical material.

4. Durability index: Not less than 35 when tested in accordance with California Test 229.
5. Aggregate grading and sand equivalent tests shall be performed to represent not more than 500 cubic yards or 1 day's production of material, whichever is smaller.
6. Sand equivalent: Not less than 25 when tested in accordance with California Test 217.
7. Resistance (R-value): Not less than 78 when tested in accordance with California Test 301.
8. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and ASTM C136:

Sieve Sizes (Square Openings)	Percent by Weight Passing Sieve
1 inch	100
3/4 inch	90 - 100
Number 4	35 - 60
Number 30	10 - 30
Number 200	2 - 9

2.04 GRAVEL

A. Material requirements:
1. Consists of hard, durable particles of stone or gravel; or crushed to the specified sizes and gradations; and free from organic matter, lumps or balls of clay, and other deleterious matter.
2. Crush or waste coarse material and add or waste fine material in order to meet the specified gradations.
3. Fraction of material passing Number 40 sieve: Material having plasticity index not greater than 5 when tested in accordance with ASTM D4318.
4. Durability: Percentage of wear not greater than 40 percent when tested in accordance with California Test 211.
5. Conform to sizes and grade within the following limits when tested in accordance with ASTM C117 and C136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve		
	Type A	Type B	Type C
2 inch	100	--	--
1-1/2 inch	95 - 100	100	--
3/4 inch	35 - 60	55 - 85	100
3/8 inch	15 - 40	35 - 65	50 - 100
Number 4	0 - 25	20 - 35	30 - 45
Number 30	--	5 - 15	10 - 20
Number 200	0 - 5	2 - 9	2 - 9

2.05 DRAIN ROCK

A. Material requirements:
   1. Durability index: Percentage of wear not greater than 40 when tested in accordance with California Test 229.
   2. Consists of hard, durable particles of stone or gravel; screened or crushed to specified size and gradation; and free from organic matter, lumps or balls of clay, or other deleterious matter.
   3. Crush or waste coarse material and waste fine material as required to meet gradation requirements.
   4. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and C136:

Sieve Size (Square Openings)	Percent By Weight Passing Sieve
2 inch	100
1-1/2 inch	95 - 100
3/4 inch	50 - 100
3/8 inch	15 - 55
Number 200	0 - 2

2.06 CLASS 2 PERMEABLE FILL

A. Material requirements:
   1. Durability index: Percentage of wear not greater 40 when tested in accordance with California Test 229**.**

2.07 SAND

A. Clean, coarse, natural sand.

B. Non-plastic when tested in accordance with ASTM D4318.

C. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and C136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
1/2 inch	100
Number 200	0 - 20

2.08 STABILIZATION MATERIAL

A. Durability percentage of wear not greater than 40 percent when tested in accordance with California Test 211.

B. Consists of clean, hard, durable particles of crushed rock or gravel; screened or crushed to the specified sizes and gradations; and free of any detrimental quantity of soft, friable, thin, elongated, or laminated pieces, disintegrated material, organic matter, oil, alkali, or other deleterious substance.

C. Shall be free of slaking or decomposition under the action of alternate wetting and drying.

D. The portion of material retained on the 3/8-inch sieve shall contain at least 50 percent of particles having 3 or more fractured faces. Not over 5 percent shall be pieces that show no such faces resulting from crushing. Of that portion which passes the 3/8-inch sieve but is retained on the Number 4 sieve, not more than 10 percent shall be pieces that show no faces resulting from crushing.

E. Conforms to size and grade when tested in accordance with ASTM C117 and ASTM C136.

Sieve Size (Square Openings)	**Percent by Weight Passing Sieve**
1 inch	100
3/4 inch	90 - 100
Number 4	0 - 10
Number 200	0 - 2

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 02200

SITE CLEARING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Clearing, grubbing, and stripping project site.

1.02 DEFINITIONS

A. Clearing: Consists of removal of natural obstructions and existing foundations, buildings, fences, lumber, walls, stumps, brush, weeds, rubbish, trees, boulders, utility lines, and any other items which interferes with construction operations or are designated for removal.

B. Grubbing: Consists of the removal and disposal of wood or root matter below the ground surface remaining after clearing and includes stumps, trunks, roots, or root systems greater than 1 inch in diameter or thickness to a depth of 6 inches below the ground surface.

C. Stripping: Includes the removal and disposal of all organic sod, topsoil, grass and grass roots, and other objectionable material remaining after clearing and grubbing from the areas designated to be stripped. The depth of stripping is estimated to be 6 inches, but the required depth of stripping will be determined by the Engineer.

1.03 QUALITY ASSURANCE

A. Regulatory requirements: Verify and comply with applicable regulations regarding those governing noise, dust, nuisance, drainage and runoff, fire protection, and disposal.

B. Pre-construction conference: Meet with Engineer to discuss order and method of work.

1.04 PROJECT CONDITIONS

A. Environmental requirements:
   1. For suspected hazardous materials found: As specified in Section 01354 - Hazardous Material Procedures.

1.05 SEQUENCING AND SCHEDULING

A. Clearing and grubbing: Perform clearing and grubbing in advance of grading operations.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Examine site and verify existing conditions for beginning work.

3.02 PREPARATION

A. Protect existing improvements from damage by site preparation work.

3.03 INSTALLATION

A. Clearing:
   1. Clear areas where construction is to be performed and other areas as indicated on the Drawings, or specified in this Section, of fences, lumber, walls, stumps, brush, roots, weeds, trees, shrubs, rubbish, and other objectionable material of any kind which, if left in place, would interfere with proper performance or completion of the work, would impair its subsequent use, or form obstructions.
   2. Do not incorporate organic material from clearing and grubbing operations in fills and backfills.
   3. Contractor's temporary construction facilities: Fill or remove pits, fill, and other earthwork required for erection of facilities, upon completion of the work, and level to meet existing contours of adjacent ground.

B. Grubbing:
   1. From excavated areas: Grub stumps, roots, and other obstructions 3 inches or over in diameter to depth of not less than 18 inches below finish grade.
   2. In embankment areas or other areas to be cleared outside construction area: Do not leave stumps, roots, and other obstructions higher than the following requirements:

Height of Embankment over Stump	Depth of Clearing and Grubbing
0 feet to 2 feet	Grub stumps or roots 3 inches or over in diameter to 18 inches below original grade. Cut others flush with ground.
2 feet to 3 feet	Grub stumps 1 foot and over in diameter to 18 inches below original grade. Cut others flush with ground.
Over 3 feet	Leave no stumps higher than stump top diameter, and in no case more than 18 inches.

   3. Backfill and compact cavities left below subgrade elevation by removal of stumps or roots to density of adjacent undisturbed soil.

C. Stripping:
   1. Remove soil material containing sod, grass, or other vegetation to depth of 6 inches from areas to receive fill or pavement and from area within 5 feet outside foundation walls.

2. Deposit stripped material in accordance with following requirements:
    a. At locations acceptable to Engineer.
    b. Use accepted material in top 6 inches of areas to be used for future planting.
3. Replace topsoil where indicated on the Drawings.

D. Material reuse and recycling:
1. 100 percent of trees, stumps, rocks and associated vegetation and soils resulting primarily from land clearing shall be reused or recycled. For a phased project, such material may be stockpiled on site until project completion.
2. Contractor shall provide Engineer with list of local markets and salvage sites for reuse of clearing debris.

END OF SECTION

SECTION 02260

EXCAVATION SUPPORT AND PROTECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for designing, providing, maintaining, and removing excavation support and protection.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. Guidelines of Engineering Practice for Braced and Tied-Back Excavations.

B. California Code of Regulations (CCR):
   1. Title 8 - Industrial Relations:
      a. Division 1. Department of Industrial Relations:
         1) Chapter 4. Division of Industrial Safety.
            a) Subchapter 4. Construction Safety Orders:
               (1) Article 6. Excavations.

C. Department of the Navy Naval Facilities Engineering Command (NAVFAC):
   1. Design Manual 7.2 - Foundations and Earth Structures.
   2. Design Manual 7.3 - Soil Dynamics and Special Design Aspects.

D. State of California Department of Transportation (Caltrans):
   1. Caltrans California Trenching and Shoring Manual.

E. United States Steel Corporation (USS):
   1. Steel Sheet Piling Design Manual.

1.03 DEFINITIONS

A. General Engineering Design Practice: General engineering design practice in area of the Project, performed in accordance with recent engineering literature on subject of shoring and stability of excavations.

B. Shoring: A temporary structural system designed to support vertical faces, or nearly vertical faces, of soil or rock for purposes of excavation. Shoring includes internally braced sheet piling, slurry walls, soldier piles and lagging, and other similar shoring systems. Sloping of the soil is not shoring.

C. Support levels: Level of tiebacks, wales, rakers, bottom of excavation, and other types of support.

1.04 SUBMITTALS

A. Shop drawings and calculations:
   1. Calculations for different load, support, and other conditions that occur during the sequence of installation of shoring, construction of facilities protected by shoring, and sequence of removal of shoring.
   2. Sketches showing the condition at various stages of installation and removal of shoring.
   3. Show on plan shoring, structures, pipelines, and other improvements located near shoring.
   4. When utilities penetrate shoring, show location of penetrations on elevation of sides of shoring.
   5. Show details for ground support and sealing around utility penetrations.
   6. Indicate method used for installing driven shoring.

B. Control points and schedule of measurements:
   1. Submit location and details of control points and method and schedule of measurements.
   2. Survey data.

C. Detailed sequence of installation and removal of shoring:
   1. Consider effects of ground settlement in sequence of installation and removal of shoring.
   2. Provide sketches showing conditions at various stages in sequence of installation and removal of shoring.

D. Submit submittals for excavation support and protection as complete package and include items required in this Section:
   1. Incomplete submittals will not be reviewed and will be returned for resubmittal as complete package.

1.05 SEQUENCING

A. Do not begin construction of any shoring or excavation operations until:
   1. Submittals for shoring and dewatering have been accepted.
   2. Control points as specified in this Section and on existing structures and other improvements as indicated on the Drawings have been established and surveyed to document initial elevations and locations.
   3. Materials necessary for installation are on site.

B. Submit submittals minimum of 60 days prior to scheduled date to begin excavation work.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Where general engineering design practice is specified, provide drawings and calculations that are performed and signed by civil or structural engineer registered in State where Project is located:
   1. Clearly disclose assumptions made, criteria followed, and stress values used for materials being used in design calculations.

2. Submit list of references acceptable to Engineer that substantiating appropriateness of design assumptions, criteria, and stress values.

B. Design requirements:
   1. General:
      a. In accordance with requirements in CCR, Title 8, Chapter 4, Subchapter 4, Article 6 for trench excavations 5 feet or more in depth and for trenches less than 5 feet in depth when there is potential for cave-in:
         1) Where such designs vary from excavation support standards set forth in CCR, Title 8, Chapter 4, Subchapter 4, Article 6, submit design calculations pursuant to general engineering design practice.
         2) Provide means for safe and stable excavations that are not less effective than required in CCR, Title 8, Chapter 4, Subchapter 4, Article 6.
         3) The preceding requirements do not apply to trench excavation support conforming to standards set forth CCR, Title 8, Chapter 4, Subchapter 4, Article 6.
      b. When electing to design with material stresses for temporary construction higher than allowable stresses prescribed in building code as specified in Section 01410 - Regulatory Requirements, increase in such stresses shall not exceed 10 percent of value of prescribed stresses.
      c. Minimum safety factor used for design shall not be less than 1.5.
      d. The calculated minimum depth of penetration of shoring below bottom of excavation shall be increased not less than 30 percent if full value of allowable passive pressure is used in design.
      e. Maximum height of cantilever shoring above bottom of excavation shall not exceed 15 feet. Use braced shoring when height of shoring above bottom of excavation exceeds 15 feet.
      f. The location of point of fixity for shoring shall not be less than half calculated minimum embedment depth below bottom of excavation.
      g. Generally acceptable references for design of shoring and excavations are as follows:
         1) ASCE Guidelines of Engineering Practice for Braced and Tied-Back Excavations.
         2) Caltrans California Trenching and Shoring Manual.
         3) NAVFAC Design Manual 7.2.
         4) NAVFAC Design Manual 7.3.
         5) USS Steel Sheet Piling Design Manual.
   2. Soldier piles and lagging:
      a. Provide lagging over full face of excavation. Joints between pieces of lagging shall be tight to prevent loss of soil.
      b. Provide full face lagging all around penetrations through lagging.
      c. If the soldier piles are installed in predrilled holes and are not concrete encased, fill predrilled holes with controlled low strength material as specified in Section 02312 - Controlled Low Strength Material (CLSM) after soldiers piles are installed.
      d. Assumed effective width for passive soil resistance:
         1) Effective width of driven soldier piles shall not exceed 2 times width of pile.
         2) Effective width of CLSM encased soldier piles in drilled holes shall not exceed 2 times width of pile.

3) Effective width of concrete encased soldier piles shall not exceed 2 times width of concrete encasement.

e. Fill voids behind lagging with gravel or other material acceptable to Engineer.

f. Apply loads from tie back soil, rock, or deadman anchors concentrically to soldier piles or wales spanning between soldier piles:
   1) Wales shall be back-to-back double channels or other members acceptable to Engineer.
   2) Do not eccentrically load structural section of soldier piles or wales.

g. Design soldier piles for downward loads including vertical loads from tieback anchors.

3. Soil anchors, rock anchors, and deadman anchors:
   a. Design tieback anchors for a safety factor of not less than 2 times calculated load from shoring.
   b. Proof load production anchors to 125 percent of calculated load from shoring.
   c. Lock off production anchors at calculated load from shoring.
   d. Length of soil anchors used to calculate resistance to load from shoring shall not include any length within potential active pressure soil failure zone behind face of shoring.
   e. Design tie rods for tieback anchors for 130 percent of calculated load from shoring.
   f. Design tie rods for tieback anchors for 150 percent of the calculated load from shoring when tie rod couplers are used and for other conditions where stress concentrations can develop.

4. Set inside face of shoring back from structure not less than greater of following:
   a. 5 feet from face of wall.
   b. 2 foot 6 inches from edge of foundation.
   c. Depth of excavation below bottom of foundation.

C. Performance requirements:
   1. General:
      a. Support faces of excavations and protect structures and improvements in vicinity of excavations from damage and loss of function due to settlement or movement of soils, alterations in ground water level caused by such excavations, and related operations.
      b. Specified provisions:
         1) Complement, but do not substitute or diminish, obligations of Contractor for furnishing of safe place of work pursuant to provisions of the Occupational Safety and Health Act of 1970 and its subsequent amendments and regulations and for protection of Work, structures, and other improvements.
         2) Represent minimum requirement for:
            a) Number and types of means needed to maintain soil stability.
            b) Strength of such required means.
            c) Methods and frequency of maintenance and observation of means used for maintaining soil stability.
   2. Provide safe and stable excavations by means of sheeting, shoring, bracing, sloping, and other means and procedures, such as draining and recharging groundwater and routing and disposing of surface runoff, required to maintain stability of soils and rock.

3. Provide support for trench excavations for protection of workers from hazard of caving ground.
4. Provide shoring:
    a. Where, as result of excavation work and analysis performed pursuant to general engineering design practice, as defined in this Section:
        1) Excavated face or surrounding soil mass may be subject to slides, caving, or other types of failures.
        2) Stability and integrity of structures and other improvements may be compromised by settlement or movement of soils, or changes in soil load on structures and other improvements.
    b. For trenches 5 feet and deeper.
    c. For trenches less than 5 feet in depth, when there is potential for cave-in.
    d. Where indicated on the Drawings.
5. For safe and stable excavations, use appropriate design, construction, and maintenance procedures to minimize settlement of supported ground and to prevent damage to structures and other improvements, including:
    a. Using stiff shoring systems.
    b. Following appropriate construction sequence.
    c. Using shoring system that is tight enough to prevent soil loss through the shoring.
    d. Using shoring system that extends far enough below bottom of excavation to prevent piping, heave, or flow of soil under shoring.
    e. Design for safety factor of not less than 1.50.
    f. Providing surface runoff routing and discharge away from excavations.
    g. Where dewatering inside shoring is necessary, recharge groundwater outside shoring as necessary to prevent settlement in area surrounding shored excavation.
    h. Where sheet piling is used, use interlocking type sheets:
        1) Sheet piles shall be continuous and driven in interlock.
        2) If bottom of the excavation is located below the water table, use “ball and socket” or "thumb and finger" type interlock.
    i. Not applying shoring loads to existing structures and other improvements.
    j. Not changing existing soil loading on existing structures and other improvements.
    k. Provide welded steel packing between soil retaining members such as sheet piles and wales and similar members when gap exceeds 1/4 inch before wales are loaded.
6. Do not use cantilever sheet pile shoring. When sheet piling is used, provide a braced shoring system with minimum of 1 level of wales and braces. Locate top level of wales and bracing near top of sheets.
7. Use template for driving sheet piles to minimize need for pulling and redriving sheet piles in attempt to drive them plumb.
8. Sheet piles used in shoring system shall be abandoned in place:
    a. Cut off and remove the first 4 feet of sheet pile length below grade upon completion of Work.

PART 3 EXECUTION

3.01 CONSTRUCTION

A. Installation of shoring:
   1. Install means for providing safe and stable excavations as indicated in submittals.

B. Removal of shoring:
   1. Except for concrete encased soldier piles**,** slurry walls, and similar shoring systems, remove shoring by completion of Work.
   2. Select shoring system and method of removal, which will minimize soil that sticks to shoring from creating voids and causing settlement.
   3. To prevent settlement caused by pulling shoring, fill voids with pressure injected grout:
      a. Inject grout starting at bottom of void and progressively fill void to grade.
      b. Minimize length of shoring removed ahead of grouting operation and limit time void is left ungrouted to prevent void from closing up before being grouted.
   4. Pressure preservative treated wood lagging may be left in place if acceptable to Engineer.

C. Control points:
   1. Establish control points on shoring and on structures and other improvements in vicinity of excavation for measurement of horizontal and vertical movement:
      a. Set control points on shoring support system:
         1) Set points at distances not exceeding 25 feet at each support level.
   2. Promptly upon completion of construction of control points survey control points. Submit copy of field notes with measurement.
   3. Perform horizontal and vertical survey and measurement of control points at least once every week:
      a. Field notes shall show current measurement and change in measurement from first measurement taken.
   4. Set control points on corners of existing structures and on curbs, manholes, and other improvements at the locations indicated on the Drawings.
   5. Provide plumb bobs with horizontal targets indicating original position of plumb bobs in relation to shoring at control points.

D. Maintenance:
   1. Where loss of soil occurs, plug gap in shoring and replace lost soil with fill material acceptable to Engineer.
   2. Where measurements and observations indicate possibility of failure or excessive movement of excavation support, determined in accordance with general engineering design practice, take appropriate action immediately.

END OF SECTION

SECTION 02300

EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loosening, excavating, filling, grading, borrow, hauling, preparing subgrade, compacting in final location, wetting and drying, and operations pertaining to site grading for buildings, basins, reservoirs, boxes, roads, and other facilities.
   2. Backfilling and compacting under and around structures.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. ASTM International (ASTM):
   1. D698-Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).
   2. D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
   3. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.03 DEFINITIONS

A. Backfill adjacent to structure: Backfill within volume bounded by the exterior surfaces of structure, the surface of undisturbed soil in the excavation around structure, and finish grade around structure.

B. Embankments: Dikes, levees, berms, and similar facilities.

C. Excavation: Consists of loosening, removing, loading, transporting, depositing, and compacting in final location, wet and dry materials, necessary to be removed for purposes of construction of structures, ditches, grading, roads, and such other purposes as are indicated on the Drawings.

1.04 SUBMITTALS

A. Copy of Property Owner’s Agreement allowing placement of surplus soil material on their property.

B. Excavation plan.

1.05 QUALITY ASSURANCE

A. Initial compaction demonstration:
   1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
      a. 50 cubic yards of backfill adjacent to structures.
      b. 100 cubic yards of embankment work.
      c. 100 cubic yards of fill.
      d. 50 cubic yards of roadway base material.
      e. 100 cubic yards of road fill.
   2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
   3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under "FIELD QUALITY CONTROL."

B. Contractor shall perform work related to this Section in accordance with the approved Stormwater Pollution Prevention Plan (SWPPP).

1.06 SEQUENCING AND SCHEDULING

A. Schedule earthwork operations to meet requirements specified in this Section for excavation and uses of excavated material.

B. If necessary, stockpile excavated material in order to use it at specified locations.

C. Excavation, backfilling, and filling: Perform excavation, backfilling, and filling during construction in manner and sequence that provides drainage at all times.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Where mud or other soft or unstable material is encountered, remove such material and refill space with stabilization material. Wrap stabilization material with stabilization fabric.
   2. Obtain acceptable import material from other sources if surplus obtained within Project site does not conform to specified requirements or are not sufficient in quantity.
   3. No extra compensation will be made for hauling of fill materials nor for water required for compaction.

2.02 MATERIALS

A. Water for compacting: Use water from source acceptable to Engineer.

B. Soil and rock materials:
   1. General:
      a. Provide aggregate base course, Class 2 permeable, controlled low-strength material, drain rock, gravel, native material, sand, select material, and stabilization material where specified or indicated on the Drawings.
      b. If suitable surplus materials are available, obtain native material and select material from cut sections or excavations or imported materials.
   2. Aggregate base course materials: As specified in Section 02050 - Soils and Aggregates for Earthwork.
   3. Class 2 permeable: As specified in Section 02050 - Soils and Aggregates for Earthwork.
   4. Drain rock: As specified in Section 02050 - Soils and Aggregates for Earthwork.
   5. Gravel: As specified in Section 02050 - Soils and Aggregates for Earthwork.
   6. Native material: As specified in Section 02050 - Soils and Aggregates for Earthwork.
   7. Sand: As specified in Section 02050 - Soils and Aggregates for Earthwork.
   8. Select material: As specified in Section 02050 - Soils and Aggregates for Earthwork.
   9. Stabilization material: As specified in Section 02050 - Soils and Aggregates for Earthwork.

C. Controlled low-strength material: As specified in Section 02312 - Controlled Low Strength Materials (CLSM).

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:
   1. Character and quantity of material:
      a. Verify character and quantity of rock, gravel, sand, silt, water, and other inorganic or organic materials to be encountered in work to be performed.
      b. Determine gradation, shrinkage, and swelling of soil, and suitability of material for use intended in work to be performed.
      c. Determine quantity of material, and cost thereof, required for construction of backfills, cuts, embankments, excavations, fills, and roadway fills, whether from onsite excavations or imported materials. Include in cost of work to be performed.
      d. Include wasting of excess material, if required, in cost of work to be performed.

3.02 PREPARATION

A. Backfills:
   1. After clearing and excavation are completed, scarify entire areas that underlie backfills or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
   2. Recompact scarified areas to density specified before placing backfill material or concrete.

3. If foundation areas have soft soils, do not scarify the top 6 inches prior to compaction. Remove loose material using hand equipment or with a flat-edged backhoe bucket. Do not remold and weaken the remaining soil by operating heavy equipment on final bottom elevation of excavation**.**
4. Do not place backfill against walls until:
    a. Walls have been cast full height of structure and concrete has reached the specified strength.
    b. Connecting slabs and beams have been cast, and concrete has reached the specified strength.
5. Prior to backfilling:
    a. Remove forms.
    b. Clean trash and debris from the excavation site.
6. After inspection of foundation, walls, and pipes, place backfill symmetrically around structures to prevent eccentric loading of structures.

B. Embankments:
1. After clearing is completed, scarify entire areas that underlie embankments to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
2. Recompact scarified areas to density specified for embankments before placing of embankment material.

C. Fills:
1. After clearing is completed, scarify entire areas that underlie fill sections or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
2. Recompact scarified areas to density specified for compacted fills before placing of fill material or concrete.

D. Roadway fills:
1. After clearing is completed, scarify entire areas that underlie roadway fills to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
2. Recompact scarified areas to density specified for roadway fills before placing of roadway fill material.

E. Sloped surfaces for fill or foundations:
1. Foundations for fill having slopes in excess of 1 vertical to 4 horizontal:
    a. Bench or terrace to adequately key existing ground and fill built thereon.
2. Slopes of original hillsides and old fills: Bench minimum of 10 feet horizontally as fill is placed.
3. Provision of new benches:
    a. Start new bench wherever vertical cut of next lower bench intersects existing grade.
    b. Recompact material thus cut out along with new embankment material at no additional cost to the Owner.

3.03 INSTALLATION

A. General:
   1. Dispose of excavated materials that are not required or are unsuitable for fill and backfill in lawful manner.
   2. Dispose of surplus material on private property only when written permission agreement is furnished by owner of property. Submit copies of such agreements.
   3. Rocks, broken concrete, or other solid materials larger than 4 inches in greatest dimension: Remove from project site at no additional cost to the Owner.
   4. Stabilization of subgrade: Provide materials used, or perform work required, to stabilize subgrade so it can withstand loads that may be placed upon it by Contractor's equipment.

B. Compaction:
   1. Provide specified compaction for backfills, cuts, embankments, fills, roadway fills, and other earthwork.
   2. Perform confirmation tests to verify and confirm that work has complied, and is complying at all times, with compaction requirements specified in this Section for initial compaction demonstration and field quality control testing.
   3. In-place density of compacted backfills, cuts, embankments, fills, and roadway fills determined in accordance with ASTM D1556, or with ASTM D6938.
   4. Maximum density, laboratory compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.
   5. To prevent damage to structures due to backfilling operations, place backfill with equipment that does not exceed AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading, within a distance from the face of the structure of not less than 1/2 the depth of backfill. The depth of backfill is the distance between the level being compacted and the bottom of the excavation. Outside this distance, heavier compaction equipment may be used.
   6. Compact to percentage of maximum density as follows:
      a. Backfill adjacent to structures: 95 percent.
      b. Backfilling voids: 95 percent.
      c. Other areas: 85 percent.
      d. Under present and future structures: 95 percent.
      e. Under roadways, parking and storage areas, curbs, and sidewalks: 95 percent.
      f. Upper 6 inches of cuts: 95 percent.
      g. Fills: 95 percent.

C. Excavation:
   1. Blasting: Not permitted.
   2. Excavations for trenching: As specified in Section 02318 - Trenching.
   3. Excavations for structures:
      a. Provide excavations conforming to dimensions and elevations indicated on the Drawings for each structure.
      b. After clearing is complete, excavate for the structure, down to the elevation indicated on the Drawings. Unless directed by Engineer, do not carry excavations below elevation indicated on the Drawings.

c. Where soil is encountered having unsuitable bearing value, Engineer may direct in writing that excavation be carried to elevations below those indicated on the Drawings.
d. Where excavations are made below elevations indicated on the Drawings, adjust elevations of excavations in accordance with the following requirements:
    1) Under slabs: Restore to proper elevation in accordance with procedure specified for backfill in this Section.
    2) Under footings: Restore to the proper elevation using one of the following:
        a) Aggregate base course.
        b) Controlled low-strength material.
e. Excavation width:
    1) Extend excavations at least 2 feet clear from walls and foundations of structures to allow for placing and removal of forms, installation of services, and inspection.
    2) Do not undercut slopes.
f. Difficulty of excavation: No extra compensation will be made for removal of rock or any other material due to difficulty of excavation.

4. Excavation of lined channels:
    a. Excavations in open cut for lined channels may be made so as to place concrete directly against excavated surfaces providing faces of excavations are:
        1) Firm and unyielding.
        2) Will stand or can be made to stand without sloughing.
    b. Excavations to provide subgrade for lined channel or subdrainage material: Excavate to lines and grades indicated on the Drawings.
5. Excavation of unlined channels and basins:
    a. Excavate to lines and grades indicated on the Drawings.
    b. Perform excavation and grading so that finish surfaces are in uniform planes with no abrupt breaks in surface.
6. Excavation of ditches and gutters:
    a. Cut ditches and gutters accurately to cross sections and grades indicated on the Drawings.
    b. Take care not to excavate ditches and gutters below grades indicated on the Drawings.
    c. Backfill excessive ditch and gutter excavations to grade with suitable material acceptable to the Engineer.
    d. Do not deposit any material within 3 feet of edge of ditch unless otherwise indicated on the Drawings.
7. Necessary over excavation:
    a. Where it becomes necessary to excavate beyond normal lines of excavation in order to remove boulders or other interfering objects, backfill voids remaining after removal as specified in backfilling of voids below, or as acceptable to the Engineer.
    b. Backfill voids with material acceptable to the Engineer:
        1) With acceptance of the Engineer, backfill with one of the following:
            a) Aggregate base course.
            b) Controlled low-strength material.

D. Materials for backfills, embankments, fills, and roadway fills:
   1. General:
      a. Obtain import material from other sources if surplus materials from cuts and excavations obtained from within Project site do not conform to specified requirements or are not sufficient in quantity for construction of Project.
   2. Backfills:
      a. Backfill adjacent to structures, slabs, or walls: Native material or imported material meeting the requirements of native material, unless otherwise specified or indicated on the Drawings.
      b. Backfill material under concrete structures: Aggregate base course material, except in areas where controlled low-strength material or concrete encasement are indicated on the Drawings.
      c. Extend backfill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
   3. Embankments:
      a. Native material or imported material meeting the requirements of native material, unless otherwise specified or indicated on the Drawings.
   4. Fills:
      a. Native material or imported material meeting the requirements of native material, unless otherwise specified or indicated on the Drawings.
      b. Extend fill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
   5. Roadway fills: One of the following, unless otherwise specified or indicated on the Drawings:
      a. Aggregate base course material.

E. Placement:
   1. General:
      a. Lines and grades:
         1) Construct backfills, embankments, fills, and road fills, at locations and to lines and grades indicated on the Drawings.
         2) Overbuild permanent fill slopes by at least 1 foot and then cut to final grade to provide adequate compaction of the remaining fill.
   2. Backfills:
      a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
      b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
      c. Defective compacted backfills: Remove and recompact.
   3. Fills:
      a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
      b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
      c. Defective compacted fills: Remove and recompact.
   4. Embankments:
      a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
      b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
      c. Defective compacted embankments: Remove and recompact.

5. Roadway fills:
    a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
    b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
    c. Defective compacted roadway fills: Remove and recompact.

3.04 FIELD QUALITY CONTROL

A. Confirmation tests:
    1. Contractor's responsibilities:
        a. Adequacy of compaction equipment and procedures:
            1) Demonstrate adequacy of compaction equipment and procedures.
            2) At each test location include tests for each type or class of backfill from bedding to finish grade.
        b. Compaction sequence requirements:
            1) Do not perform additional earthwork of the same kind until specified degree of compaction has been demonstrated.
        c. Cost of confirmation tests: Paid for by the Contractor.
        d. Qualifications of Contractor's testing laboratory: Acceptable to Engineer.
        e. Copies of confirmation test reports: Submit promptly to the Engineer.

B. Tolerances:
    1. Finish grading of backfills, cuts, embankments, fills, and roadway fills:
        a. Perform fine grading under concrete structures such that finish surfaces are never above the grade or cross section indicated on the Drawings and are never more than 0.10 feet below.
        b. Provide finish surface for areas outside of structures that are within 0.10 feet of grade or cross section indicated on the Drawings.
    2. Unlined channels and basins:
        a. In both cut and fill, and levee and access road side slopes in cut: Vertical tolerance of none above and 3 inches below grade indicated on the Drawings on bottom and side slopes.
        b. On top surface of levee and access road in both cut and fill, and levee and access road side slopes in fill: Vertical tolerance of none below and 3 inches above grade indicated on the Drawings.
    3. Areas which are not under structures, concrete, asphalt, roads, pavements, sidewalks, dikes, and similar facilities:
        a. Provide finish graded surfaces of either undisturbed soil, or cohesive material not less than 6 inches deep.
        b. Intent of proceeding is to avoid sandy or gravelly areas.
    4. Finish grading of surfaces:
        a. Reasonably smooth, compacted, and free from irregular surface changes.
        b. Provide degree of finish that is ordinarily obtainable from blade grader operations, except as otherwise specified.
        c. Uniformly grade areas that are not under concrete.
        d. Finish ditches and gutters so that they drain readily.

C. Compliance tests:
    1. Frequency of testing: Periodic compliance tests will be made by the Engineer to verify that compaction is meeting requirements previously specified.

3.05 ADJUSTING

A. Finish grades of excavations, backfills, and fills:
   1. Repair and reestablish grades to required elevations and slopes due to any settlement or erosion that may occur from action of the elements or any other cause prior to final acceptance.

3.06 PROTECTION

A. Finish grades of backfills, cuts, excavations, and fills:
   1. Protect newly graded areas from erosion and deterioration by action of the elements.

B. Ditches and gutters:
   1. Maintain ditches and gutters free from detrimental quantities of debris that might inhibit drainage until final acceptance.

END OF SECTION

SECTION 02312

CONTROLLED LOW STRENGTH MATERIAL (CLSM)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Controlled low strength material (CLSM), also known as "flowable fill."

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 229R - Report on Controlled Low-Strength Materials.
   2. 301 - Specifications for Structural Concrete.

B. ASTM International (ASTM):
   1. C94 - Standard Specification for Ready Mix Concrete.
   2. C143 - Standard Test Method for Slump of Hydraulic Cement Concrete.
   3. C150 - Standard Specification for Portland Cement.
   4. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
   5. C494 - Standard Specification for Chemical Admixtures for Concrete.
   6. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   7. D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3(2,700 kN-m/m^3)).
   8. D4832 - Standard Test Method of Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
   9. D5971 - Standard Practice for Sampling Freshly Mixed Controlled Low Strength Material.
   10. D6023 - Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material.

1.03 SUBMITTALS

A. Product data: Submit data completely describing materials in the mix and demonstrating compliance with the requirements of this Section:
   1. Cement: Mill tests. Indicate alkali content representative of each shipment.
   2. Fly ash: Identify source and type of fly ash.
   3. Water: Identify source and quality if not from a municipal treatment source.
   4. Admixtures: Manufacturer’s product data indicating suitability for use in CLSM mixes and recommended dosage rates.
   5. Aggregate:
      a. Submit source, type, and sieve analyses.
      b. Resubmit at any time there is a significant change in grading of materials.

B. Mix design:
   1. Submit full details, including mix design calculations for mix proposed for use.
   2. Trial batch test data:
      a. Submit data for each test cylinder.
      b. Submit data that identifies mix and slump for each test cylinder.

1.04 DELIVERY, STORAGE AND HANDLING

A. Store or stockpile cement, fly ash, and aggregate in accordance with ACI 301.

B. Store admixtures in accordance with the manufacturer's recommendations.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Mixture of portland cement, water, pozzolan, fine aggregate and admixtures, proportioned in accordance with the recommendations of ACI 229 to produce a homogeneous mixture that is flowable, that will readily work into corners and angles; that will not segregate in the plastic state; and that is self-compacting at the time of placement without the use of mechanical vibration.

B. Performance requirements:
   1. Air content, total calculated in accordance with ASTM D6023: Not less than 8.0 percent, nor greater than 12.0 percent.
   2. Compressive strength, measured in accordance with ASTM D4832 at 28 days: Not less than 50 pounds per square inch, nor greater than 150 pounds per square inch.
   3. Wet density: Not greater than 132 pounds per cubic foot.
   4. Slump, measured in accordance with ASTM C143 at the point of placement: Greater than 9 inches and that allows CLSM to flow freely and to be self-compacting during placement.

2.02 MATERIALS

A. Cement:
   1. Portland cement in accordance with ASTM C150, Type I or Type II.
   2. Having total alkali content not more than 0.60 percent.

B. Fly ash: Class C or Class F fly ash in accordance with ASTM C618.

C. Water:
   1. Potable water: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.

D. Admixtures: Products of a single manufacturer, specifically manufactured or recommended by that manufacturer for use in CLSM:
   1. Air entraining admixture: In accordance with ASTM C260.
   2. Water reducing admixture: In accordance with ASTM C494, Type A.

E. Aggregate:
   1. Non-expansive, non-reactive, inert natural sand conforming to the following requirements:
      a. Not more than 12 percent passing a No. 200 sieve.
      b. No plastic fines present.
      c. Including pea gravel no larger than 3/8 inch.

2.03 MIXES

A. See System Description for performance requirements of the plastic and hardened mix.

2.04 SOURCE QUALITY CONTROL

A. Trial batch:
   1. After mix design has been accepted by Engineer, have trial batch of the accepted mix design prepared by testing laboratory acceptable to Engineer.
   2. Prepare trial batches using the specific cement, fly ash, admixtures, aggregates, and water proposed for the Work.
   3. Prepare trial batch with quantity sufficient to determine slump, workability, and consistency; and to provide test cylinders as indicated in this Section.

B. Trial batch testing:
   1. Determine slump in accordance with ASTM C143, with the following modifications:
      a. Do not rod the concrete material.
      b. Place material in slump cone in one semi-continuous filling operation, slightly overfill, tap lightly, strike off, and then measure and record slump.
   2. Prepare and test trial batch specimens in accordance with ASTM D4832, with the following modifications:
      a. Provide cylindrical test specimens, each 6-inches in diameter by 12-inch high.
      b. Provide a minimum of 8 cylinders for testing of each trial batch.
      c. Fill the molds to overflowing and tap sides lightly to settle the mix.
      d. Do not rod the mix for consolidation in the cylinder.
      e. Strike off the excess material.
   3. Place test cylinders in a moist curing room. Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
   4. Do not remove the test cylinder from mold until that cylinder is to be capped and tested:
      a. Perform the capping carefully to prevent premature fractures.
      b. Do not perform initial compression test until the cylinders reach a minimum age of 3 days.
   5. Provide compressive strength tests:
      a. Test 4 test cylinders at 7 days after casting, and another 4 cylinders at 28 days after casting.
      b. The compression strength of the 4 test cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength.

C. If the trial batch tests do not meet the Specifications for strength or density, revise and re-submit the mix design, prepare additional trial batch(es), and complete additional trial batch tests. Repeat until an acceptable trial batch is that conforms to the Specifications is produced.
   1. All the trial batches and acceptability of materials shall be paid by the Contractor.
   2. After acceptance, do not change the mix design without submitting a new mix design, trail batches, and test information.

PART 3 EXECUTION

3.01 PREPARATION

A. Do not place CLSM until preparation and condition of surfaces receiving the fill have been observed and accepted by the Engineer.

B. Remove debris foreign matter, and standing or running water from excavations and areas receiving CLSM before placement.

3.02 INSTALLATION

A. Pipes and trenches.
   1. Where CLSM is placed around and over pipes, secure pipes in place, or place CLSM in lifts to prevent pipe flotation.
   2. Where CLSM is placed in long, open trenches, confine material using bulkheads of sandbags, earth dams, or stiffer concrete at open ends of placement.

B. Soil preparation:
   1. Prior to placement of CLSM, prepare underlying soils as follows:
      a. Scarify surface to a depth of 8 inches.
      b. Adjust moisture content to or slightly above the optimum in accordance with ASTM D1557.
      c. Re-compact scarified surface to a minimum of 95 percent relative density in accordance with ASTM D1557.

3.03 MEASURING, BATCHING, MIXING AND TRANSPORTING

A. Measure, batch, mix and transport CLSM in accordance with the requirements of ASTM C94 and this Section.

B. Mix until there is uniform distribution of materials.

C. Discharge mixer completely prior to recharging.

D. After trial batch testing and mix acceptance, maintain slump during construction within plus or minus 1 inch of the design slump.

3.04 PLACING

A. Place controlled low strength material by method that preserves the quality of the material in terms of compressive strength and density.

B. Maintain fluid properties of the mix during placement:
   1. At point of placement, provide material that flows easily around, beneath, or through walls, pipes, conduits, or other structures.
   2. Do not place CLSM that has partially hardened or that has been contaminated by foreign materials.
   3. Handle and place CLSM using methods that minimize segregation of the mix.
   4. Deposit mix as near its final position as possible to avoid segregation due to rehandling or flowing.
   5. Contain and confine mix while it is fluid. Design containment structures and bracing at walls and forms to withstand lateral pressures of wet mix.

C. Lifts:
   1. Limit lift heights of CLSM placed against structures and other facilities that could be damaged due to the pressure from the CLSM, to the lesser of 3 feet or the lift height indicated on the Drawings.
   2. Do not place another lift of CLSM until the last lift of CLSM has set and gained sufficient strength to prevent additional lateral load against the forms or structure due to the weight of the next lift of CLSM.

D. Water conditions:
   1. Do not place CLSM in standing or flowing water.
   2. Do not permit water to flow over the surface of freshly placed or un-hardened CLSM.
   3. Do not submerge CLSM in water within 24 hours after placement.

E. Manage CLSM bleed water:
   1. Grade top surface of CLSM to drain away from the fill.
   2. Provide side containment that permits bleed water to drain to a contained management area away from the fill.

3.05 CURING AND PROTECTION

A. Curing:
   1. Prior to and during curing, install barriers to prevent equipment or personnel from falling into or becoming entrapped in CLSM.

B. Protect CLSM from:
   1. Damage from the elements.
   2. Damage of any nature during surrounding construction operations.

3.06 FIELD QUALITY CONTROL

A. Provide quality control over the Work of this Section as specified in Section 01450 - Quality Control and as specified in this Section.

B. General:
   1. Engineer inspection and acceptance required prior to placement.
   2. Make provisions for and furnish all material for the test specimens, and provide manual assistance to assist the Engineer in preparing said specimens.

3.07 FIELD QUALITY ASSURANCE

A. Provide quality control over the work of this Section as specified in Section 01450 - Quality Control.

B. Field inspections:
   1. Engineer shall provide on-site inspection for the Work of this Section.
   2. Advise Engineer of readiness to proceed at least 24 hours prior to each placement of CLSM.
   3. Required inspections:
      a. Engineer will observe the prepared areas. Do not place CLSM until Engineer has observed and accepted preparations.
   4. Record of inspections.

C. Field sampling and testing:
   1. During construction, Contractor shall provide sampling and testing to determine whether the CLSM, as produced and placed, complies with the requirements specified.
   2. Sample CLSM for testing in accordance with ASTM D5971.
   3. Required tests:
      a. Air content: Prepare sample and test in accordance with ASTM D6023.
      b. Compressive strength: Prepare and test cylinder specimens in accordance with ASTM D4832:
         1) Prepare 6-inch diameter by 12-inch high specimens for testing:
            a) Provide one set of specimens for each 150 cubic yards of CLSM placed, but not less than 1 set for each half day's placement.
            b) Prepare and test not less than 3 cylinders for each set.
            c) Place CLSM in the molds in accordance with ASTM D4832. Do not rod or otherwise consolidate the material in the mold.
            d) In accordance with ASTM D4832 recommendations for displacing bleed water at the top of the molds and refilling the molds before covering with a lid. Do not use air-tight lids.
         2) Place the cylinders in a safe location away from construction activities:
            a) Protect cylinders from bumping and impact.
            b) Maintain temperature surrounding cylinders between 60 and 80 degrees Fahrenheit until delivery to the laboratory for testing.
            c) After the first day, surround molds with a high humidity environment by covering with wet burlap, or equivalent highly absorptive material. Maintain saturation of the cover. Do not sprinkle water directly on the cylinders.
         3) After 4 days, place the cylinders in a protective container for transport to the laboratory for testing:
            a) Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
            b) Transport container may be a box with a Styrofoam or similar lining that will limit jarring and bumping of the cylinders.
         4) Upon receipt at the testing laboratory, place test cylinders in a moist curing room until dates for testing.
         5) Do not remove test cylinders from molds until the day that cylinders is to be capped and tested.

6) Cap and test for compressive strength in accordance with ASTM D4832:
   a) Do not perform initial compression test until the cylinders reach an age of at least 4 days.
   b) Test 1 cylinder at 7 days and 2 at 28 days.
7) Compressive strength of the cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength specified.

3.08 NON-CONFORMING WORK

A. When testing or observation indicates CLSM with properties outside the specified and accepted range, Engineer will issue instructions regarding disposition of nonconforming materials.

B. Engineer may:
   1. Reject CLSM represented by those test specimens and require its removal and replacement.
   2. Require modification of the mix design to provide CLSM with the properties specified.

C. Make such modifications at no additional expense to the Owner and with no adjustment to the schedule.

END OF SECTION

SECTION 02318

TRENCHING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Trench excavation and trench backfill for pipelines, manholes, vaults, and appurtenances.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3).
   2. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.03 SUBMITTALS

A. As specified in Section 01330 - Submittal Procedures.

B. Product data on soils and aggregates:
   1. Material source.
   2. Gradation.
   3. Test data to demonstrate compliance with requirements as specified in this Section.

C. Samples:
   1. Provide 50-pound sample of materials when requested by the Engineer.

D. Confirmation testing:
   1. Certification of Contractor's testing laboratory.
   2. Record copy report for tests performed by Contractor's testing laboratory.

1.04 DEFINITIONS

A. Backfill: Material placed in trench above the pipe embedment zone.

B. Bedding: Material placed under, around, and over pipes or ducts in trenches.

C. Fine grading: bedding material placed directly below pipes or ducts to provide support at the bottom of the trench and to bring those elements to required grades and elevations.

D. Pipe foundation: Stabilization material placed at the bottom of trench to provide support when the trench bottom is not firm, dry or uniform.

E. Pipe embedment zone: Includes bedding, fine grading, and haunch zone.

F. Haunch zone: Material placed below and beside the pipe up to the pipe springline.

G. Pipe springline: A horizontal reference line located at mid-height, or halfway point, of a circular conduit, pipe, or tunnel. It is the maximum horizontal dimension or diameter of a circular conduit, pipe, or tunnel.

H. Rigid pipe: Includes reinforced non-cylinder concrete, reinforced concrete cylinder, prestressed concrete cylinder, vitrified clay, polymer concrete, cast iron, asbestos cement and cast-in-place pipes.

I. Flexible pipe: Includes steel, ductile iron, thermoplastics such as polyvinyl chloride (PVC) and high-density polyethylene (HDPE), thermosetting plastics such as fiberglass-reinforced polymer (FRP), bar-wrapped concrete cylinder pipe, and corrugated steel pipes.

J. Haunch zone: Material placed below and beside the pipe up to the pipe springline.

K. Lift: A layer of soil or aggregate material, measured before compaction.

L. Maximum density, laboratory compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.

M. Maximum density, field compaction: Soil density and water content when tested in accordance with ASTM D6938.

N. Pavement section: Includes pavement plus underlying courses such as base course and subgrade.

O. Pipe embedment zone: Includes bedding, fine grading, and haunch zone.

P. Pipe foundation: Material placed at the bottom of trench to provide support.

PART 2 PRODUCTS

2.01 MATERIALS

A. As specified in Section 02050 - Soils and Aggregates for Earthwork.

B. Controlled low-strength material: As specified in Section 02312 - Controlled Low Strength Material (CLSM)

PART 3 EXECUTION

3.01 PREPARATION

A. Stabilize excavations as specified in Section 02260 - Excavation Support and Protection.

B. Perform subsurface utility engineering (SUE) for utility locating and verification prior to any excavation work.

3.02 TRENCH EXCAVATION

A. Excavate bottom of trench to depth indicated on the Drawings.

B. Areas of new fill or embankment:
   1. Prior to laying pipes or electrical service, place fill and compact as specified to not less than 2 feet above top of pipe, conduit, or duct bank.
   2. Excavate through fill for pipe trench.

C. Trench widths as specified in the following table:

Buried Pipe or Accessory	Minimum Trench Width	Maximum Trench Width
Nominal Pipe Diameter: 4 inch to 24 inch	OD + 18 inches	OD + 24 inches
Nominal Pipe Diameter: Greater than 24 inch	OD + 24 inches	OD + 36 inches
Manholes, vaults, valves, or other accessories	12 inches between outer surface and trench side or shoring	Not applicable

D. Potable water pipe and appurtenances:
   1. Lay in trenches separate from those used for sewers and recycled water.
   2. Unless otherwise specified or indicated on the Drawings, lay in trenches having cover of not less than 3 feet below surface of ground located at distance of not less than 10 feet clear horizontally from any parallel sewer and 1 foot clear vertically above any parallel sewer.

E. At road crossings or existing driveways:
   1. Provide notification, vehicular access, and traffic control as required by permits and special conditions.
   2. Provide temporary asphalt or plating for traffic or access at the end of each work day unless approved in writing by Engineer.
   3. If unexpected utility conflicts or changed site conditions require trenchless technologies or temporary bridges, immediately notify the Engineer in writing. Approval is required before proceeding with construction.
   4. When trench width at top of pipe is increased beyond width specified in this Section because of soil conditions, safety requirements, or other reasons, Engineer approval for remedy is required without additional cost to Owner:
      a. Remedy may include upgrade laying conditions or install stronger pipe designed in accordance with Specifications.

3.03 TRENCH BACKFILL - GENERAL

A. Trench area terminology and locations as indicated on the Drawings.

B. Place material, except CLSM and concrete, in maximum 8 inch lifts, measured before compaction.

C. Backfilling of manhole excavation: Conform to backfilling requirements for trenches as specified in this Section.

3.04 PIPE FOUNDATION

A. Provide trench bottom with firm, dry, uniform bearing surface at the grade indicated on the Drawings.

B. Excess excavation below elevation indicated on the Drawings will require installation of pipe foundation material to bring the trench bottom back to the elevation indicated on the Drawings at no additional cost to Owner.

C. If bottom of trench excavation consists of soil:
   1. Scarify bottom of trench to a depth of 6 inches below the grade indicated on the Drawings.
   2. Materials and placement:
      a. Recompact scarified material to 95 percent of maximum density.

D. If bottom of trench excavation consists of rock or any material that, by reason of its hardness, cannot be excavated to provide uniform bearing surface:
   1. Remove such rock or other material to a depth of not less than 4 inches below pipe embedment zone.
   2. Materials:
      a. CLSM.
      b. Class C concrete.

E. If bottom of trench excavation consists of mud or other soft unstable material:
   1. Remove such unacceptable material to a depth of not less than 18 inches below pipe embedment zone.
   2. Material and placement:

3.05 PIPE EMBEDMENT ZONE

A. Pipe displacement:
   1. Take necessary precautions in placement and compaction of bedding material to prevent displacement of piping.
   2. In event there is movement or floating of the piping, re-excavate, re-lay, and backfill the pipe.

B. Fine grading:
   1. Place 6-inches of approved haunch zone bedding material from the trench bottom to the bottom of the pipe or duct to provide support at the bottom of the trench and to bring those elements to required line and grade.

C. Depressions for joints or couplings:
   1. Excavate holes in the fine grading material at the bottom of the trench.
   2. Provide holes of sufficient width to provide ample room for grouting, banding, or welding as necessary for making joints and to ensure that pipe rests upon prepared trench bottom and not supported by any portion of the joint.

D. Rigid pipe:
   1. Pipe embedment zone: Below pipe springline:
      a. Materials and placement:
         1) Aggregate base course compacted to 95 percent maximum dry density.

2. Pipe embedment zone: Above pipe springline:
    a. Compacted to a depth above pipe: 12-inch minimum.
    b. Materials and placement:
        1) Aggregate base course compacted to 95 percent maximum dry density.

E. Flexible pipe:
1. Pipe embedment zone:
    a. Compacted to a depth above pipe: 12-inch minimum.
    b. Materials and placement:
        1) Aggregate base course compacted to 95 percent maximum dry density.

3.06 BACKFILL

A. Trenches:
1. Materials and placement:
    a. Native soil (except for Young Bay Mud)compacted to 90 percent maximum dry density.
    b. Imported fill compacted to 95 percent maximum dry density.
    c. Aggregate base course compacted to 95 percent maximum dry density.
    d. CLSM.

B. Trenches in rock:
1. Backfill to top of rock:
    a. Materials and placement:
        1) CLSM.
        2) Class C concrete.
2. Backfill from top of rock to grade, if applicable:
    a. Materials and placement:
        1) Aggregate base course compacted to 95 percent of maximum density.

C. Trenches below or within 10 feet of the outside perimeter of structures:
1. Backfill to underside of structure.
2. Materials and placement:
    a. Aggregate base course compacted to 95 percent of maximum density.
    b. CLSM.

D. Trenches in roadways and paved areas:
1. Backfill trench to underside of pavement.
2. Materials and placement:
    a. Aggregate base course compacted to 95 percent of maximum density.
    b. CLSM.

E. Trenches in areas outside the improved section of roadways or in open country:
1. Backfill to finished grade.
2. Materials and placement:
    a. Native soil, native soil - select, imported material, or aggregate base course compacted to 90 percent of maximum density.

F. Trenches under existing intersecting pipes, duct banks, or conduits larger than 3 inches in diameter:
   1. Backfill from above top of new pipe embedment zone to springline of intersecting pipe or conduit:
      a. Extend backfill at least 2 feet on either side of intersecting pipe or conduit to ensure backfill material remains in place while other backfill is being placed.
      b. Materials and placement:
         1) CLSM, unless otherwise indicated on the Drawings.
   2. Backfill remainder of trench:
      a. Materials and placement:
         1) CLSM.
         2) Class C concrete.

3.07 EXCESS MATERIAL

A. Remove excess excavated material from the Project site as specified in Section 02300 - Earthwork.

3.08 FIELD QUALITY CONTROL

A. Provide field quality control for the Work as specified in Section 01450 - Quality Control.

B. Confirmation tests: As specified in Section 02300 – Earthwork:
   1. Minimum frequency of confirmation testing:
      a. At each test location include tests for each type or class of backfill from bedding to finished grade.
      b. For trenches: 1 location every 200 linear feet.
      c. In open fields: 2 locations every 1,000 linear feet or 1 location every 200 cubic yards.
      d. Along dirt or gravel road or off traveled right-of-way: 1 location at every 500 linear feet.
      e. Crossing paved roads: 1 location at each crossing.
      f. Under pavement cuts or within 2 feet of pavement edges: 1 location every 400 linear feet.

C. Compliance tests:
   1. Make periodic compliance tests to verify that compaction is meeting requirements as specified in this Section.
   2. Perform remedial work if compaction test fails to meet specified requirements using one of the following methods:
      a. Remove and replace backfill at the proper density.
      b. Other means acceptable to the Engineer.
   3. Retesting:
      a. Costs of retesting: Contractor is responsible for the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
      b. Contractor's confirmation tests during performance of remedial work:
         1) Performance: Perform tests in manner acceptable to the Engineer.
         2) Frequency: Double amount specified for initial confirmation tests.

D. Piping system testing:
   1. As specified in Section 15956 - Piping Systems Testing.

END OF SECTION

SECTION 02455

DRIVEN PILES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Driven piles and related items including testing of driven piles and indicator piles.

B. Payment procedures:
   1. Payment for pile work:
      a. Base lump sum bid price for pile work on the number and lengths of piles indicated on the Drawings:
         1) This price shall include costs in connection with the work, including pile material, predrilling, installation, cutting the piles off less than 6 inches in order to meet cutoff elevations, reinforcing and prestressing steel, pile connectors, concrete, and other related items for a complete installation.
      b. In addition, quote a unit price per foot for additional pile length and reduction in pile length for changes in pile length made before the manufacture of production piles:
         1) This change in length will be based on the results of Engineer's analysis of the indicator piles
      c. In addition, quote a unit price for pile extensions made after the production piles have been manufactured:
         1) Pile extensions due to piles that are driven too deep, or otherwise unacceptable piles, shall be at the Contractor's expense.
      d. Provide a per pile unit cost for pile cut-off, for piles which meet refusal in the designated space of the bidding form:
         1) Include in cutoff costs, the cost of deepening dowel holes.
         2) Pile cutoffs of less than 6 inches long will not receive separate payment.
      e. Payment will be made only for the length of pile established by the Engineer's analysis of the indicator piles:
         1) No payment will be made for any defective pile.
         2) Piles shall be driven to the elevations and lengths indicated on the Drawings, unless otherwise indicated in writing by the Engineer:
            a) No payment will be made for the length of pile greater than the length indicated on the Drawings or for pile extension unless this additional length or pile extension is directed by the Engineer in writing.

1.02 DEFINITIONS

A. Low driving resistance: Shall be defined by the ENGINEER following the evaluation of the indicator pile test results. Refusal: Shall be defined by the ENGINEER following the evaluation of the indicator pile test results.

1.03 SUBMITTALS

A. Product data: Description of equipment proposed for driving piles, including information concerning type and rating of pile drivers.

B. Pile location plan:
   1. Plan showing layout as indicated on the Drawings, indicating location of each pile, including:
      a. Assigned number for each pile as identification for use in pile installation record.
      b. Pile cutoff elevation.
      c. Pile tip elevation: -64.50 feet.

C. Pile location survey information.

D. Pile hammer:
   1. The manufacturer's specifications and catalog for hammers proposed for use.

E. Where the cushion block is different from that specified in this Section, submit at least 2 weeks before the start of driving operations, detailed drawings of the cushion block including records of successful use.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Protect piles from damage during transportation, storage, and handling.

1.05 PROJECT CONDITIONS

A. Project environmental requirements:

1.06 SEQUENCING AND SCHEDULING

A. Fabrication and driving of piles: Do not fabricate or drive piles until submittals have been accepted by the Engineer:
   1. Do not order production piles until the analysis of the indicator pile program has been completed:
      a. Allow 3weeks for the analysis of indicator pile program by the Engineer, after the indicator piles have been driven.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Type of piles:
   1. Precast, prestressed concrete piles as specified in Section 02468 - Precast Prestressed Concrete Piles.

2.02 EQUIPMENT

A. Pile driving equipment:
   1. Use fixed leads on pile driver which are capable of guiding the hammer from the highest to lowest point of travel while holding the pile firmly in axial alignment with the hammer:
      a. Secure leads to the body of the crane or supporting tower by rigid members in a manner that will prevent movement and maintain alignment of the leads at all times during the driving operations.
      b. Do not use swinging leads without prior acceptance by Engineer.
   2. Maintain and operate driving equipment in accordance with the manufacturer's instructions at all times.

B. Pile hammer:
   1. The CONTRACTOR should perform a driveability analysis to select the appropriate hammer and related equipment to drive the piles to the design embedment depths without overstressing or damaging piles.
   2. Drive piles with a hammer maintained in good operating condition, operated according to the manufacturer's recommendations, and capable of consistently developing the manufacturer's rated energy:
      a. Single-acting or a double-acting hammer, at the option of the Contractor.
      b. Drop hammers shall not be used.
   3. Use hammer as directed by the Geotechnical Engineer.

C. Pile driving cap:
   1. Use a steel driving helmet or cap, including a cushion block or cap block, between the top of the pile and the ram to prevent impact damage to the pile.
   2. Use driving cap and cushion block combination capable of protecting the butt of the pile, minimize energy absorption and dissipation, and transmit hammer energy uniformly and consistently during the entire driving period.
   3. Use driving helmet or cap, which fits loosely around the top of the pile so that the pile may rotate slightly without binding within the driving helmet.
   4. The cushion block may be a solid or laminated softwood block with the grain parallel to the end of the pile. Enclosed cushion block in a close-fitting steel housing:
      a. Use block at least 4 inches thick and suitable for the length of pile to be driven and the character of subsurface material to be encountered.
      b. Generally, thicker blocks will be required for longer piles and softer subsurface material.
   5. Replace cushion block if it has been damaged, split, highly compressed, charred, or burned, or has become spongy or deteriorated in any manner.
   6. Do not use small wood blocks, wood chips, rope, or other material permitting excessive loss of hammer energy.
   7. Where the block is different from that specified in this Section, submit, at least 2 weeks before the start of driving operations, detailed drawings of the cushion block including records of successful use.

D. Pile driving follower:
   1. Follower shall adequately and properly transmit the energy of the hammer blow to the head of the pile.
   2. Make drive head and cap so that it fits snugly over the head of the pile.

2.03 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Pile driving resistance:
      a. Driving resistance:
         1) Drive piles with low driving resistance minimum of 5 feet deeper or until blow count is greater than blow count for low driving resistance is obtained.
         2) Where hammer delivers higher driving energy, the Engineer will provide equivalent values for determining low driving resistance for respective types of pile.
   2. Pile driving refusal:
      a. Where refusal is met within 5 feet of specified tip elevation indicated on the Drawings, pile will be satisfactory.
      b. Where refusal is met more than 5 feet above tip elevation, notify the Engineer:
         1) After notification, the Engineer will determine whether additional piles will be required.
      c. Where hammer delivers higher driving energy, the Engineer will provide equivalent values for determining refusal for respective types of pile.

PART 3 EXECUTION

3.01 PREPARATION

A. General:
   1. Install pile sonly in the presence of the ENGINEER.
   2. The CONTRACTOR shall provide sufficient notice to the ENGINEER for coordination staff to provide required inspections during pile installation.

B. Predrilling:
   1. Predrilling for difficult driving conditions: For all piles:
      a. Predrill hole immediately before pile is driven.
      b. Do not have open predrilled holes adjacent to pile being driven.
      c. Predrill hole to a depth not deeper than to a depth 60 feet above the tip elevation of the pile.
      d. Predrill holes using a continuous flight auger.
      e. Predrill holes to a diameter of less than 3/4 the diagonal width of the piles.

C. Pile protection:
   1. Laterally support piles during driving, but do not unduly restrain piles from rotation in the leads:
   2. Ensure that top of piles are perpendicular to longitudinal axis of piles.
   3. When driving through soft soil of little or no resistance to penetration, reduce length of stroke of hammer to prevent longitudinal tensile stresses in pile shaft.
      a. When point of pile is being driven into firm ground, use full stroke of hammer.

3.02 INSTALLATION

A. Pile driving:
   1. General:
      a. Protect piles from damage during driving.
      b. Marking piles:
         1) Mark each pile prominently with paint of color that contrasts with color of piles at 1-foot intervals over entire length of pile, starting at the tip.
         2) Number each 5-foot interval in consecutive order.
      c. Pile driving record: Assist Engineer in preparing the following and maintaining a pile driving record for each pile. The record will include the following as a minimum:
         1) Type and size of the hammer used.
         2) Rate of operation.
         3) Number of blows per foot for the last 10 feet of penetration and blows per inch for the last foot of driving.
         4) Type and dimensions of driving helmet and cushion block.
         5) Predrilled hole diameter and depth.
         6) Time of start and finish of each pile driving and any interruption.
         7) Cutoff elevation and tip elevation of pile driven.
         8) Unusual occurrences during driving of the pile.
   2. Pile driving operations:
      a. Pile driving for new structures shall start at the side nearest to the existing structures and progress in a direction away from the existing structures.
      b. Do not perform driving when following conditions exist:
         1) Within 10 feet of concrete that is less than 3 days old.
         2) Within 200 feet of concrete that is less than 1 day old.
         3) Adjacent to predrilled hole.
      c. Piles may be driven from natural grade prior to excavation or they may be driven from the bottom of excavation after excavation is completed:
         1) Provide necessary means to carry out the pile driving operations.
         2) Additional thickness of Aggregate Base Course Material, filter fabric, or other methods may be required to support pile driving equipment at the bottom of the excavation.
      d. Perform pile driving only in the presence of the Engineer.
      e. Drive piles continuously, without interruption, to tip elevations indicated on the Drawings.
      f. Do not pull or push piles into place.
      g. Jetting of piles will not be allowed.

3.03 CONSTRUCTION

A. Site tolerances:
   1. Pile driving tolerances:
      a. Deviation of pile butt centers: Do not deviate from locations indicated on the Drawings more than 3 inches in any direction.
      b. Cut-off elevation of pile tops: Not more than 1 inch higher nor more than 3 inches lower than elevation indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

A. Pile tests:
   1. Indicator piles:
      a. Prior to ordering production piles, drive 1 indicator piles at locations indicated on the Drawings. Retap 1 indicator piles selected by the Engineer 2 days after they have been driven.
      b. Do not order production piles until analysis pile tests have been completed.
      c. Allow 3 weeks for analysis of indicator piles by the Engineer, after the indicator piles have been driven.
      d. Use or non-use of indicator piles for structural foundation piles:
         1) If alignment, location indicated on the Drawings, minimum blow count, and refusal requirements are met, use indicator piles for structural foundation piles.
         2) If driven indicator piles are not suitable for use as structural foundation piles, drive or cut off indicator piles minimum of 1 foot below bottom of pile cap. Fill holes created with compacted aggregate base course material.
      e. Indicator piles for structures:
         1) Provide piles 10 feet longer than longest pile indicated on the Drawings for that structure:
            a) Provide prestressed, precast concrete indicator piles having additional 3 feet of corrugated sleeves installed.
      a. Driving of indicator piles:
         1) To 5 feet below tip elevation indicated on the Drawings.
         2) Using same methods and driving equipment proposed to be used to drive production piles.
      b. The Engineer will observe driving of indicator piles and will keep pile driving record including record of blow counts:
         1) Pile driving record data will be used by the Engineer to confirm or modify pile tip elevations indicated on the Drawings, pile lengths indicated on the Drawings, preboring diameters, lengths of preboring.

B. Field measurements:
   1. Pile location survey:
      a. After piles are driven and prior to placing reinforcing steel, formwork, or concrete for structure, prepare pile location survey showing coordinates of final location of butt of piles and elevations of butt of piles to accuracy of plus or minus 0.01 feet.
      b. Pile location survey shall be performed by Surveyor registered in the state where the Project is located.
      c. Provide survey that includes the minimum following information:
         1) Location of piles:
            a) Location of pile butts as indicated on the Drawings.
            b) Location of pile butts as driven.
            c) Calculated distances between location coordinates of the pile butts as indicated on the Drawings and actual location coordinates of the pile butts as driven.
         2) Elevation of pile butts:
            a) Elevation of pile butts as indicated on the Drawings.
            b) Elevation of pile butts as driven or cut off.

c) Calculate difference between elevations of pile butts as indicated on the Drawings and actual elevation of pile butts as driven.

3) Highlight piles that are not within specified tolerances for location in plan and butt elevation.

4) Provide preceding information in tabular form and keyed to a pile location drawing by pile number:

a) Provide pile location drawing that shows each pile for each structure.

d. Engineer will utilize pile location survey information to evaluate acceptability of pile locations.

3.05 ADJUSTING

A. Correction of defective pile work:

1. Pile work not in accordance with the requirements indicated on the Drawings and specified is considered defective.
2. Take corrective measures acceptable to the Engineer if piles are damaged, out of tolerance, mislocated, heaved by subsequent driving of adjacent piles, or otherwise defective:
   a. Cost of redesign of foundation elements by the Engineer required by reason of defective pile work shall be borne by Contractor.
   b. Allow 15 working days from submittal of pile location survey, for design of corrections for defective pile work.
3. Measures to be used to correct defective pile work will be selected by the Engineer. Corrective measures that may be acceptable to the Engineer include:
   a. Redrive piles heaved by subsequent driving of adjacent piles.
   b. Drive additional piles at locations selected by the Engineer.
   c. Pile caps will be redesigned by the Engineer and required details of modifications to pile caps will be given to the Contractor to accommodate piles that were driven out of tolerance.
4. Leave piles which are not accepted in the ground:
   a. Cut off such piles at least 1 foot below bottom of pile cap and fill holes with aggregate base course material.

END OF SECTION

SECTION 02468

PRECAST PRESTRESSED CONCRETE PILES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Precast prestressed concrete piles.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 543R - Design, Manufacture, and Installation of Concrete Piles.

B. ASTM International (ASTM):
   1. A82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   2. A416 - Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.
   3. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   4. C33 - Standard Specification for Concrete Aggregates.
   5. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   6. C125 - Standard Terminology Relating to Concrete and Concrete Aggregates.
   7. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
   8. C150 - Standard Specification for Portland Cement.
   9. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
   10. C494 - Standard Specification for Chemical Admixtures for Concrete.

1.03 SUBMITTALS

A. Shop drawings: Shop drawings of piles proposed for use on the project showing details of piles, reinforcing, concrete mix design, calculations, pile pickup points, and other information required to describe proposed materials and construction methods.

B. Concrete mix design.

C. Curing procedures for concrete.

D. Type and detail of anchorage for tensioning prestressing steel.

E. Calculations for pile prestressing.

F. Schedule for precast plant days of production of stressing and casting of piles to provide minimum of 14 days of advance notice for ENGINEER to witness.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cement: ASTM C150, Type II.

B. Water:
   1. For curing, washing aggregates, and mixing:
      a. Free from oil and not containing more than 650 parts per million of chlorides as Cl ions nor more than 1,300 parts per million of sulfates as SO_4 ions.
      b. Not contain impurities that will cause change in setting time of portland cement of more than 25 percent.
   2. Water used for fabrication of piles: Be from same source and of similar quality as water used in developing concrete mix designs.

C. Aggregates:
   1. General: ASTM C33, except as modified in this Section.
   2. Aggregates shall be free of deleterious substances, which may react with the alkalies in cement and cause excessive expansion of the concrete.
   3. Fine aggregates:
      a. Aggregates from different sources of supply shall not be mixed or stored in same stockpile nor used alternatively in same concrete mix or same structure without acceptance by the Engineer.
      b. Aggregates which show variation in fineness modulus greater than 0.20 more or less than that of random sample tested for concrete mix design, shall not be used:
         1) Fineness modulus shall be in accordance with ASTM C125.

D. Admixtures:
   1. Where required, water reducing admixture in accordance with Type A of ASTM C494 may be used.
   2. Admixtures containing chlorides shall not be used.

E. Steel:
   1. Prestressing steel:
      a. 1/2 inch, 7 wire, stress relieved strand in accordance with ASTM A416, Grade 270.
      b. Free of grease, oil, wax, paint, soil, dirt, and other matter or coatings that may reduce bond.
      c. Protected against rust or other effects of corrosion from manufacture until encased in concrete.
      d. Prestressing strands having kinks, bends, nicks, rust, or other defects shall not be used.
   2. Spirals: ASTM A82:
      a. Lap splice length of spiral pile reinforcement minimum of 80 wire diameters.
      b. Terminate spiral pile reinforcement at splices and at ends of pile by 135 degree hook with 6-inch tail hooked around longitudinal bar or strand.

2.02 MIXES

A. Concrete mix:
   1. Design concrete mix capable of producing concrete having minimum compressive strength of 7,000 pounds per square inch at 28 days when tested in accordance with ASTM C39.
   2. The water to cement ration shall be equal to or less than 0.40.
   3. Maximum aggregate size: 1-1/2 inches.
   4. Maximum slump: 2 inches.

2.03 FABRICATION

A. Plant fabrication:
   1. General:
      a. Protect piles from damage during manufacture.
      b. Workmanship: conform to standard commercial practice in modern prestressing plants.
      c. Splicing of piles will not be acceptable.
      d. Mark piles clearly with date of casting and length of pile.
   2. Pile pickup:
      a. Providing pile pickup points for lifting the piles at project site:
         1) Plainly mark pickup points on piles after removal from forms.
      b. Lift piles by a suitable spreader bar or slings attached to pickup points.
      c. If lifting anchors are used during fabrication, remove them to depth of at least 1 inch below concrete surface:
         1) Fill resulting holes with epoxy grout before piles are delivered to project site.
   3. Forms:
      a. Provide forms that:
         1) Are metal, well braced, stiffened against deformation, accurately constructed, mortartight, smooth, and supported to prevent appreciable deformation or settlement.
         2) Permit movement of pile without damage during release of prestressing force.
      b. Inside void tubes: Galvanized, mortar tight, corrugated steel tube:
         1) Anchor void tubes firmly so they will not move, float, or collapse during the placing of concrete.
   4. Prestressing:
      a. Prestress piles to minimum working stress of 800 pounds per square inch after losses:
         1) Specified working stress is for structural load capacity of prestressed precast concrete piles, after installation.
         2) Contractor shall increase specified working stress as necessary where loads resulting from methods used to handle piles, from methods and equipment used to drive the piles, or from other operations that result in higher stresses.
      b. Stresses in prestressing steel:
         1) Maximum temporary tensile stress (jacking stress) in prestressing steel shall not exceed 75 percent of specified minimum ultimate tensile strength of prestressing steel.

2) Anchor prestressing steel at stresses (initial stress) that will result in the retention of working stress of not less than those specified, but in no case shall initial stress exceed 70 percent of the specified minimum ultimate tensile strength of prestressing steel.
3) Average working stress in prestressing steel shall not exceed 60 percent of specified minimum ultimate tensile strength of prestressing steel:
a) Working stress shall be stress remaining in prestressing steel after deduction of losses, including losses due to creep and shrinkage of concrete, elastic compression of concrete, creep of prestressing steel, and other losses peculiar to method or system of prestressing.
b) Loss in stress in pretensioned prestressing steel due to creep and shrinkage of concrete, creep of steel, and elastic compression of concrete shall be assumed to be:
(1) 4,500 pounds per square inch for normal relaxation strand, and
(2) 3,500 pounds per square inch for low relaxation strand.

c. Determine tension in prestressing steel by reading pressure on calibrated gauge connected to jack and verify by measuring elongation of prestressing steel:
1) Use pressure gauge that has been calibrated by independent engineering testing laboratory accepted by Engineer or checked against pile manufacturer's standard gauge which has been calibrated by laboratory within 6 months of commencing work and every 6 months thereafter from date of recalibration, during term of manufacture of piles for the Work.
2) Provide means for measuring elongation of prestressing steel to at least the nearest 1/8 inch.
3) Where prestressing steel tension determined from measurement of elongation and reading of pressure gauge differ by more than 3 percent, correct cause of such discrepancy.

d. Pull prestressing steel to uniform low stress level to remove slack prior to application of full tension.
e. Cut off pretensioned prestressing steel flush with ends of piles:
1) Clean and paint exposed ends of prestressing steel and 1-inch strip of adjoining concrete:
a) Perform cleaning by wire brushing or abrasive blast cleaning to remove all dirt and residue which is not firmly bonded to metal or concrete surfaces.
b) Cover surfaces with 2 applications or unthinned commercial quality zinc-rich primer (organic vehicle type).
c) Thoroughly mix paint at the time of application, and work paint into any voids in prestressing strands.

5. Casting concrete:
a. Manufacturer piles using dense concrete.
b. Perform concrete placement within 3 days after pretensioning prestressing steel:
1) However, do not deposit concrete in forms before placement of reinforcement and before prestressing anchorages has been inspected and approved by pile manufacturer's quality control representative.

2) Retain reinforcement in its proper position during concrete placement.

c. Clean conveying equipment before each run, and remove concrete which has segregated in conveying.

d. Convey concrete from mixer to forms as rapidly as practicable by methods which will not cause segregation or loss of ingredients:
   1) Place concrete as nearly as practicable to its final position in forms.
   2) Free vertical drop of concrete shall not exceed 3 feet at any point in conveying.

e. Use vibrator heads that are smaller than minimum distance between steel.

f. Do not remove piles from forms before concrete has attained compressive strength of 7,000 pounds per square inch:
   1) After piles have been removed from forms, do not move, handled, or otherwise subject piles to stress during entire curing period.

g. Cure concrete as specified in the Contract Documents except concrete which is steam cured in accordance with requirements specified in this Section.

6. Steam curing:
   a. Steam curing of prestressed precast concrete piles for period of at least 12 hours may be used provided piles are kept continuously moist for minimum of 72 hours including steam curing period.
   b. Use casting bed for piles cured with steam that is enclosed completely with suitable enclosure to minimize moisture and heat losses.
   c. Measure temperatures within steam chamber by means of recording type thermometers.
   d. After placement of concrete, moist cure piles for minimum of 4 hours unless ambient air temperature is below 50 degrees Fahrenheit, in which case apply steam to hold air surrounding piles at a temperature between 50 degrees and 70 degrees Fahrenheit.
   e. Do not apply steam directly upon concrete surfaces:
      1) During application of steam, increase curing air temperature at rate not exceeding 60 degrees Fahrenheit per hour until maximum temperature range of 140 to 160 degrees Fahrenheit is reached.
      2) Hold maximum temperature range until concrete has reached specified release strength.
      3) While discontinuing steam application, decrease curing air temperature at rate not exceeding 60 degrees Fahrenheit per hour until temperature has been reached 20 degrees Fahrenheit above the temperature of air to which concrete will be exposed.
   f. Do not expose concrete to temperatures below freezing until at least 6 days after casting.

7. Releasing prestressed steel:
   a. Release prestressing steel stress after approval by manufacturer's quality control representative:
      1) In addition, do not transfer prestressing force to concrete before concrete has reached compressive strength of 4,000 pounds per square inch.
   b. Perform releasing of prestressed steel in sequence that minimizes eccentricity of prestress.
   c. Release tension in strands from anchorage gradually.

B. Tolerances:
   1. Dimensional tolerances: In accordance with ACI-543R, except as modified in this Section.
   2. Bottom of form: Within 1/4-inch of true plane in length of 50 feet.
   3. Piles: Provide piles that are straight with smooth surfaces and that comply with following:
      a. Finish unformed surfaces to smooth surface.
      b. Upon removal from forms, piles shall:
         1) Present true, smooth, even surfaces free from honeycombs and voids.
         2) Be so straight that line stretched from butt to tip on any face will not be more than 1 inch from face of pile at any point.
         3) Provide edges at ends of piles and at faces of square piles that have 3/4-inch chamfer.
         4) Provide piles that have the plane of heads that are perpendicular to axis of piles.

2.04 SOURCE QUALITY CONTROL

A. General:
   1. Perform sampling and testing by an independent engineering testing laboratory approved by the Engineer.
   2. Perform testing under direction of the pile fabricator.
   3. Submit test results.
   4. Costs of sampling, testing, and related work shall be borne by the Contractor.

B. Tests:
   1. Aggregate:
      a. Fine and course: Take samples at concrete batch plant and test as follows:
         1) Perform mechanical sieve analysis and specific gravity of 1 sample for each aggregate size.
         2) Test results: Tabulated in accordance with ASTM C33.
   2. Slump tests: Perform tests in accordance with ASTM C143.
   3. Concrete strength:
      a. Verify specified strengths for mix design and placed concrete by testing standard 6 inch diameter by 12-inch high cylinders.
      b. Mold, cure, and test six cylinders each day or for every 20 cubic yards of concrete placed, whichever results in greater number of cylinders.
      c. Preform strength tests 28 days after molding cylinders, except field cure and test 2 cylinders of test set at 7 days or 14 days, or at time for establishing transfer of prestressing force (release strength) and removal of piles from forms:
         1) Cure field cured cylinders in same manner as piles:
            a) Place at coolest point in bed for steam curing.
         2) Moist cure in laboratory test cylinders for 28-day testing.
      d. Sampling of concrete: Take samples in accordance with ASTM C172 at time concrete is deposited for each production line to determine strength of castings at different areas.
      e. Making and curing cylinders: Perform in accordance with ASTM C31.
      f. Compression tests: Perform in accordance with ASTM C39.

PART 3 EXECUTION

3.01 INSTALLATION

A. Pile driving:
   1. Do not drive piles until concrete attains a compressive strength of not less than 5,000 pounds per square inch as indicated by breaking test cylinders.

B. Extending piles:
   1. When, during the process of driving piles, the Engineer determines that the pile length is insufficient and the final elevation of the pile butt is below the indicated cutoff elevation, extend pile to the required elevation by means of a cast-in-place reinforced concrete build-up detail indicated on the Drawings.
   2. Use concrete in the build-up with minimum compressive strength of 6,000 pounds per square inch at 28 days.
   3. Where build-ups are exposed to water, protect the cast-in-place section from the water until the concrete has set, but not less than 24 hours.

C. Install piles as specified in Section 02455 - Driven Piles.

END OF SECTION

SECTION 02742A

ASPHALTIC CONCRETE PAVING (CA)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Asphalt pavement on prepared subgrade or aggregate base course to lines, grades, and compacted thickness as indicated on the Drawings.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft. lbf/f_4^3)(2,700 kN-m/m^3).
   2. D1561 - Standard Practice for Preparation of Bituminous Mixture Test Specimens by Means of California Kneading Compactor.

B. Caltrans Standard Test Methods:
   1. Calif Test 202 - Sieve Analysis of Fine and Coarse Aggregates.
   2. Calif Test 304 - Preparation of Bituminous Mixtures for Testing.
   3. Calif Test 362 - Determining Asphalt Content in Bituminous Mixtures by Vacuum Extraction.
   4. Calif Test 375 - Determining the In-Place Density and Relative Compaction of AC Pavement.
   5. Calif Test 379 - Determining Asphalt Content in Bituminous Mixtures (Troxler Nuclear Gauge Model 3241).

C. State of California Department of Transportation Standard Specifications, latest edition (Caltrans Standard Specifications):
   1. Section 37 - Bituminous Seals.
   2. Section 39 - Hot Mix Asphalt.
   3. Section 88 - Geosynthetics.
   4. Section 92 - Asphalts.
   5. Section 93 - Liquid Asphalts.
   6. Section 94 - Asphaltic Emulsions.

1.03 DEFINITIONS

A. “Asphalt Concrete” as used by Caltrans shall be considered the “Surface Course,” or the final lift of the pavement section.

B. “Asphalt Concrete Base” as used by Caltrans shall be the remaining portion of the asphalt pavement section excluding the final lift.

C. “Asphalt Pavement” shall be the total pavement section of asphalt including Asphalt Concrete and Asphalt Concrete Base.

1.04 SUBMITTALS

A. Mix design.

B. Shop drawings.

C. Product data:
   1. Asphalt.
   2. Asphalt aggregate.
   3. Pavement reinforcing fabric.

D. Quality control submittals:
   1. Test results.
   2. Certificate of Compliance.
   3. Certificate of Competence.

E. Equipment list.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Asphalt pavement delivery:
   1. Transport the mixture from the mixing plant to the point of use in vehicles having tight bodies previously cleaned of foreign materials.
   2. Treat bodies as necessary to prevent material from sticking to the bodies.
   3. Cover each load with canvas or other suitable material of sufficient size and thickness to protect the asphalt mixture from the weather.

1.06 PROJECT CONDITIONS

A. Environmental requirements:
   1. Asphalt concrete:
      a. Place asphalt concrete only when surface is dry, and when atmospheric temperature in the shade is 40 degrees Fahrenheit and rising, or above 50 degrees Fahrenheit if falling.
      b. Do not place asphalt concrete when weather is foggy or rainy, when base on which material is to be placed is in wet or frozen conditions, or when, in the opinion of the Engineer, weather conditions will prevent proper handling, finishing, or compaction of the mixtures.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. This Work shall consist of furnishing and mixing aggregate and asphalt binder at a central mixing plant, spreading and compaction of the mixture as specified and as indicated on the Drawings.

B. In general, asphalt concrete and asphalt concrete base shall conform to Section 39 “Hot Mix Asphalt,” and applicable referenced sections of the Caltrans Standard Specifications:
   1. Where conflicts exist, this specification shall govern.

2.02 ASPHALT PAVEMENT MATERIALS

A. Asphalts:
   1. Asphalt binder: Steam-refined paving asphalt, PG 64-10, conforming to Section 92-1.02C “Grades” of the Caltrans Standard Specifications.
   2. Tack coat: Grade SC-70, conforming to Section 93 of the Caltrans Standard Specifications.
   3. Fog seal: Asphaltic emulsion, Grade SS-1h, conforming to Section 94 of the Caltrans Standard Specification.

B. Asphalt aggregate:
   1. Aggregate for asphalt concrete shall conform to Section 39-1.02E of the Caltrans Standard Specifications for Type B grading, 1/2-inch maximum, medium.
   2. Aggregate for asphalt concrete base shall conform to Section 39-1.02E of the Caltrans Standard Specifications for Type B grading.

C. Asphalt pavement shall be produced in a batch mixing plant, a continuous pugmill mixing plant, or dryer-drum mixing plant:
   1. Proportioning shall conform to Section 39-3.03 of the Caltrans Standard Specifications.
   2. Mixing shall conform to Section 39-3.04 of the Caltrans Standard Specifications.

2.03 AGGREGATE BASE COURSE

A. Aggregate base course: As specified in Section 02050 - Soils and Aggregates for Earthwork.

B. Aggregate base course shall be placed at the following locations:
   1. All asphalt pavement.

C. Compacted thickness of aggregate base course shall be as indicated on the Drawings**.**

2.04 EQUIPMENT

A. Spreading and compacting equipment:
   1. Spreading equipment shall conform to Section 39-1.10 and applicable referenced sections of the Caltrans Standard Specifications:
      a. Only in areas inaccessible to the machine, by approval of the Engineer, will hand spreading be permitted.
   2. Compaction equipment shall conform to Section 39-1.10 and applicable referenced sections of the Caltrans Standard Specifications.

2.05 SOURCE QUALITY CONTROL

A. The Engineer will perform sampling and tests of materials in accordance with California Test Method Number 304 and California Test Method Number 362 or 379, as applicable. Samples will be taken from materials as delivered to the site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Verify surfaces and site conditions are ready to receive work. If unsatisfactory conditions exist, do not commence installation until such conditions have been corrected. Beginning application means acceptance of existing conditions.

3.02 PREPARATION

A. Protection:
   1. Protect concrete pavements and walks, curbs and bases, and other improvements adjacent to the operations with suitable materials.
   2. Building and other surfaces shall be covered with paper or other protection, when required.
   3. Contractor shall be responsible for any damage caused by Contractor's employees. Damage caused by the Contractor's operations shall be repaired to the satisfaction of the Engineer at no additional cost to Owner.

B. Subgrade preparation:
   1. Immediately prior to applying tack coat, or immediately prior to placing the asphalt pavement when tack coat is not required, the subgrade to receive asphalt pavement shall conform to the compaction requirement and elevation tolerances specified for the material involved and shall be cleaned to remove any loose or extraneous material.
   2. If the asphalt pavement is to be placed on an existing base or pavement that was not constructed as part of the contract, the Contractor shall clean the surface by sweeping, flushing, or other means to remove loose particles of paving, dirt, and other extraneous material immediately before applying the tack coat.

3.03 TACK COAT

A. Tack coat:
   1. A tack coat of asphaltic emulsion shall be applied to vertical surfaces of existing pavement, curbs, gutters, and construction joints in the surfacing against which additional material is to be placed, or as otherwise specified in this Section.
   2. Tack coat shall be applied in one application at a rate of 0.1 gallons per square yard of surface covered.

3.04 ASPHALT PAVEMENT

A. Placing materials in a windrow, then picking it up and placing it in the asphalt paver with loading equipment, will be permitted provided that:
   1. The asphalt paver is of such design that the material will fall into a hopper that has a movable bottom conveyor to feed and screed.
   2. The loader is constructed and operated so that substantially of the material deposited into windrows is picked up and deposited into the paving machine.
   3. The windrow is deposited only so far in advance of the paver to provide for continuous operation of the paver and not so far as to allow the temperature of the asphalt pavement in the windrow to fall below 260 degrees Fahrenheit.

B. Unless lower temperatures are directed by the Engineer, asphalt concrete shall be spread, and the first coverage of initial or breakdown compaction shall be performed when the temperature of the mixture is not less than 250 degrees Fahrenheit, and breakdown compaction shall be completed before the temperature of the mixture drops below 205 degrees Fahrenheit.

C. Asphalt pavement shall be spread and compacted in the number of layers and of the thicknesses indicated in the following table:
   1. A thickness tolerance of within 0.1 inches is allowed for asphalt concrete.
   2. A total thickness tolerance of within 0.2 inches is allowed for asphalt concrete base.

Total Thickness Indicated on Drawings(1)	**Number of Lifts**	**Top Layer Thickness (inches)**		**Next Lower Layer Thickness (inches)**		**All Other Lower Layer Thicknesses (inches)**	
		Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
<2-3/4 inches	1	-----	-----	-----	-----	-----	-----
3 inches(2)	2	1-1/4	1-1/2	1-1/4	1-1/2	-----	-----
3-1/4 - 4-3/4 inches	2	1-3/4	2-1/"	1-3/4	3	-----	-----
>5 inches	(3)	1-3/4	2-1/4	1-3/4	3	1-3/4	4-3/4

Notes:
(1) When pavement-reinforcing fabric is shown to be placed between layers of asphalt pavement, the thickness of asphalt pavement above the pavement-reinforcing fabric shall be considered to be the "Total Thickness Indicated on the Drawings" for the purpose of spreading and compacting the asphalt pavement above the pavement-reinforcing fabric.
(2) If approved by the Engineer, one lift of 3 inches may be placed.
(3) At least 2 layers shall be placed if the total thickness is less than 5 inches. At least 3 layers shall be placed if the total thickness is more than 5 inches, and less than 10-1/2 inches. At least 4 layers shall be placed if the total thickness is greater than 10-1/2 inches.

D. A layer shall not be placed over another layer which exceeds 3 inches in compacted thickness until the temperature of the layer which exceeds 3 inches in compacted thickness is less than 160 degrees Fahrenheit at mid depth:
   1. If the temperature of any layer drops below 140 degrees Fahrenheit, or if directed by the Engineer, apply tack coat before placing next layer.

E. Unless otherwise indicated on the Drawings, asphalt mixtures shall not be handled, spread, or windrowed in a manner that will stain the finished surface of any pavement or other improvements.

F. The completed mixture shall be deposited on the prepared subgrade at a uniform quantity per linear foot, as necessary to provide the required compacted thickness without resorting to spotting, picking up, or otherwise shifting the mixture.

G. Spreading:
    1. All layers of asphalt pavement shall be spread with an asphalt paver and shall conform to Section 39-1.11 and applicable referenced sections of the Caltrans Standard Specifications.
    2. At locations where the asphalt pavement is to be placed over areas inaccessible to spreading and rolling equipment, layers of asphalt pavement shall be distributed directly out of the back of the dump truck and spread by hand:
        a. Asphalt pavement spread by hand shall be compacted thoroughly to the required lines, grades, and cross-sections by means of pneumatic tampers, or by other methods that will produce the same degree of compaction as pneumatic tampers.

H. Compaction:
    1. Compaction of asphalt pavement shall conform to Sections 39-1.11, 39-3.03, 39-3.04, and applicable referenced sections of the Caltrans Standard Specifications.
    2. Minimum required density for each layer of asphalt pavement shall be 95percent of that obtained in the laboratory in accordance with ASTM Test Method D1561.

I. Segregation shall be avoided, and the surfacing shall be free of pockets of coarse or fine material. Asphalt pavement containing hardened lumps shall not be used:
    1. In areas inaccessible to paving and compacting equipment where spreading is done by hand, minimize the amount of segregation.

J. Location of longitudinal joints in the top layer will be determined by the Engineer and shall not adversely affect the quality of the finished product.

K. At locations, or as directed by the Engineer, the asphalt concrete shall be square and at least 1-inch thick when conforming to existing surfacing. Tapering or feathering is not allowed.

3.05 FIELD QUALITY CONTROL

A. Contractor shall control the quality of Work and shall provide adequate testing to ensure compliance with these Specifications:
    1. The type and size of the samples shall be suitable to determine conformance with stability, density, thickness, and other specified requirements. Use an approved power saw or core drill for cutting samples. Furnish tools, labor, and materials for cutting samples, testing, and replacing the pavement where samples were removed. Take a minimum of 1 sample for every 4,000 square feet of asphalt pavement placed.

B. All asphalt pavement shall match the grades indicated on the Drawings and shall be completely free from unintended hollows and high spots:
    1. After completion of paving work, paving shall be flooded with water. Any ponding that results in standing water greater than 3/4 inch in depth shall be ringed with chalk. Such hollows shall be corrected by removing and replacing the asphalt concrete. The asphalt concrete patch shall be square and at least 1-inch thick when conforming to existing surfacing. Tapering or feathering is not allowed.

C. Contractor shall perform in-place density and compaction tests of the completed pavement in accordance with California Test Method Number 375, to determine compliance with the specified requirements. Submit test results to Engineer for approval.

D. Cracks, settling of surface, improper drainage, improper compaction, and sloppy connection to previously laid surfaces will be construed as improper workmanship and will not be accepted.

3.06 MAINTENANCE OF PAVEMENT

A. Upon completion of final rolling, traffic shall not be permitted on the finished pavement for at least 6 hours, or until the asphalt pavement has cooled sufficiently to withstand traffic without being deformed.

3.07 WORKMANSHIP AND WARRANTY

A. Contractor shall provide written warranty against defects in materials or workmanship for a period of not less than 1 year upon completion of Work.

END OF SECTION

SECTION 02772

CONCRETE CURBS, GUTTERS, AND SIDEWALKS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Concrete curbs, gutters, sidewalks, driveways, access ramps, and alley intersections.

1.02 SUBMITTALS

A. Product data: Submit data completely describing products.

B. Samples: Submit samples when requested.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements: Construct various types of concrete curb, gutter, sidewalk, driveways and alley intersections to dimensions and details indicated on the Drawings.

2.02 MATERIALS

A. Concrete: Class A.

B. Curb finishing mortar: 1 part portland cement to 2 parts sand.

C. Form release material: Light oil or other releasing agent of type which does not discolor concrete or interfere with the application of finishing mortar to curb tops and faces.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of Conditions:
   1. Verify field conditions, including subgrade condition and interferences, before beginning construction.

3.02 PREPARATION

A. Surface preparation:
   1. Subgrade:
      a. Construct and compact true to grades and lines indicated on the Drawings and requirements as specified Section 02050 - Soils and Aggregates for Earthwork.
      b. Remove soft or unsuitable material to depth of not less than 6 inches below subgrade elevation and replace with satisfactory material.
   2. Forms and subgrade: Water immediately in advance of placing concrete.

3.03 INSTALLATION

A. Special techniques:
   1. Contractor's option:
      a. Construct concrete curbs and gutters by conventional use of forms, or by means of curb and gutter machine when acceptable to the Engineer.
      b. When use of machines designed specifically for work of this Section are accepted by the Engineer, results must be equal to or better than those produced by use of forms.
      c. Applicable requirements of construction that apply to use of forms also apply to use of machines.
      d. Discontinue use of machines when results are not satisfactory to the Engineer.

B. Forms:
   1. Carefully set to line and grade and securely stake in position forms conforming to dimensions of items to be constructed.
   2. Thoroughly clean prior to each use and coat with form releasing material.

C. Expansion and weakened-plane joints:
   1. Expansion joints:
      a. Construct vertically, and at right angles to centerline of street and match joints in adjacent pavement or sidewalks.
      b. Constructed at radius points, driveways, alley entrances, and at adjoining structures.
      c. Fill joints with expansion joint filler material.
   2. Weakened-plane joints:
      a. Construct as indicated on the Drawings.
      b. Match joint locations and details in adjacent curbs, gutters, and sidewalks.

D. Concrete:
   1. Placing:
      a. Thoroughly spade concrete away from forms so that no rock pockets exist next to forms and so that no coarse aggregate will show when forms are removed.
   2. Compacting:
      a. Compact by mechanical vibrators accepted by the Engineer.
      b. Continue tamping or vibrating until mortar flushes to surface and coarse aggregate is below concrete surface.

3. Form removal:
    a. Front form faces: Do not remove before concrete has taken initial set and has sufficient strength to carry its own weight.
    b. Gutter and rear forms: Do not remove until concrete has hardened sufficiently to prevent damage to edges. Take special care to prevent damage.
4. Finishing and curing: Comply with requirements as specified in Section 03366 - Tooled Concrete Finishing except as modified here:
    a. As soon as curb face forms are stripped, apply finishing mortar to the top and face of curb and trowel to a smooth, even finish. Finish with fine haired broom in direction of work.
    b. Where curb is installed without integral gutter, extend finish 2 inches below grade.
    c. Edge concrete at expansion joints to 1/4 inch radius.
    d. Flow lines of gutters shall be troweled smooth 4 inches out from curb face for integral curb and gutter and 4 inches on both sides of flowline for gutters without curbs.
    e. Sidewalks and ramps: Broom finish.

E. Backfilling:
1. Unless otherwise specified, backfill behind curbs, gutters, or sidewalks with soil native to area and to lines and grades indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

A. Tests:
1. Curbs and gutters:
    a. Test face, top, back, and flow line with 10 foot straightedge or curve template longitudinally along surface.
    b. Correct deviations in excess of 1/4 inch.
2. Gutters:
    a. Frequency of testing: When required by the Engineer, where gutters have slope of 0.8 foot per 100 feet or less, or where unusual or special conditions cast doubt on capability of gutters to drain.
    b. Test method: Establish flow in length of gutter to be tested by supplying water from hydrant, tank truck, or other source.
    c. Required results:
        1) 1 hour after supply of water is shut off, inspect gutter for evidence of ponding or improper shape.
        2) In event water is found ponded in gutter to depth greater than 1/2 inch, or on adjacent asphalt pavement, correct defect or defects in manner acceptable to the Engineer without additional cost to the Contract.

3.05 ADJUSTING

A. Repair portions of concrete damaged while stripping forms or, when damage is severe, replace such work at no additional cost to the Contract. Evidence of repairs shall not be noticeable in the finished product.

B. Remove and replace sections of work deficient in depth or not conforming to requirements indicated on the Drawings and specified in the Specifications at no additional cost to the Contract. Removal and replacement shall be the complete section between 2 joints.

END OF SECTION

SECTION 02952

PAVEMENT RESTORATION AND REHABILITATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Resurfacing roads and paved surfaces in which surface is removed or damaged by installation of new work.

1.02 SUBMITTALS

A. Mix designs:
   1. Prior to placement of asphalt concrete, submit full details, including design and calculations for the asphalt concrete mix proposed.
   2. Submit gradation of aggregate base.
   3. Submit proposed mix design of portland cement concrete.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Limiting dimensions:
      a. Determine the exact lengths and dimensions of such roads, pavements, parking areas, and walks that will require removal and replacement for new work.
      b. Join existing surfaces to terminals of new surfacing in smooth juncture.

2.02 MATERIALS

A. Aggregate base course: As specified in Section 02050 – Soil and for Earthwork.

B. Asphalt pavement.

C. Portland cement concrete replacement material: Class A concrete.

2.03 EQUIPMENT

A. Roads, pavements, parking areas, and walks:
   1. Equipment requirements: Good condition, capable of performing work intended in satisfactory manner.

2.04 ACCESSORIES

A. Material for painting asphalt concrete pavement: Tack coat.

PART 3 EXECUTION

3.01 INSTALLATION

A. Aggregate surface removal replacement:
   1. When trench cut is in aggregate surfaced areas, replace aggregate base course material with material matching existing material compacted to 95 percent of its maximum density.

B. Pavement removal and temporary asphalt replacement:
   1. Install temporary asphalt pavement or first course of permanent pavement replacement immediately following backfilling and compaction of trenches that have been cut through existing pavement.
   2. Except as otherwise provided, maintain this temporary pavement in safe and reasonably smooth condition until required permanent pavement is installed.
   3. Remove and dispose of temporary paving from project site.
   4. Where longitudinal trench is partly in pavement, replace pavement to original pavement edge, on a straight line, parallel to centerline of roadway.
   5. Where no part of longitudinal trench is in pavement, surfacing replacement shall only be required where existing surfacing materials have been removed.

C. Asphalt pavement replacement:
   1. Replace asphalt pavement to same thickness as adjacent pavement and match as nearly as possible adjacent pavement in texture, unless otherwise indicated on the Drawings.
   2. Cut existing asphalt pavements to be removed for trenches or other underground construction by wheel cutter, clay spade, or other device capable of making neat, reasonably straight and smooth cut without damaging adjacent pavement. Cutting device operation shall be subject to acceptance of Engineer.
   3. Cut and trim existing pavement after placement of required aggregate base course and just prior to placement of asphalt concrete for pavement replacement, and paint trimmed edges with material for painting asphalt concrete pavement immediately prior to constructing new abutting asphalt pavements. No extra payment will be made for these items, and costs incurred in performing this work shall be incidental to pipe laying or pavement replacement.
   4. Conform replacement of asphalt pavement to contour of original pavement.

D. Portland cement concrete pavement replacement:
   1. Where trenches lie within portland cement concrete section of streets, alleys, sidewalks, and similar concrete construction, saw cut such concrete (to a depth of not less than 1-1/2 inches) to neat, vertical, true lines in such manner adjoining surfaces are not damaged.
   2. Place portland cement concrete replacement material to dimension as indicated on the Drawings.
   3. Provide expansion joints that match existing.
   4. Before placing replacement concrete, thoroughly clean edges of existing pavement and wash with neat cement and water.
   5. Surface finish: Wood float finish.

E. Curb, gutter, and sidewalk replacement:
   1. Where any concrete curb, gutter, or sidewalk has been removed or displaced, replace to nearest construction joints with new Class A curb, gutter, or sidewalk to same dimensions and finish as original construction that was removed:
      a. Provide expansion joints of same spacing and thickness as original construction.

F. Asphalt pavements:
   1. Trim existing asphalt pavements which are to be matched by pavement widening or pavement extension to neat true line with straight vertical edges free from irregularities with saw specifically designed for this purpose. Minimum allowable depth of cut shall be 1-1/2 inches.
   2. Cut and trim existing pavement after placement of required aggregate base course and just prior to placement of asphalt concrete for pavement widening or extension, and paint trimmed edges with material for painting asphalt concrete pavement immediately prior to constructing new abutting asphalt concrete pavements.
   3. No extra payment will be made for these items and costs incurred in performing this work shall be incidental to widening or pavement extension.

3.02 FIELD QUALITY CONTROL

A. Tests:
   1. Asphalt concrete.
   2. Concrete.

B. Inspection:
   1. Asphalt concrete:
      a. Lay 10-foot straightedge parallel to centerline of trench when the trenches run parallel to street, and across pavement replacement when trench crosses street at angle.
      b. Remove and correct any deviation in cut pavement replacement greater than 1/4 inch in 10 feet.
   2. Portland cement concrete replacement pavement:
      a. Lay 10-foot straightedge either across pavement replacement or longitudinal with centerline of gutter or ditch.
      b. Remove and correct any deviation in cut pavement replacement greater than 1/4 inch in 10 feet.

END OF SECTION

SECTION 03055

ADHESIVE-BONDED REINFORCING BARS AND ALL THREAD RODS IN CONCRETE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Bonding reinforcing bars and all thread rods in concrete using adhesives.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 355.4 - Qualification of Post-Installed Adhesive Anchors in Concrete and Commentary.

B. American National Standards Institute (ANSI):
   1. Standard B212.15 - Carbide Tipped Masonry Drills and Blanks for Carbide Tipped Masonry Drills.

C. ASTM international (ASTM):
   1. C881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.

D. Concrete Reinforcing Steel Institute (CRSI).

E. ICC Evaluation Service, Inc. (ICC-ES):
   1. AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

F. Society for Protective Coatings (SSPC):
   1. SP-1 - Solvent Cleaning.

1.03 DEFINITIONS

A. Evaluation Service Report (ESR): Report prepared by ICC-ES, or other testing agency acceptable to Engineer and to the Building Official, that documents testing and review of a product to confirm that it complies with the requirements of designated ICC-ES Acceptance Criteria, and to document its acceptance for use under the Building Code specified in Section 01410 - Regulatory Requirements.

1.04 SUBMITTALS

A. Product data: Technical data for adhesives, including:
   1. Manufacturer's printed installation instructions (MPII).
   2. Independent laboratory test results indicating allowable loads in tension and shear for concrete of the types included in this Work, with load modification factors for temperature, spacing, edge distance, and other installation variables.
   3. Handling and storage instructions.

B. Quality control submittals:
    1. Special inspection: Detailed step-by-step instructions for the special inspection procedures required by the building code specified in Section 01410 - Regulatory Requirements.
    2. For each adhesive to be used, Evaluation Report confirming that the product complies with the requirements of AC308 for both un-cracked and cracked concrete and for use in Seismic Design Categories A through F.
    3. Installer qualifications:
        a. Submit evidence of successful completion of adhesive manufacturer's installation training program.
        b. Submit evidence of current certification for installation of inclined and overhead anchors under sustained tension loading.

C. Inspection and testing reports:
    1. Inspections: Field quality control: Reports of inspections and tests:
        a. Inspections: Field quality assurance: Reports of special inspections and tests.

1.05 QUALITY ASSURANCE

A. Qualifications:
    1. Installation requirements:
        a. Have available at the site, and install anchors in accordance with, the adhesive manufacturer's printed installation instructions.
    2. Installer qualifications:
        a. Demonstrating successful completion of adhesive manufacturer's on-site training program for installation of adhesive-bonded anchors.
        b. Holding current certification for installation of adhesive-bonded anchors by a qualified organization acceptable to the Engineer and to the Building Official:
            1) Organizations/certification programs deemed to be qualified are:
                a) ACI-CRSI Adhesive Anchor Installer Certification Program.
                b) Adhesive anchor manufacturer's certification program, subject to acceptance by the Engineer and the Building Official.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store and protect products as follows, unless more restrictive requirements are recommended by the manufacturer:
    1. Store adhesives and adhesive components on pallets or shelving in a covered- storage area protected from weather.
    2. Control temperature to maintain storage within manufacturer's recommended temperature range:
        a. If products have been stored at temperatures outside manufacturer's recommended range, test by methods acceptable to the Engineer to confirm acceptability before installing in the Work.
    3. Dispose of products that have passed their expiration date.

1.07 PROJECT CONDITIONS

A. As specified in 01612 - Seismic Design Criteria.

PART 2 PRODUCTS

2.01 GENERAL

A. Like items of materials: Use end products of one manufacturer in order to achieve structural compatibility and singular responsibility.

B. Adhesives shall have a current Evaluation Report documenting testing and compliance with the requirements or ACI 355.4 and of ICC-ES AC308 for use with un-cracked concrete and with cracked concrete in the Seismic Design Category specified.

C. Bond reinforcing bars and all thread rods in concrete using epoxy adhesive unless other adhesives specified are specifically indicated on the Drawings or approved in writing by the Engineer.

2.02 EPOXY ADHESIVE

A. Materials:
   1. Meeting the physical requirements of ASTM C881, Type IV, Grade 3, Class B or C depending on site conditions.
   2. 2-component, 100 percent solids, insensitive to moisture.
   3. Cure temperature, pot life, and workability: Compatible with intended use and environmental conditions.

B. Packaging:
   1. Disposable, self-contained cartridge system furnished in side-by-side cartridges designed to fit into a manually or pneumatically operated caulking gun, and with resin and hardener components isolated until mixing through manufacturer's static mixing nozzle:
      a. Nozzle designed to dispense components in the proper ratio and to thoroughly blend the components for injection from the nozzle directly into prepared hole.
      b. Provide nozzle extensions as required to allow full-depth insertion and filing from the bottom of the hole.
   2. Container markings: Include manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

C. Manufacturers: One of the following or equal:
   1. Hilti, Inc., HIT-RE 500-V3.
   2. Simpson Strong-Tie Co., Inc., SET-XP.

2.03 ALL THREAD RODS

A. Materials: As specified in Section 05120 - Structural Steel for rods, nuts, and washers.

2.04 REINFORCING BARS

A. As specified in Section 03301 - Concrete Work.

PART 3 EXECUTION

3.01 GENERAL

A. Execution of this work is restricted to installers who have personally completed the adhesive manufacturer's on-site training for the products to be installed, and who are personally certified through a qualified certification program described under Quality Assurance and accepted by the Engineer and the Building Official:
   1. Do not install holes or adhesive until training is complete.

B. Perform work in strict compliance with the accepted MPII and the following instructions. Where the accepted MPII and the instructions conflict, the MPII shall prevail.

C. Install reinforcing bars and all thread rods to embedment depth, and at spacing and locations indicated on the Drawings:
   1. If embedment depth is not indicated, contact Engineer for requirements.
   2. Do not install adhesive-bonded all thread rods or reinforcing bars in upwardly inclined or overhead applications unless accepted in advance by Engineer**.**

3.02 PREPARATION

A. Do not begin installation of adhesive bonded anchors until:
   1. Concrete has achieved an age of at least 21 days after placement.
   2. On-site training in installation of adhesive bonded anchors by manufacturer's technical representative is complete. Do not drill holes in concrete or install adhesive and embeds in holes.

B. Review manufacturer's printed installation instructions (MPII) and "conditions of use" stipulated in the Evaluation Report before beginning work:
   1. Bring to the attention of the adhesive manufacturer's technical representative any discrepancies between these documents, and resolve before proceeding with installation.

C. Install adhesive bonded anchors in full compliance with manufacturer's printed installation instructions using personnel who have successfully completed manufacturer's on-site training for products to be used and who hold certifications specified in this Section.

D. Confirm that adhesive and substrate receiving adhesive are within manufacturer's recommended range for temperature and moisture conditions, and will remain so during the curing time for the product.

3.03 HOLE SIZING AND INSTALLATION

A. Drilling holes:
   1. Determine location of reinforcing bars or other obstructions with a nondestructive indicator device, and mark locations with construction crayon on the surface of the concrete.
   2. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without prior acceptance by Engineer.

B. Hole drilling equipment:
   1. Electric or pneumatic rotary impact type with medium or light impact:
      a. Installation of anchors in cored holes is not permitted.
      b. Set drill to "rotation only" mode, or to "rotation plus hammer" mode in accordance with the manufacturer's installation instructions and the requirements of the Evaluation Report.
      c. Where edge distances are less than 2 inches and "rotation plus hammer" mode is permitted, use lighter impact equipment to prevent micro-cracking and concrete spalling during the drilling process.
   2. Drill bits: Carbide-tipped in accordance with ANSI B212-15 unless otherwise recommended by the manufacturer or required as a "condition of use" in the Evaluation Report:
      a. Hollow drill bits with flushing air systems are preferred. Air supplied to hollow drill bits shall be free of oil, water, or other contaminants that will reduce bond.

C. Hole diameter: As recommended in the manufacturer's installation instructions and the Evaluation Report.

D. Hole depth: As recommended in the manufacturer's installation instructions to provide minimum effective embedment indicated on the Drawings.

E. Obstructions in drill path:
   1. If an existing reinforcing bar or other obstruction is hit while drilling a hole, unless otherwise accepted by Engineer, stop drilling. Prepare and fill the hole with dry-pack mortar. Relocate the hole to miss the obstruction and drill another hole to the required depth:
      a. Obtain Engineer's acceptance of distance between abandoned and relocated holes before proceeding with the relocation.
      b. Allow dry-pack mortar to cure to a strength equal to that of the surrounding concrete before resuming drilling in the area.
      c. Epoxy grout may be substituted for dry-pack mortar when accepted by Engineer.
   2. Avoid drilling an excessive number of holes in an area of a structural member, which would excessively weaken the member and endanger the stability of the structure.
   3. When existing reinforcing steel is encountered during drilling and when specifically accepted by Engineer, enlarge the hole by 1/8 inch, core through the existing reinforcing steel at the larger diameter, and resume drilling at original hole diameter using pneumatic rotary impact drill.
   4. Bent bar reinforcing bars: Where edge distances are critical, and interference with existing reinforcing steel is likely, if acceptable to Engineer, drill hole at 10 degree (or less) angle from axis of reinforcing bar or all thread rod being installed.

F. Cleaning holes:
   1. Insert air nozzle to bottom of hole and blow out loose dust:
      a. Use compressed air that is free of oil, water, or other contaminants that will reduce bond.
      b. Provide minimum air pressure of 90 pounds per square inch for not less than 4 seconds.

2. Using a stiff bristle brush with diameter that provides contact around the full perimeter of the hole, vigorously brush hole to dislodge compacted drilling dust:
    a. Insert brush to the bottom of the hole and withdraw using a simultaneous twisting motion.
    b. Repeat at least 4 times.
3. Repeat the preceding steps as required to remove drilling dust or other material that will reduce bond, and in the number of cycles required by the MPII and the Evaluation Report.
4. Leave prepared holes clean and dry.
5. Protect prepared and cleaned holes from contamination and moisture until adhesive is installed.
6. Re-clean and dry previously prepared holes if, in the opinion of the Engineer, the hole has become contaminated after initial cleaning.

3.04 INSTALLATION OF ADHESIVE AND INSERTS

A. Clean and prepare inserts reinforcing bars and all thread rods:
    1. Prepare embedded length of reinforcing bars and all thread rods by cleaning to bare metal. Inserts shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.
    2. Solvent clean prepared reinforcing bars and all thread rods over the embedment length in accordance with SSPC SP-1. Provide an oil and grease free surface for bonding of adhesive to steel.

B. Fill holes with adhesive:
    1. Starting at the bottom of the hole, fill hole with adhesive inserting the reinforcing bar or all thread rod.
    2. Fill hole as nozzle is withdrawn without creating air voids.
    3. Unless otherwise indicated on the Drawings, fill hole with sufficient adhesive so that excess adhesive is extruded out of the hole when the reinforcing bar or all thread rod is inserted.
    4. Where necessary, seal hole at surface of concrete to prevent loss of adhesive during curing.

C. Installing reinforcing bars and all thread rods:
    1. Unless otherwise indicated on the Drawings, install bars and rods perpendicular to the concrete surface.
    2. Insert reinforcing bars and all thread rods into adhesive in accordance with manufacturer's recommended procedures.
    3. Confirm that insert has reached the designated embedment in the concrete, and that adhesive completely surrounds the embedded portion.
    4. Securely brace bars and all thread rods in place to prevent displacement while the adhesive cures. Bars and rods displaced during curing will be considered damaged and replacement will be required.
    5. Clean excess adhesive from the mouth of the hole.

D. Curing and loading:
    1. Provide and maintain curing conditions recommended by the adhesive manufacturer for the period required to fully cure the adhesive at the temperature of the concrete.

2. Do not disturb or load bonded embeds until manufacturer's recommended cure time, based on temperature of the concrete, has elapsed.

3.05 POST-INSTALLATION ACTIVITIES

A. Do not bend bars or all-thread rods after bonding to the concrete, unless accepted in advance by the Engineer.

B. Attachments to all thread rods:
   1. After assemblies to be connected are placed, install nuts and washers for threaded rods as indicated on the Drawings.

3.06 FIELD QUALITY CONTROL

A. Provide field quality control over the Work of this Section as specified in Section 01450 - Quality Control.

B. Do not allow work described in this Section to be performed by individuals who do not hold the specified certifications and who have not completed the specified job site training.

C. Manufacturer's services:
   1. Before beginning installation, furnish adhesive manufacturer's technical representative to conduct on-site training in proper storage and handling of adhesive, drilling and cleaning of holes, and preparation and installation of reinforcing bars and all thread rods:
      a. Provide notice of scheduled training to Engineer and to Special Inspector(s) not less than 10 working days before training occurs. Engineer and Special Inspector may attend training sessions.
   2. Submit record, signed by the manufacturer's technical representative, listing Contractor's personnel who completed the training. Only qualified personnel who have completed manufacturer's on-site training shall perform installations.

D. Field inspections and testing:
   1. Hole drilling and preparation.
   2. Results: Submit records of inspections and testing to Engineer by electronic copies within 24 hours after completion.

3.07 FIELD QUALITY ASSURANCE

A. Provide field quality assurance over the Work of this Section as specified in Section 01450 - Quality Control.

B. Special inspections, special tests, and structural observation:
   1. Provide as specified in Section 01455 - Regulatory Quality Assurance.
   2. Frequency of inspections:
      a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Evaluation Report for the product installed.
      b. Provide continuous inspection for the initial installation of each type and size of adhesive bonded reinforcing bar and all thread rod. Subsequent installations of the same anchor may be installed with periodic inspection as defined in subsequent paragraphs.

3. Preparation:
    a. Review Drawings and Specifications for the Work to be observed.
    b. Review adhesive manufacturer's MPII and recommended installation procedures.
    c. Review Evaluation Report "Conditions of Use" and "Special Inspection" requirements.
4. Inspection: Periodic:
    a. Initial inspection. Provide an initial inspection for each combination of concrete and reinforcing bar strength or concrete strength and all thread rod material being installed. During initial inspection, observe the following for compliance with the installation requirements:
        1) Concrete: Class (minimum specified compressive strength) and thickness.
        2) Environment: Temperature conditions at work area, and moisture conditions of concrete and drilled hole.
        3) Holes: Locations, spacing, and edge distances; verification of drill bit compliance with requirements; cleaning equipment and procedures; cleanliness of hole. Before adhesive is placed, confirm that depth and preparation of holes conforms to the requirements of the Contract Documents, the MPII, and the "conditions of use" listed in the Evaluation Report.
        4) Adhesive: Product manufacturer and name; lot number and expiration date; temperature of product at installation; installation procedure. Note initial set times observed during installation.
        5) Reinforcing bars and all thread rods: Material diameter and length; steel grade and/or strength; cleaning and preparation; cleanliness at insertion; minimum effective embedment provided.
    b. Subsequent inspections: Subsequent installations of the same reinforcing bars or all thread rods may be performed without the presence of the special inspector, provided that:
        1) There is no change in personnel performing the installation, the general strength and characteristics of the concrete receiving the inserts, or the reinforcing bars and all thread rods being used.
        2) For ongoing installations, the special inspector visits the site at least once per day during each day of installation to observe the work for compliance with material requirements and installation procedures.
5. Inspection: Continuous:
    a. Make observations as described under "Inspection - Periodic, Initial Inspection" during all drilling, cleaning, and bonding activities for all bars and rods installed.
6. Records of inspections:
    a. Provide a written record of each inspection using forms acceptable to the Engineer and to the Building Official.
    b. Submit electronic copies of inspection reports to Engineer within 24 hours after completion of inspection.

END OF SECTION

SECTION 03071

EPOXIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Epoxy.
   2. Epoxy gel.
   3. Epoxy bonding agent.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C881 - Standard Specification for Epoxy-Resin-Base Systems for Concrete.
   2. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
   3. D638 - Standard Test Method for Tensile Properties of Plastics.
   4. D695 - Standard Test Method for Compressive Properties of Rigid Plastics.

1.03 SUBMITTALS

A. General: Submit as specified in Section 01330 - Submittal Procedures.

B. Product Data: Submit manufacturer's data completely describing epoxy materials:
   1. Submit evidence of conformance to ASTM C881. Include manufacturer’s designations of Type Grade, Class, and Color.
   2. Submit documentation that materials meet or exceed the specified strength and performance characteristics. Indicate test methods and test results.

C. Quality control submittals:
   1. Manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Provide epoxy materials that are new.
   2. Store and use products within limitations set forth by manufacturer.
   3. Perform and conduct work of this Section in neat orderly manner.

2.02 MATERIALS

A. General:
   1. Moisture tolerant, water-insensitive, two-component epoxy resin adhesive material containing 100 percent solids, and meeting or exceeding the performance properties specified when tested in accordance with the standards specified.

B. Epoxy: Low viscosity product in accordance with ASTM C881; Types I, II and IV; Grade 1; Class C:
   1. Manufacturers: One of the following or equal:
      a. BASF, MasterInject 1500.
      b. Dayton Superior, Sure Inject J56.
      c. Sika Corporation, Sikadur 35 Hi-Mod LV.
   2. Required properties:

Table 1 - Material Properties - Epoxy.

Property	Test Method	Required Results ("neat")
Tensile Strength (7-day)	ASTM D638	7,100 pounds per square inch, minimum.
Compressive Strength (7-day)	ASTM D695	11,000 pounds per square inch, minimum.
Bond Strength (2-day)	ASTM C882	1,500 pounds per square inch, minimum. Concrete failure before failure of epoxy.
Viscosity (mixed)		250-550 centipoise
Notes:	Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.	

C. Epoxy gel: Non-sagging product in accordance with ASTM C881, Types I and IV, Grade 3, Class C:
   1. Manufacturers: One of the following or equal:
      a. BASF, MasterEmaco ADH 327.
      b. Dayton Superior, Sure Anchor J50.
      c. Sika Corp., Sikadur 31, Hi-Mod Gel.

2. Required properties:

Table 2 - Material Properties - Epoxy Gel.		
Property	**Test Method**	**Required Results ("neat")**
Tensile Strength (7-day)	ASTM D638	2,000 pounds per square inch, minimum.
Compressive Yield Strength (7-day)	ASTM D695	8,000 pounds per square inch, minimum.
Bond Strength (14-day)	ASTM C882	1,500 pounds per square inch, minimum.
Notes:	Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.	

D. Epoxy bonding agent: Non-sagging product in accordance with ASTM C881, Type II, Grade 2, Class C:
   1. Manufacturers: One of the following or equal:
      a. BASF, MasterEmaco ADH 326.
      b. Dayton Superior, Sure Bond J58.
      c. Sika Chemical Corp., Sikadur 32 Hi-Mod LPL**.**
   2. Required properties:

Table 3 - Material Properties - Epoxy Bonding Agent		
Property	**Test Method**	**Required Results**
Tensile Strength (7-day)	ASTM D638	3,300 pounds per square inch, minimum.
Compressive Yield Strength (7-day)	ASTM D695	8,300 pounds per square inch, minimum.
Bond Strength (14-days)	ASTM C882	1,800 pounds per square inch, minimum. Concrete failure before failure of epoxy bonding agent.
Pot Life	-	Minimum 90 minutes at 73 degrees Fahrenheit.
Notes:	Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.	

   3. If increased contact time is required for concrete placement, epoxy resin/portland cement bonding agent as specified in Section 03072 - Epoxy Resin/Portland Cement Bonding Agent may be used instead of epoxy bonding agent.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install and cure epoxy materials in accordance with manufacturer's installation instructions.

B. Epoxy:
   1. Apply in accordance with manufacturer's installation instructions.

C. Epoxy gel:
   1. Apply in accordance with manufacturer's installation instructions.
   2. Use for vertical or overhead work, or where high viscosity epoxy is required.
   3. Epoxy gel used for vertical or overhead work may be used for horizontal work.

D. Epoxy bonding agent:
   1. Apply in accordance with manufacturer's installation instructions.
   2. Bonding agent will not be required for filling form tie holes or for normal finishing and patching of similar sized small defects.

END OF SECTION

SECTION 03072

EPOXY RESIN/PORTLAND CEMENT BONDING AGENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Epoxy resin/portland cement bonding agent.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens).
   2. C348 - Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
   3. C496 - Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   4. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete By Slant Shear.

B. Federal Highway Administration (FHWA):
   1. FHWA-RD-86-193 - Highway Concrete Pavement Technology Development and Testing Volume V: Field Evaluation of SHRP C9206 Test Sites (Bridge Deck Overlays).

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Sika Corp., Sika Armatec 110.

B. Substitutions: The use of other than the specified product will be considered, providing the Contractor requests its use in writing to the Engineer. This request shall be accompanied by:
   1. A certificate of compliance from an approved independent testing laboratory that the proposed substitute product meets or exceeds specified performance criteria, tested in accordance with the specified test standards.
   2. Documented proof that the proposed substitute product has a 1-year proven record of performance of bonding portland cement mortar/concrete to hardened portland cement mortar/concrete, confirmed by actual field tests and 5 successful installations that the Engineer can investigate.

2.02 MATERIALS

A. Epoxy resin/portland cement adhesive:
   1. Component "A" shall be an epoxy resin/water emulsion containing suitable viscosity control agents. It shall not contain butyl glycidyl ether.
   2. Component "B" shall be primarily a water solution of a polyamine.

3. Component "C" shall be a blend of selected portland cements and sands.
4. The material shall not contain asbestos.

2.03 DESIGN AND PERFORMANCE CRITERIA

A. Properties of the mixed epoxy resin/portland cement adhesive:
   1. Pot life: 75 to 105 minutes.
   2. Contact time: 24 hours.
   3. Color: Dark gray.

B. Properties of the cured epoxy resin/portland cement adhesive:
   1. Compressive strength in accordance with ASTM C109:
      a. 3 day: 4,500 pounds per square-inch minimum.
      b. 7 days: 6,500 pounds per square-inch minimum.
      c. 28 days: 8,500 pounds per square-inch minimum.
   2. Splitting tensile strength in accordance with ASTM C496:
      a. 28 days: 600 pounds per square-inch minimum.
   3. Flexural strength:
      a. 1,100 pounds per square-inch minimum in accordance with ASTM C348.
   4. Bond strength in accordance with ASTM C882 modified at 14 days:
      a. 0 hours open time: 2,800 pounds per square-inch minimum.
      b. 24 hours open time: 2,600 pounds per square-inch minimum.
   5. The epoxy resin/portland cement adhesive shall not produce a vapor barrier.
   6. Material must be proven to prevent corrosion of reinforcing steel when tested under the procedures as set forth by the FHWA Program Report Number FHWA-RD-86-193. Proof shall be in the form of an independent testing laboratory corrosion report showing prevention of corrosion of the reinforcing steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Mixing the epoxy resin: Shake contents of Component "A" and Component "B." Empty all of both components into a clean, dry mixing pail. Mix thoroughly for 30 seconds with a jiffy paddle on a low-speed with 400 to 600 revolutions per minute drill. Slowly add the entire contents of Component "C" while continuing to mix for a minimum of 3 minutes and until uniform with no lumps. Mix only the quantity that can be applied within its pot life.

B. Placement procedure:
   1. Apply to prepared surface with stiff-bristle brush, broom, or "hopper-type" spray equipment:
      a. For hand applications: Place fresh plastic concrete/mortar while the bonding bridge adhesive is wet or dry, up to 24 hours.
      b. For machine applications: Allow the bonding bridge adhesive to dry for 12 hours minimum.

C. Adhere to all limitations and cautions for the epoxy resin/portland cement adhesive in the manufacturer's current printed literature.

3.02 CLEANING

A. Leave finished work and work area in a neat, clean condition without evidence of spillovers onto adjacent areas.

END OF SECTION

SECTION 03301

CONCRETE WORK

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PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Concrete formwork; concrete accessories; concrete reinforcement; batching and mixing of concrete to be cast-in-place; concrete placement and curing: and tooled concrete finishes.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
   2. 305 - Specification for Hot Weather Concreting.
   3. 306 - Standard Specification for Cold Weather Concreting.
   4. 318 - Building Code Requirements for Structural Concrete and Commentary.
   5. SP-66 - ACI Detailing Manual.

B. ASTM International (ASTM):
   1. A185 - Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
   2. A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   3. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   4. C33 - Standard Specification for Concrete Aggregates.
   5. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   6. C40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
   7. C88 - Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
   8. C94 - Standard Specification for Ready-Mixed Concrete.
   9. C114 - Standard Test Methods for Chemical Analysis of Hydraulic Cement.
   10. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   11. C138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.
   12. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
   13. C150 - Standard Specification for Portland Cement.
   14. C156 - Standard Test Method for Water Loss Through Liquid Membrane-Forming Curing Compounds for Concrete.
   15. C171 - Standard Specification for Sheet Materials for Curing Concrete.
   16. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
   17. C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
   18. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
   19. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   20. C311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
   21. C494 - Standard Specification for Chemical Admixtures for Concrete.

22. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
23. C989 - Standard Specification for Slag Cement for Use in Concrete and Mortars.
24. C1017 - Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
25. C1064 - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
26. C1260 - Standard Test Method of Potential Alkali Reactivity of Aggregates (Mortar Bar Method).
27. D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
28. D1752 - Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
29. D2103 - Standard Specification for Polyethylene Film and Sheeting.

C. Concrete Reinforcing Steel Institute (CRSI):
   1. Manual of Standard Practice.

1.03 DEFINITIONS

A. Average daily temperature: The average of the highest and lowest temperatures during a 24-hour period from midnight to midnight.

B. Cold weather: A period when, for more than 3 consecutive days, the average daily temperature drops below 40 degrees Fahrenheit:
   1. When the temperature is above 50 degrees Fahrenheit for more than half of any 24-hour duration, that period need not be regarded as cold weather.

C. Green concrete: Concrete whose current compressive strength is less than 100 percent of the minimum specified compressive strength, f'c.

D. Hand mixed concrete: Concrete mixed at or near the point of placement using shovels, hoes, or other similar manually operated tools.

E. Hot weather: A period when project conditions such as low humidity, high temperature, solar radiation, and high winds promote rapid drying of freshly placed concrete.

F. Neat cement grout: Grout made from a mixture of portland cement and water.

1.04 SUBMITTALS

A. General:
   1. Submittal as specified in Section 01330 - Submittal Procedures unless modified in this Section.

B. Product data:
   1. Formwork:
      a. Formwork facing materials. Data on facing materials for concrete exposed to view in the finished work, if different from that specified in this Section.

b. Form release agent. Manufacturer's name and catalog data, including materials safety data sheet and documentation of suitability for use in contact with potable water.

2. Joint materials:
   a. Preformed expansion joint material: Manufacturer's name and catalog data with documentation of conformance to materials standards specified for each type and thickness of material.
3. Reinforcement:
   a. Mill certificates for each heat of steel provided.
   b. Concrete bar supports:
      1) Precast concrete bar supports ("dobies"): Manufacturer's product data indicating compression strength of concrete supports and material used for tie wires.
      2) Wire chairs and slab bolsters: Manufacturer's product data.
4. Concrete materials:
   a. Cement:
      1) Mill certificate in accordance with ASTM C150. Include "Type" and results of testing for alkali content.
   b. Aggregates:
      1) Type, pit or quarry location, and producer's name.
      2) Commercial laboratory test reports for samples of each aggregate proposed for use. Tests shall have been made not more than 90 days prior to the date of the submittal:
         a) Fine aggregate: Gradation analysis, specific gravity, and reports of deleterious materials to document compliance in accordance with ASTM C33.
         b) Coarse aggregate: Gradation analysis, specific gravity, and reports of deleterious materials to document compliance in accordance with ASTM C33 for each size used.
   c. Admixtures:
      1) Manufacturer's catalog cuts and product data indicating compliance with the standards specified.
      2) Fly ash: Mill test reports documenting compliance in accordance with ASTM C618 and any additional requirements of this Section.
      3) Slag cement: Identify source and provide testing results to demonstrate compliance with requirements of ASTM C989 and this Section.
5. Concrete mixes: Submit full details, including:
   a. Mix proportions and concrete properties for each class of concrete proposed for use.
      1) Information on correction of batching for varying moisture contents of fine aggregate.
   b. Data to establish the average compressive strength:
      1) If established by field test records, submit:
         a) Product and test data for the materials actually used in the mix.
         b) Actual mix proportions used in the mix producing the record.
         c) Field test data for slump, air content, and 28-day compressive strength. Include not less than 15 tests in accordance with ACI 318 Chapter 5.
      2) If established by testing of trial batches, submit:
         a) Confirmation that the materials and proportions used in the trial batches are those that will be provided for the mix.

b) Mix test data for slump, air content, and 28-day compressive strength.

3) For either method, include calculations for:
   a) Standard deviation, calculated in accordance with ACI 318 requirements.
   b) Required average compression strength (f'cr) using the standard deviation calculated in accordance with ACI 318 requirements.
   c) Statement demonstrating that the average compression strength from field test records or from trial batch testing for each mix ($f'c_{avg}$) exceeds the required average compressive strength (f'cr) for that mix.

6. Concrete finishing and curing materials:
   a. Manufacturer's name and product data sheets.

C. Shop drawings:
   1. Reinforcement:
      a. Submit drawings showing bending and placement of reinforcement:
         1) Drawings shall be in accordance with ACI SP-66.
         2) Clearly show placement, shapes, and dimensions of each bar listed in the bill of materials, including additional reinforcement at corners and openings required by details in the Contract Documents.
         3) Show splice locations and bar lengths reflecting Contractor's intended placement sequence.
      b. Drawings that, in the Engineer's opinion, are not sufficiently clear or complete will be rejected and a re-submittal will be required:
         1) Such determination will be solely at the discretion of the Engineer, and rejection may occur with or without review comments.

D. Samples:
   1. Form ties: If requested by the Engineer.
   2. Concrete bar supports: If requested by the Engineer, provide samples f:
      a. Precast concrete bar supports ("dobies").
      b. Wire chairs and slab bolsters.

E. Procedures:
   1. Contractor's plans for production, placement, finishing, curing, protection, and temperature monitoring of concrete during the following environmental conditions:
      a. Hot weather.
      b. Cold weather**.**

F. Project record documents:
   1. For the following items, note location of concrete in the structure, and include tag numbers of associated cylinders for compression strength tests.
   2. Concrete delivery tickets. Submit copies of concrete delivery tickets within 24-hours after delivery
   3. Field test reports: Results of field-testing for slump, temperature, unit weight, and air entrainment.
   4. Testing laboratory reports for compression strength.

G. Notifications:
    1. Modifications to concrete mixes:
        a. Submit notification of any adjustments to mixture proportions and any changes in materials made during the course of the Work for Engineer's review.
        b. Include details of the changes and supporting documentation.
    2. Joint locations:
        a. Where joint locations other than those indicated on the Drawings are requested, submit proposed locations for Engineer's review.
        b. Provide drawings showing proposed joint locations with joint types labeled and joint details referenced.
    3. Reinforcement placement: Where necessary to move reinforcement beyond the specified placing tolerances to avoid interference, submit the proposed arrangement for Engineer's review.
    4. Concrete placements: Submit notification of readiness for each concrete placement at least 24 hours in advance.
    5. Concrete repairs:
        a. Where concrete surfaces or sections exhibit defects after removal of forms, submit description of existing conditions and of proposed repair procedures and materials.
        b. Include photos of existing conditions with submittal.

1.05 QUALITY ASSURANCE

A. Tolerances on concrete construction: In accordance with ACI 117 unless more stringent requirements are specified in the Contract Documents.

B. Concrete mixtures:
    1. Ensure that concrete produced has the specified characteristics in the freshly mixed state, and that those are maintained to during transport and delivery and to the point of final placement.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, and handle concrete materials in manner as to prevent damage and inclusion of foreign substances.

B. Deliver reinforcing steel bundled and tagged with identifying tags marked in a legible manner with waterproof markings showing the same designations as indicated on the submitted shop drawings:
    1. Store off the ground and protect from moisture, dirt, oil, and other injurious contaminants.

C. Protect concrete accessories from weather and direct exposure to sunlight before installation.

1.07 PROJECT CONDITIONS

A. Environmental requirements:
    1. Hot weather concreting: Construct in accordance with ACI 305 during conditions when the ambient air temperature is above 90 degrees Fahrenheit.

2. Cold weather concreting: Construct in accordance with ACI 306 when ambient air temperature is below 40 degrees Fahrenheit, or is 45 degrees Fahrenheit and falling.
3. Conditions that promote rapid drying of freshly placed concrete, such as low humidity, high temperature, and wind: Take corrective action to minimize loss of water from the concrete.

1.08 SEQUENCING AND SCHEDULING

A. Schedule placing of concrete in such a manner that completes any single placing operation to a construction, or expansion joint as indicated on the Drawings or accepted by the Engineer in advance of the placement.

PART 2 PRODUCTS

2.01 FORMS

A. Forms:
   1. Design and performance requirements:
      a. Design and performance of formwork shall be the responsibility of the Contractor, subject to the requirements of the Contract Documents.
      b. Design, construct, and brace formwork to:
         1) Carry all loads applied or transmitted, including the pressure resulting from placement and vibration of plastic concrete.
         2) Remain tight to prevent loss of mortar.
         3) Maintain specified tolerances and provide finished surfaces as specified in this Section.
      c. Maximum deflection of facing materials and supporting members on surfaces exposed to view in the finished work: 0.0042 times the clear span (span/240).
      d. Maximum deviation from alignment (horizontal or vertical): In accordance with ACI 117.
   2. Form facing materials:
      a. Surfaces exposed to view in the finished work:
         1) Facing materials shall produce a smooth, uniform texture on the concrete.
         2) Do not use materials with raised grain, tears, worn edges, patches, dents, or other similar defects.
         3) Acceptable materials: Plywood with “C” or better face; plastic-faced plywood; tempered concrete form grade hardboard; or steel.
      b. Surfaces not exposed to view in the finished work: Special form facing material not required.
   3. Forms for chamfers and keyways:
      a. Uniform steel, plastic, or lumber section of dimensions shown or specified.
      b. Provide adequate stiffness and support to maintain a true line at the concrete surface.
      c. Treated to eliminate bond with the concrete if required to produce a smooth, uniform, and undamaged finish upon removal.

B. Form ties:
   1. General:
      a. Provide form ties fabricated by recognized manufacturer of concrete forming equipment and suitable for use with the forming system selected.
      b. Provide ties that accurately tie, lock, and spread forms:
         1) Do not use wire ties or wood spreaders.
      c. Provide form ties of such design that, when forms are removed, the tie leaves no metal or other material within 1-1/2 inches of the surface of the concrete.
      d. Do not allow tie holes through forms for ties to leak during concrete placement.
   2. Cone snap ties: Tie with removable plastic cone leaving a tapered depression having a minimum diameter of 1 inch at the surface of the concrete and a depth of 1-1/2 inches below the surface.

C. Dry-pack mortar for filling cone snap tie holes:
   1. Proportioned mix of 1 part of portland cement to 1 part plaster sand with potable water added to provide a stiff consistency that can be driven into holes and properly compacted.
   2. Admixtures or additives to mortar are not permitted.

D. Form release agent: Commercially manufactured, non-staining formwork release agent that will prevent absorption of water by the formwork and will prevent bond between the formwork and the concrete:
   1. Form release agent to comply with all local air quality management regulations.

2.02 JOINT MATERIALS

A. Preformed synthetic sponge rubber expansion joint material:
   1. Elastic sponge rubber compound in accordance with ASTM D1752, Type I.
   2. Concrete-gray color unless otherwise noted.
   3. Thickness: As indicated on the Drawings.
   4. Manufacturers: One of the following or equal:
      a. Tamms Industries Inc., Horn Expansion Joint Fillers: Cementone.
      b. Williams Products Inc., Everlastic 1300.
      c. WR Meadows, Seal Tight Sponge Rubber Expansion Joint.

B. Preformed bituminous fiber expansion joint material:
   1. Asphalt-impregnated fiberboard in accordance with ASTM D1751.

C. Sealants and caulking: As specified in Section 07900 - Joint Sealants.

D. Waterstops:
   1. Polyvinyl chloride (PVC) waterstops.

2.03 REINFORCEMENT

A. Materials:
   1. Deformed bars: In accordance with ASTM A615 Grade 60 indicated on the Drawings.
   2. Welded wire fabric: Sheets of plain wire in accordance with ASTM A185.

3. Bar supports:
    a. Over ground or “mud mat”:
        1) Precast concrete blocks with cast-in annealed steel tie wires, 16 gauge or heavier.
            a) Compressive strength of blocks equal to or exceeding the compressive strength of the surrounding concrete.
        2) Height as required for minimum 3 inches of clear concrete cover below reinforcement.
        3) Minimum block “footprint” of 4 square inches, or as required to supporting load from reinforcement while maintaining the required concrete cover.
    b. Wire supports: Class 2, Type B stainless steel in accordance with CRSI Manual of Standard Practice.
4. Tie wire: Annealed steel.

B. Fabrication:
1. Cut and cold-bend bars in accordance with provisions of ACI 315 and ACI 318.
2. Fabricate reinforcement to the tolerances in accordance with ACI 117.
3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.

2.04 CONCRETE MIXES

A. Source quality control:
1. Trial batches:
    a. After concrete mix designs have been accepted by Engineer, have trial batches of the accepted Class A, Class B, and Class D concrete mix designs prepared by testing laboratory acceptable to the Engineer.
    b. Prepare trial batches using cementitious materials and aggregates proposed to be used for the Work.
    c. Prepare trial batches with sufficient quantity to determine slump, workability, consistency, and finishing characteristics, and to provide sufficient test cylinders.
    d. Test cylinders: Provide cylinders having 6-inch diameter by 12-inch length and that are prepared in accordance with ASTM C31 for tests specified in this Section.
    e. Determine slump in accordance with ASTM C143.
    f. Test cylinders from trial batch:
        1) Test 8 cylinders for compressive strength in accordance with ASTM C39:
            a) Test 4 cylinders at 7 days and 4 at 28 days.
            b) Establish ratio between 7-day and 28-day strength for mix. 7- day strength may be taken as satisfactory indication of 28-day strength provided effects on concrete of temperature and humidity between 7 day and 28 day are taken into account.
    g. If trial batch tests do not meet specified requirements for slump, strength, workability, consistency, and finishing, change concrete mix design proportions and, if necessary, source of aggregate:
        1) Perform additional trial batches and tests until an acceptable trial batch is produced that meets requirements of this Section.

h. Perform test batches and tests required to establish trial batches and acceptability of materials without change in Contract Price.
i. Do not place concrete until the concrete mix design and trial batch have been accepted by Engineer.

2. Aggregate:
   a. Testing of concrete aggregate is at Contractor's expense.
   b. Provide test reports representing samples of materials taken and tested at the following times:
      1) Not more than 60 days prior to the date on the proposed materials for concrete mixes.
      2) Not more than 60 days prior to any change in the source of aggregates, including suppliers and/or quarries.
      3) Whenever there is a significant change in aggregate quality or gradation from a previously submitted and accepted source.
   c. Sample aggregate in accordance with ASTM D75.
   d. Fine and coarse aggregates:
      1) Gradation: Test in accordance with ASTM C136. Use sieves with square openings for testing grading of aggregates.
      2) Alkali-silica reactivity.
      3) Provide fine and coarse aggregate with expansion not greater than 0.10 percent at 14 days when tested in accordance with ASTM C1260, unless the aggregate has been determined to be not deleteriously reactive based on testing in accordance with one of the following.
      4) ASTM C227: Expansion not greater than 0.05 percent and 3 months, and not greater than 0.10 percent at 6 months.
      5) ASTM C1293: Expansion not greater than 0.04 percent at 1 year.
   e. Fine aggregate:
      1) Provide fine aggregate that does not contain strong alkali nor organic matter which gives color darker than standard color when tested in accordance with ASTM C40.
      2) Provide aggregate having soundness in accordance with ASTM C33 when tested in accordance with ASTM C88.
   f. Coarse aggregate:
      1) Soundness when tested in accordance with ASTM C88: Have loss not greater than 10 percent when tested with sodium sulfate.
      2) Abrasion Loss: Not exceed 45 percent after 500 revolutions when tested in accordance with ASTM C131.

3. Fly ash:
   a. Sampling and testing: Sample and test fly ash in accordance with ASTM C311.

4. Portland cement:
   a. Determination of alkali content: In accordance with ASTM C114.

5. Submit documentation that the proposed concrete mixes will conform to the requirements of this Section and will produce concrete having the required proportions and properties specified:
   a. Do not place concrete until the design for that mix and the results of any trial batch testing have been accepted by the Engineer.
   b. If the Engineer requires changes to the mix design, modify mixes within limits set forth in this Section and submit new mix design for Engineer’s review.

6. After acceptance, do not change mixes or mix proportions without prior acceptance by the Engineer:
    a. Exception: At all times, adjust batching of water to compensate for free moisture content of aggregates. Total water content in the mix shall not exceed that specified.
7. If there is change in source of cement or aggregate, or if there is a significant change in the characteristics or quality of any constituent material received from a source accepted to supply materials, submit new design mixes for each class of concrete affected.
8. Testing of materials and mixes before placement to demonstrate that they comply with the requirements of this Section shall be at the Contractor's expense.

B. Constituent materials:
1. Cement:
    a. Portland cement: In accordance with ASTM C150, Type II or Type I/II, Low Alkali; or ASTM C150, Type III, Low Alkali.
    b. Low Alkali materials shall be those having total alkali content of not more than 0.60 percent when determined in accordance with ASTM C114.
    c. Cement for finishes or repairs: Provide cement from same source and of same type as concrete to be finished.
2. Aggregates:
    a. General:
    b. Provide normal weight concrete aggregates that are sound, uniformly graded, and free of deleterious material in excess of the amounts specified.
    c. Provide unit weight of fine and coarse aggregate that produces in place concrete with weight of not less than 140 pounds per cubic foot.
    d. Grade aggregate in accordance with ASTM C136 and D75.
    e. Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, or other construction waste.
    f. Obtain aggregate from source that is capable of providing uniform quality, moisture content, and grading during any single day's operations.
    g. Alkali-silica reactivity:
        1) Provide fine and coarse aggregate with expansion not greater than 0.10 percent at 14 days when tested in accordance with ASTM C1260, unless the aggregate has been determined to be not deleteriously reactive based on testing in accordance with one of the following:
            a) ASTM C227: Expansion not greater than 0.05 percent and 3 months, and not greater than 0.10 percent at 6 months.
            b) ASTM C1293: Expansion not greater than 0.04 percent at 1 year.
            c) ASTM C1567:
                (1) Expansion not greater than 0.10 percent at 16 days.
                (2) Percentage of pozzolan (fly ash or blast furnace slag) used in test must equal the mix design pozzolan percentage.
                (3) Percentage of pozzolan may only exceed limits given with concurrence of the Engineer.
    h. Fine aggregate:
        1) Provide fine aggregate consisting of clean, natural sand or of sand prepared from crushed stone or crushed gravel.

2) In accordance with ASTM C33 and the following:
a) Provide fine aggregate that does not contain strong alkali nor organic matter that gives color darker than standard color when tested in accordance with ASTM C40.

i. Coarse aggregate:
1) Provide coarse aggregate consisting of gravel or crushed stone made up of clean, hard, durable particles free from calcareous coatings, organic matter, or other foreign substances; and in accordance with ASTM C33, Class 4S and the following:
a) Soundness when tested in accordance with ASTM C88:
(1) Have loss not greater than 10 percent when tested with sodium sulfate.
b) Abrasion loss: Not exceeding 45 percent after 500 revolutions when tested in accordance with ASTM C131.
2) Grading: Unless otherwise specified or accepted in writing by the Engineer, provide the following:
a) Aggregate for Class A, and C, Concrete: ASTM C33, Size Number 57.
b) Where a combination of 2 or more sizes of coarse aggregate are used, the gradation of the blend shall conform to the grading requirements in accordance with ASTM C33 for the size number specified.

3. Water:
a. Water for concrete mixes, for washing aggregate, and for curing concrete: Potable water, clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.

4. Admixtures:
a. General:
1) Do not use admixtures, except those specified, unless written authorization has been obtained from the Engineer.
2) Admixtures shall be compatible with concrete and other admixtures. Admixtures (other than fly ash) shall be the products of a single manufacturer to ensure compatibility.
3) Do not use admixtures containing chlorides in excess of 0.5 percent by weight of cement when calculated as chloride ion.
4) Use in accordance with manufacturer's recommendations. Add each admixture to concrete mix separately.
b. Air entraining admixture: In accordance with ASTM C260.
c. Water reducing admixture:
1) May be used at the Contractor's option.
2) In accordance with ASTM C494, Type A or Type D.
3) Not containing air-entraining agents.
4) Liquid form before adding to the concrete mix.
5) No decrease in cement is permitted as result of use of water reducing admixture.
d. Coloring agent:
1) To produce red-colored concrete for encasement of electrical ducts, conduits, and similar items:
a) Mix 10 pounds of coloring agent into each cubic yard of concrete, unless otherwise recommended by the manufacturer and accepted by the Engineer.

2) Manufacturers: One of the following or equal:
a) Davis Co., #100 Utility Red.
b) I. Reiss Co., Inc., equivalent product.
c) Euclid Chemical Co., Increte Division, “Colorcrete Brick Red.”
3) Conduit encasement concrete: Mix into each cubic yard of concrete 10 pounds of coloring agent.

5. Fly ash:
a. In accordance with ASTM C618, Class F.
b. Sampling and testing: In accordance with ASTM C311.
c. Loss on ignition: Not to exceed 4 percent.
6. Slag cement:
a. Grade 80, 100, or 120 in accordance with ASTM C989, except as modified below:
1) Fineness: Amount retained on a No. 325 sieve: 20 percent maximum.
2) Total alkalies Na2O + 0.658 K2O:
a) Minimum: 0.60 percent.
b) Maximum: 0.90 percent.
b. In accordance with NSF 61.

C. Mix design and proportioning:
1. Proportion mixes to provide compression strength, workability, and durability as specified in this Section.
2. Submit documentation that the proposed mixes will conform to the requirements of this Section and will produce concrete having the required properties
3. Compression strength:
a. Proportion each concrete mix to provide the required average compressive strength (f’cr) determined in accordance with the provisions of ACI 318 Chapter 5.
b. Determine required average compressive strength (f’cr) for each class of concrete using the specified compressive strength of the mix, f’c, and the standard deviation determined in accordance with ACI 318:
1) Establish the standard deviation in accordance with ACI 318 and based on either field test records, or based on trial batches.
2) Documentation of standard deviation based on field test records:
a) Calculate standard deviation in accordance with ACI 318 procedures using test records that:
(1) Represent materials, quality control procedures, and conditions similar to those expected for this Work.
(2) Do not include provisions for materials and proportions that are more restrictive than the materials proposed for use in this Work.
(3) Represent a mix proportioned to provide a specified compressive strength (f’c) within 1,000 pounds per square inch of that specified for the corresponding mix in this Section.
3) Documentation of standard deviation based on trial batches plus empirical code requirements:
a) When records including at least 15 consecutive tests that span a period of at least 45 calendar days are not available, determine required average compressive strength (f'cr) from Table A:

TABLE A Required Average Compressive Strength	
Specified Compressive Strength f'_c (pounds per square inch)	**Required Average Compressive Strength f'cr (pounds per square inch)**
Less than 3,000	f'c + 1,000
3,000 to 5,000	f'c + 1,200

4. Workability:
   a. Provide concrete with workability and consistency that can be readily worked into corners and angles of forms and around reinforcement without excessive vibration and without permitting materials to segregate or free water to collect on the surface.
5. Cement content:
   a. Use only 1 brand of portland cement for all exposed concrete surfaces in any single structure.
   b. Minimum cementitious materials content: Conform to values specified in Table B of this Section.
   c. Ratio of water to cementitious materials:
      1) Conform to values specified in Table B of this Section.
      2) Total water, including that from moisture content of aggregates and admixtures, shall not exceed that specified in Table C of this Section.
6. Aggregates:
   a. Ratio of coarse aggregate to fine aggregate: Not less than 1.0 or more than 2.0 for all concrete classes.
7. Admixtures:
   a. Use in accordance with manufacturer’s instructions.
   b. Air entraining admixture:
      1) Provide concrete with entrained air content indicated in Table B and consisting of evenly dispersed air bubbles.
   c. Water reducing admixture:
      1) May be used at the Contractor's option.
      2) No decrease in cementitious materials content is permitted as a result of use of water reducing admixture.
   d. High range water reducing admixture/plasticizing admixture:
      1) Not permitted.
   e. Coloring admixture:
      1) Unless otherwise recommended by the manufacturer, mix into each cubic yard of concrete 10 pounds of coloring agent.
8. Fly ash:
   a. Maximum of 15 percent by weight of total weight of cementitious materials
9. Slag Cement:
   a. Minimum of 20 precent by weight of total weight of cementitious material.
   b. Maximum of 30 percent by weight of total weight of cementitious material.
10. Concrete mix design requirements by class:
    a. Provide concrete mixes for each “class” specified in this Section and indicated in Table B.
    b. Use each class at the locations specified in the following paragraphs or indicated on the Drawings:
       1) “Class A” Concrete: General use. Use at all locations unless otherwise indicated on the Drawings or listed in the following paragraphs.

2) "Class C" Concrete: May be used as fill for unauthorized excavation, for thrust blocks and ground anchors for piping, for bedding of pipe, and elsewhere as indicated on the Drawings.

c. Pumped concrete: Provide a separate mix design and substantiation testing for each "class" to be placed by pumping.

TABLE B
Concrete Classes

Concrete Class	Minimum Specified Compressive Strength at 28 days, f'c[1] (pounds per square inch)	Ratio of Water to Cementitious Materials[2,3] (minimum - maximum)	Cementitious Materials Content[3] (pounds per cubic yard of concrete by weight)	Cement Type (ASTM C150, low alkali)	Maximum Coarse Aggregate Size[4]	Air Entrainment (percent) (N/R: not required.)	Slump Range (inches)
A	4,000	0.40 to 0.45	564 to 658	II	57	5+1.0	2 to 4
C	2,500	Maximum 0.62 max.	Minimum 423	II	57	5+1.5	3 to 6

Notes:
(1) At locations where concrete will not be subjected to load from other elements of the structure or from Contractor's placing operations, maximum time period for achievement of specified compressive strength may be extended to 56 days when accepted by the Contractor's Engineer.
(2) W/C Ratio = Ratio of water to cementitious materials by weight.
(3) Provide mix within the range of W/C ratio and cementitious materials content indicated.
(4) Size number in ASTM C33, Table 2.

2.05 CONCRETE BATCHING AND MIXING EQUIPMENT

A. Provide equipment and facilities for accurate measurement and control of materials:
   1. At all times, maintain proportions of concrete mix within specified limits.
   2. Control and adjust batch weights to secure maximum yield.

B. Measuring or weighing equipment:
   1. Furnish apparatus for weighing aggregates and cementitious materials that is suitably designed and constructed for this purpose.
   2. Devices shall bear the current and valid seal of the Sealer of Weights and Measures having jurisdiction.
   3. Furnish devices that have capability of providing successive quantities of individual materials measured to within 2 percent of desired amount of that material.

C. Mixing equipment:
   1. Mixes shall be ready-mix or transit-mixed concrete in accordance with ASTM C94. Hand-measured or hand-mixed batches shall not be used.

2. Provide equipment capable of combining aggregates, cementitious materials, water, and admixtures into a thoroughly mixed and uniform mass during the time periods specified, and capable of discharging the resulting mixture without segregation.
3. Maintain mixing equipment in good working order. Operate at loads and speeds, and for periods of time recommended by the manufacturer or specified in this Section.

2.06 CONCRETE FINISHING AND CURING MATERIALS

A. Evaporation retardant:
   1. Manufacturers: One of the following or equal:
      a. Master Builders Technologies, Confilm.
      b. Euclid Chemical Co., Eucobar.

B. Plastic membrane:
   1. White polyethylene film in accordance with ASTM C171:
      a. Nominal thickness not less than 0.0040 inches when measured in accordance with ASTM D2103, and thickness at any point not less than 0.0030 inches.
      b. Loss of moisture: Not to exceed 0.055 grams per square centimeter of surface when tested in accordance with ASTM C156.

C. Sprayed-on membrane curing compound:
   1. In accordance with ASTM C309, Type 1D. Clear with fugitive dye.

PART 3 EXECUTION

3.01 GENERAL

A. Preparation:
   1. Use construction methods and sequences that allow time for concrete to reach adequate strength to prevent damage to or overstress of the concrete structure or its elements during construction.
   2. Locations of construction and expansion joints are indicated on the Drawings:
      a. Make no other joints, except as accepted in advance by the Engineer.
      b. Schedule placing of concrete to complete any single placing operation between designated joints.
      c. Schedule and sequence placements to allow adequate time for concrete to achieve adequate strength before subsequent placements and loads are applied to the structure.
      d. Place concrete for beams, girders, brackets, column capitals, haunches, and drop panels at the same time as the concrete for the adjacent slabs.

B. Verification of conditions:
   1. Do not place concrete until:
      a. Forms have been cleaned and form release agents have been applied.
      b. All forms have been thoroughly checked for alignment, level, strength, and accurate location of reinforcement, joint accessories, and all mechanical and electrical inserts or other embedded items.
      c. Reinforcement is secure and properly fastened in its correct position.

d. Dowels, bucks, sleeves, hangers, pipes, conduits, anchor bolts, and any other fixtures required to be embedded in concrete have been placed and adequately anchored.
e. Forms are aligned and secured, and loose form ties at construction joints have been retightened.

2. Notify the Engineer in writing of readiness, not just intention, to place concrete in any portion of the work:
   a. Provide this notification in such time in advance of operations, as the Engineer deems necessary to make final observation of preparations at location of the concrete placement.
   b. Have forms, reinforcement, screeds, anchors, ties, embeds, and inserts in place before notifying Engineer of readiness for final observations.
3. Do not place concrete until Engineer has completed final observations of conditions at the placement, and has given acceptance to proceed.

3.02 FORMING

A. General:
   1. Do not use earth cuts as forms for vertical or sloped surfaces unless specifically required by or indicated on the Contract Documents.
   2. Joints: Locate joints as indicated on the Drawings:
      a. Submit joint locations other than or differing from those indicated on the Drawings for Engineer's review before construction.
   3. Chamfers:
      a. Permanently exposed outside corners: Provide 3/4-inch chamfer.
      b. Re-entrant corners:
         1) Chamfer not required.
         2) Corner may be left square.
      c. Edges of formed joints: Chamfer not required unless indicated on the Drawings.
   4. Level strips: Install level strips at top of wall concrete placements to maintain true line at horizontal construction joints.

B. Constructing and erecting formwork:
   1. Brace and anchor formwork to ensure vertical and lateral stability and to maintain finish tolerances when subjected to uplift pressures and lateral pressures from plastic concrete:
      a. Ensure that formwork is positioned, braced, and firmly held against previously placed concrete to maintain true surfaces and to prevent loss or leaking of mortar at construction joints:
         1) At joints with flush surfaces exposed to view, lap contact surface of form a maximum of 1-inch over the previously placed concrete.
      b. Design and construct forms with sufficient strength and stiffness that deflections resulting from loading by plastic concrete will not exceed the surface tolerance limits specified.
      c. Set facing materials in an orderly and symmetrical arrangement, keeping the number of seams to a practical minimum.
      d. Form ties: Tie forms together using cone snap ties placed at not more than 2-foot centers vertically and horizontally.
      e. Construct formwork to permit easy removal without damage to formed surfaces.

f. Provide temporary openings at the base of column and wall formwork to allow cleaning and inspection immediately before concrete placement.
g. Cracks, openings, or offsets at joints in formwork: Close those that are 1/16-inch or larger by tightening forms or by filling with acceptable crack filler.

2. Where forms are re-used, clean surfaces of mortar, grout, and foreign materials before coating with form release agent and setting.
3. Cover formwork surfaces with form release agent to prevent bond with the concrete:
   a. Do not allow form release agent to puddle in the forms.
   b. Do not allow form release agent to contact reinforcement, embeds, or previously placed concrete.
4. Provide runways supported directly on the formwork for moving equipment and supplies during preparations for concreting:
   a. Do not rest such runways on reinforcement.

C. Embeds, joints, and accessories:
1. Position pipes, sleeves, conduits, inserts, anchors, castings, and other embedded items in the forms, and anchor to formwork to prevent displacement.
2. Fill voids in sleeves, pipes, inserts and anchor slots with readily removable material, and seal if required to prevent entry of mortar.
3. For pipe or conduit runs, position embeds to allow at least 3 inches of clear concrete separation between parallel runs of pipes, conduits or any combination of these items with each other or with reinforcement.

D. Removing formwork:
1. Remove forms after the specified time for curing and protection has been provided and when operations will not damage concrete.
2. Immediately after forms are removed, carefully examine concrete surfaces:
   a. Report any irregularities in surfaces and finishes to the Engineer.
   b. Where surface repairs are needed, contact Engineer with description of conditions and description of repair procedures before proceeding with work.
3. Immediately follow form removal with installation of specified curing materials and procedures.
4. After forms are removed from wall and curing is complete, fill tie holes as follows:
   a. Remove form ties and cones from surfaces.
   b. Roughen cone-shaped tie holes by heavy sandblasting before repair.
   c. Clean and dampen tie holes, maintaining a saturated surface for at least 2 hours before applying dry-pack mortar.
   d. Dry pack cone-shaped tie holes with dry-pack mortar as specified in this Section.

3.03 PLACING CONCRETE REINFORCEMENT, EMBEDS, AND ACCESSORIES

A. Preparation:
1. Cut and bend deformed steel reinforcement in the shop, and deliver completed bars to the site for installation:
   a. Do not field-bend deformed reinforcement.

2. Surface preparation:
    a. Thoroughly clean reinforcing bars from rust scale, loose mill scale, rust coat, dirt, oil, and other coatings that adversely affect bonding capacity when placed in the work:
        1) Thin coating of red rust resulting from short exposures will not be considered objectionable.
    b. Remove concrete or other deleterious coatings from dowels and other reinforcement projecting from previous placements by wire brushing or sandblasting before the reinforcement is embedded in the subsequent placement.

B. Support of reinforcement and accessories:
1. Provide supports for deformed bars and wire fabric to maintain reinforcement position indicated on the Drawings and to provide specified minimum clear concrete cover around the reinforcement.
2. Use number of supports required to prevent reinforcement form sagging and to support loads during construction, but in no fewer quantities and locations than in accordance with ACI SP-66.
3. Support wire fabric from reinforcing supports:
    Do not place wire fabric on grade or forms for subsequent lifting into plastic concrete during the concrete placement.
    a. Take care to maintain specified position of wire fabric in the concrete section and to prevent bending, draping, or kinking of the wires.
4. Do not:
    a. Use brick, broken concrete masonry units, concrete spalls, rocks, or other such material for supporting reinforcement.
    b. Support reinforcement on additional reinforcing bars installed with less cover than that required by the Contract Documents (“give away bars”).
    c. Adjust location of reinforcement indicated on the Drawings to increase cover over support bars.
5. Furnish and use templates for placing column dowels.

C. Placing reinforcement:
1. Locate reinforcement to provide minimum clear concrete cover specified:
    a. Where cover is not specified, in accordance with ACI 318.
2. Accurately place reinforcement in accordance with the tolerances of ACI 117:
    a. Where reinforcement must be moved beyond the specified placing tolerances to avoid interference with other reinforcement, conduits, or embeds, submit the proposed arrangement for Engineer’s review.
3. Fasten reinforcement securely in place with wire ties:
    a. After tying, bend ends of wire ties inward towards the center of the concrete to match clear concrete cover provided for reinforcement.
4. Do not weld reinforcing bars or wires.
5. Deformed reinforcing bars:
    a. Tie slab bars at every intersection around the perimeter of slabs.
    b. Tie wall bar and slab bar intersections, other than those around the perimeter, at every fourth intersection, but not more than 48 inches on center each way.
    c. Lap splices:
        1) Lap reinforcement at splices as indicated on the Drawings or specified.

2) Unless indicated on the Drawings, install lap splices with bars in contact and fastened together with tie wire.
3) If lap splice length is not indicated on the Drawings, install in accordance with ACI 318.

6. Welded wire fabric reinforcement:
   a. Bend fabric as indicated on the Drawings or required to fit work.
   b. Unroll or otherwise straighten fabric to make perfectly flat sheet before placing in the Work.
   c. Extend welded wire fabric across concrete section to provide fabric to within 2 inches of vertical concrete edges.
   d. Lap splice welded wire fabric as indicated on the Drawings:
      1) If no splice details are indicated, lap fabric at least 12 inches, fasten with wire ties spaced not more than 24 inches on center, and lace lap with wire of the same diameter of the fabric.

3.04 BATCHING, MIXING, TRANSPORTING AND DELIVERING CONCRETE

A. General:
   1. Measure, batch, mix, transport, and deliver ready-mixed concrete in accordance with ASTM C94.
      a. On-site volumetric batching using pre-packaged dry materials is not permitted.

B. Measuring and batching:
   1. Measure materials by weighing, except as otherwise specified or where other methods are specifically authorized in writing by the Engineer.
      a. Weigh cementitious materials separately.
   2. Furnish satisfactory means for checking moisture content of aggregates before batching.
      a. Adjust mix water to compensate for free moisture content of aggregate.
   3. Mixing water:
      a. Measure by volume or by weight.
      b. Maximum water-to-cementitious materials ratio for each concrete class shall not exceed that specified in Table B of this Section.
   4. Admixtures:
      a. Provide admixtures as specified.
      b. Batch products by means of mechanical batcher capable of accurate measurement, and in accordance with the admixture manufacturer's instructions.

C. Mixing and transporting:
   1. Mixing:
      a. Equip each truck mixer with device capable of counting number of drum revolutions, and interlocked to prevent discharge of concrete from drum before required number of revolutions is complete.
      b. Once drum revolutions commence, continuously revolve drum until it has completely discharged its batch.
      c. Do not add water until drum commences revolutions.
      d. The Engineer may require an increase in the designated minimum number of revolutions, or a decrease in the designated maximum number of revolutions if necessary to obtain satisfactory mixing:
         1) Incorporate such changes without additional costs to the Owner.

2. Do not exceed the following time period for mixing and delivery:
    a. Total elapsed time from addition of water at batch plant through discharging of mix: Not to exceed the lesser of 90 minutes nor 300 revolutions of the mixer drum.
    b. Total elapsed time for from arrival at the project site to completing discharge of mix: Not to exceed 30 minutes.
    c. Under conditions contributing to quick setting, the Engineer may reduce total elapsed time permitted.

D. On-site acceptance of concrete mixes:
1. Concrete shall possess the properties specified in this Section at the point of placement.
2. Do not place concrete:
    a. Having slump outside the limits indicated in Table B.
    b. That does not conform to specifications for entrained air content.
    c. For which the total elapsed time of mixing or elapsed time at the site exceeds the specified maximums.

3.05 CONVEYING, DEPOSITING, AND CONSOLIDATING CONCRETE

A. Preparation:
1. General:
    a. Clean construction joints and forming surfaces of dirt, sawdust, chips, and other debris after forms are built and immediately before concrete or grout placement:
        1) Use vacuum cleaner if required to provide clean surfaces.
    b. Remove snow, ice, frost, and standing water from surfaces of formwork, reinforcement, and embeds in contact with concrete.
    c. Secure reinforcement, joint materials, anchors, embeds and other items in place.
    d. During conveying, placement, consolidation, and finishing of concrete, protect surrounding construction, including concrete walls and slab surfaces, from concrete splatter.
    e. Thoroughly clean surrounding construction at the completion of each placement and before splatter sets up.
2. Slabs of concrete construction on grade:
    a. Provide subgrade preparation, base materials, and compaction as required by the Contract Documents.
    b. Remove loose soils, debris, standing water, snow, or ice from subgrade.
    c. Provide moist subgrade with no standing or free water and no muddy or soft spots:
        1) When subgrade is not moist, sprinkle with water not less than 2 nor more than 6 hours in advance of placing concrete.
        2) If subgrade becomes dry prior to actual placing of concrete, sprinkle again, without forming pools of water.
3. Weather conditions:
    a. Hot weather: In hot weather conditions, make provisions in advance of placement for windbreaks, shading, fogging, sprinkling, ponding, or wet covering.
    b. Cold weather: In cold weather conditions, make provisions to maintain the required concrete temperatures without overheating or drying, and without exposing concrete to carbon dioxide from heater exhaust.

c. Precipitation:
    1) Do not begin placements while rain, sleet, or snow is falling or anticipated, or unless adequate protection is provided.
    2) Do not allow precipitation to increase concrete water content or to damage the surface of the concrete.
d. Wind:
    1) Do not begin placements during wind events that will blow dust or debris into the plastic concrete.
    2) Do not allow wind-blown debris to become embedded in or to damage the surface of the concrete.
    3) At all times, have sufficient coverings on hand to protect new concrete from excessive drying or blowing debris.

B. Conveying concrete:
1. Convey concrete from mixer to place of final deposit by methods that prevent segregation or loss of materials.
2. Use chutes, pumps, and conveyors of size and design that will ensure continuous flow of concrete at point of delivery without cold joints.
3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from the chute or conveying device.
4. Keep conveying equipment clean by thoroughly washing and scraping upon completion of any placement.

C. Depositing concrete:
1. Do not place concrete under the following conditions:
    a. After initial set has occurred.
    b. When re-tempering has occurred.
2. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing:
    a. Do not use vibrators to move concrete from its point of deposit.
    b. Use tremies for placing concrete where drop is over 5 feet.
3. Place concrete continuously in approximately horizontal layers not exceeding 24 inches in depth. Bring level up evenly in all parts of forms:
    a. After placement begins, continue without significant interruption and as a continuous operation until the end of that placement is reached.
    b. Do not allow “cold joints” to form between adjacent layers or areas of the placement, or initial set to form on “wet edge” of placements.
    c. Take precautions to prevent delays between placement of adjacent layers or areas from exceeding 20 minutes:
        1) If more than 20 minutes elapse after the initial surface was placed, spread a layer of neat cement grout, not less than 1/2 inch in thickness nor more than 1 inch in thickness, over the previously placed surface before depositing additional concrete.
4. Placing concrete on slopes: Commence placement at bottom of slope and work upward.
5. Placing horizontal concrete monolithically with structures below:
    a. If concrete for slabs, beams, or walkways is to be cast monolithically with walls or columns below, do not place the horizontal concrete elements until the concrete in walls or columns below has been placed, consolidated, and allowed to achieve initial set.
    b. Allow set time of not less than 1 hour.

c. Maintain a moist surface at the top of the walls or columns during the setting period.

6. Placing a second concrete lift over hardened concrete below:
   a. Take special precautions in form work at top of old lift and bottom of new lift to prevent:
      1) Spreading and vertical or horizontal displacement of forms.
      2) Grout "bleeding" onto finished concrete surfaces.

D. Consolidating concrete:
   1. Thoroughly consolidate concrete into forms and around reinforcement, pipes, and other embeds using mechanical vibrators:
      a. Take special care to place concrete solidly against forms, leaving no voids.
      b. Make concrete solid, dense, compact, and smooth.
   2. Provide vibration energy sufficient to cause concrete to flow and readily settle into place, leaving no voids. Vibration should visibly affect concrete over a radius of at least 18 inches without segregation.
   3. Vibrators:
      a. At all times, have sufficient vibrators on hand to consolidate concrete as it is placed.
      b. In addition to vibrators in use while concrete is being placed, have on hand at least 1 spare vibrator in serviceable condition.
      c. Place no concrete until it has been ascertained that all vibrating equipment, including spares, are in serviceable condition.

3.06 FINISHING CONCRETE

A. Provide concrete finishes specified in Section 03366 - Tooled Concrete Finishing.

B. Liquid evaporation retardant:
   1. Apply evaporation retardant when environmental conditions will result in rapid evaporation of moisture from the surface of the fresh concrete during finishing operations. Such conditions include low humidity, high heat, and wind occurring alone or in combination.
   2. Immediately after the concrete is screeded, coat the surface of the concrete with a liquid evaporation retardant.
   3. Apply the evaporation retardant again after each work operation as necessary to prevent drying shrinkage cracks and crazing at the surface.

3.07 CURING AND PROTECTING CONCRETE

A. Curing concrete:
   1. Cure concrete by methods specified in this Section.
   2. Keep concrete continuously moist and at a temperature of at least 50 degrees Fahrenheit for at least 7 days after placement, unless the details of a particular method specify a longer period.
   3. Make provisions to maintain moisture or curing membrane integrity at edges of slabs, tops of walls, and joint surfaces, and to prevent loss of protection.

4. Schedule of curing methods:
    a. Concrete surfaces that will receive additional materials that require bond to the initial placement (including concrete; concrete repairs, coatings, paints, sealers; grout, and other materials):
        1) Water curing or plastic membrane curing.
    b. Formed surfaces:
        1) If non-absorbent forms are left in place for 7 days after placement: No additional requirements.
        2) For absorbent forms or when forms are removed during the 7 days following placement: Cure by water curing, plastic membrane curing, or sprayed membrane curing.
    c. Unformed concrete surfaces:
        1) Water curing, plastic membrane curing, or sprayed membrane curing.
5. Water curing:
    a. Keep surfaces of concrete constantly and visibly saturated by ponding, continuous fogging, or continuous sprinkling at all times during curing period:
        1) Cover surfaces if required to maintain saturated conditions.
        2) For horizontal surfaces, pond the surface with at least 2 inches of water or cover with saturated mats or fabric kept continuously wet.
    b. Formed surfaces:
        1) Each day forms remain in place may be counted as 1 day of water curing.
        2) Do not loosen form ties while concrete is being cured by forms left in place.
        3) No further credit for curing time will be allowed after contact between the concrete surface and the forms has been broken.
6. Plastic membrane curing:
    a. Cover concrete with plastic membrane, sealing joints and edges against displacement by wind or site operations and to prevent loss of moisture.
    b. Install plastic membrane as soon as concrete is finished and can be walked on without damage.
    c. Keep all surfaces of concrete under plastic membrane moist at all times during the curing period.
7. Sprayed membrane curing:
    a. Application of curing compound:
        1) Apply curing compound to concrete surface after repairing and patching, and within 1 hour after forms are removed:
            a) If more than 1 hour elapses between removal of forms and application of curing compound, provide water curing of affected surfaces for the full curing period.
        2) Contractor is cautioned that the method of applying curing compound specified in this Section may require more compound than normally suggested by manufacturer of compound, and also more than is customary in the trade.
        3) Apply curing compound by mechanical, power-operated sprayer with mechanical agitator that will uniformly mix all pigment and compound.
        4) Apply compound in at least 2 coats, with each subsequent coat in a direction turned 90 degrees from the preceding coat.

5) Apply curing compound in sufficient quantity that concrete has uniform appearance and that the natural color of the concrete is effectively and completely concealed at time of spraying.
6) Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.
7) Apply compound to a film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
8) Take care to apply curing compound to edges of placements and over full surface profile of construction joints.

b. Removal of curing compound:
1) Do not remove curing compound from concrete in less than 7 days:
a) During this period, the Contractor may remove curing compound only after receiving Engineer's acceptance of written request to do so.
b) Include with the request a description of measures that will be provided to adequately cure surfaces where curing compound has been removed.
2) Before placing fresh concrete against a surface previously coated with curing compound, remove the curing compound by heavy sandblasting.
3) Prior to final acceptance of the work, remove any curing compound on surfaces exposed to view by sandblasting or other acceptable method. After removal, only the natural color of finished concrete shall remain visible, and such color shall be uniform over the entire surface.

B. Protecting concrete:
1. Immediately after placement, protect concrete from drying, hot, or cold weather, and mechanical damage.
2. Temperature:
a. Cold weather: Protect concrete during the curing period so that the concrete temperature is maintained within the following requirements:
1) Sections less than 12 inches thick: Minimum 55 degrees Fahrenheit.
2) Sections 12 to 36 inches thick: Minimum 50 degrees Fahrenheit.
b. Hot weather: Protect concrete during the curing period so that the concrete temperature does not exceed 90 degrees Fahrenheit.
c. Remove protection against temperature gradually so that concrete surface temperature does not drop or rise by more than 40 degrees Fahrenheit during any 24-hour period.
3. Maintain forms, shoring, and bracing in place after concrete placement for a periods after concrete placement as indicated in the following paragraphs. Forms may be removed after these periods if the concrete has developed sufficient strength and hardness to resist surface or other damage:
a. Vertical forms:
1) General: Minimum 24 hours after concrete placement.
2) Sides of footings: Minimum 24 hours after concrete placement.
3) Sides of beams, girders, and similar members: Minimum 48 hours after concrete placement.
b. Horizontal forms:
1) Slabs, beams, and girders: Until concrete reaches specified compressive strength, f'c, or until shoring is installed.

c. Shoring for slabs, beams, and girders:
    1) Shore until concrete strength reaches specified compressive strength, f'c:
        a) Temporary shoring may be required after the specified compressive strength is reached if construction loads will exceed the designated live load capacity of the structure.
d. Wall bracing:
    1) Brace until strength of concrete beams and slabs laterally supporting the wall reaches specified compressive strength, f'c.

C. Loads against or on the concrete:
    1. Loading of green concrete, by backfilling or by placing personnel and equipment on the surface, is not permitted.
    2. Backfilling: Do not place backfill against concrete walls until the wall and all elements attached to it, including connecting slabs or beams, are fully braced by the structure and have achieved their minimum specified compressive strength, f'c.

3.08 JOINTS AND JOINT PREPARATION

A. Joint locations and details:
    1. Construct concrete work as monolith to the extent practical.
    2. Construct joints as indicated on the Drawings and as specified.
    3. Locations of construction, expansion, and other joints are indicated on the Drawings or specified in this Section:
        a. Do not relocate, add, or delete joints without prior approval from the Engineer.

B. Construction joints:
    1. Where spacing is not indicated on the Drawings, provide construction joints in slabs and walls at intervals not greater than 35 feet.
    2. Construct as indicated on the Drawings.
    3. Before placing fresh concrete against the joint: Use heavy sandblast to thoroughly clean joint surfaces and reinforcement crossing the joint of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter.
    4. Just before placing concrete against the joint, wash surface with water to saturate joint surface and concrete surfaces within 12-inches of the joint.
    5. Horizontal joints:
        a. Immediately before placing concrete, thoroughly spread bed of neat cement over the joint surface.
        b. Grout thickness: Not less than 1/2 inch, nor more than 1 inch.

C. Expansion joints:
    1. Where width is not indicated on the Drawings, provide 3/4-inch wide joint.
    2. Construct as indicated on the Drawings.
    3. Do not extend through expansion joints reinforcement, conduits, or other items unless details for such crossings are indicated on the Drawings.
    4. Preformed expansion joint material:
        a. Accurately position joint filler in the joint and fasten to concrete or forms with adhesive.

b. Tape splices in joint filler to prevent intrusion of mortar.
c. Fastening joint filler using nails, bolts, screws, or similar items is not permitted.

3.09 TOLERANCES

A. Concrete:
1. Finished concrete: Conform to shapes, lines, grades, and dimensions indicated on the Drawings.
2. In accordance with ACI 117, except as modified in the following paragraphs:
a. Where more restrictive tolerances to accommodate equipment are indicated on the Drawings.
b. Slabs where slope is indicated:
1) Uniformly slope to drain.
2) Without depressions that puddle water.
c. Slabs indicated to be level:
1) Maximum deviation of 1/8 inches in 10 feet without any apparent changes in grade.
2) Without depressions that puddle water.

B. Embeds:
1. General:
a. Sleeves and inserts: Plus or minus 1/8 inch.
b. Projected ends of anchor bolts: Plus 1/4 inch; minus 0 inches.
c. Anchor bolt position: Plus or minus 1/16 inch.
2. Equipment: Set inserts to tolerances required for proper installation and operation of equipment or systems to which insert pertains.

3.10 FIELD QUALITY CONTROL

A. Contractor shall provide quality control over the Work of this Section.

B. Field testing of concrete:
1. During progress of construction, provide testing to determine whether the concrete, as it is being produced, complies with requirements specified.
2. Sampling and testing shall be performed by Contractor's testing laboratory:
a. Cooperate in testing by allowing free access to the Work for testing laboratory to sample and test materials.
b. Provide full access for Engineer to observe concrete sampling and testing at any time.
c. Contractor is responsible for providing care of and curing conditions for test specimens in accordance with ASTM C31 until specimens are collected by testing laboratory:
1) Provide at least 4 firmly braced, insulated, heated, closed wooden curing boxes, each sized to hold 10 specimens. Include cold weather temperature and hot weather temperature control thermostat for initial curing and storage from time of fabrication through receipt at Contractor's testing laboratory.
3. Testing shall include:
a. Sampling of concrete in accordance with ASTM C172.
b. Temperature of concrete at delivery in accordance with the requirements of ASTM C1064 and as specified in this Section.

c. Slump of concrete using slump cone in accordance with the requirements of ASTM C143:
    1) Test slump at the beginning of each placement, as often as necessary to keep slump within the specified range, and when requested to do so by the Engineer.
    2) Observe concrete during slump test for signs of segregation:
        a) Observe concrete for mortar or moisture flow from slumped sample.
        b) Reject concrete if mortar or moisture flows out of the mix.
d. Unit weight of concrete in accordance with ASTM C138.
e. Air entrainment in accordance with ASTM C173:
    1) Test percent of entrained air in concrete at the beginning of each placement, as often as necessary to keep entrained air within the specified range, and when requested to do so by the Engineer.
f. Compressive strength, f'c, in accordance with ASTM C39:
    1) Make and cure test specimens in accordance with ASTM C31.
    2) Number of specimens for each test:
        a) Not less than 3 cylinder specimens, 6-inch diameter by 12-inches long, for each test.
    3) Frequency of testing:
        a) Minimum of 1 set of cylinders for each 150 cubic yards of each class of concrete.
        b) Minimum of 1 set of cylinders for each class of concrete for each half-day of placement.
    4) Schedule for testing of specimens:
        a) One cylinder will be broken at 7 days and 2 cylinders will be broken at 28 days.

4. Contractor shall:
    a. Furnish concrete for test specimens, and provide manual assistance to the Engineer in preparing said specimens.
    b. Assume responsibility for providing care and on-site curing and protection for test specimens in accordance with ASTM C31.

3.11 FIELD QUALITY ASSURANCE

A. Engineer shall provide on-site observation and field quality assurance for the Work of this Section.

B. Special tests and inspections: As specified in Section 01455 - Regulatory Quality Assurance.

C. Field inspections:
1. Required inspections:
    a. Observe construction for conformance to the Contract Documents and the accepted submittals.
2. Records of inspections:
    a. Maintain record of each inspection.

D. Field tests:
   1. Engineer may request, at any time, additional testing to confirm that materials being delivered and placed conform to the requirements of the Specifications:
      a. If such additional testing shows that the materials do not conform to the specified requirements, Contractor shall pay the cost of these tests.
      b. If such additional testing shows that the materials do conform to the specified requirements, Engineer will pay the cost of these tests.

3.12 NON-CONFORMING WORK

A. Enforcement of specification requirements:
   1. Do not place concrete that does not conform to the requirements of these Specifications. Remove non-conforming materials from the site.
   2. Strength requirements:
      a. Concrete is expected to reach higher compressive strength than the minimum specified compressive strength f'c as indicated in Table B.
      b. Concrete strength will be considered acceptable if following conditions are satisfied:
         1) Averages of all sets of 3 consecutive strength test results are greater than or equal to specified compressive strength f'c.
         2) No individual strength test (average of 2 cylinders tested at 28-days) falls below specified compressive strength f'c by more than 500 pounds per square inch.
      c. Whenever 1, or both of the conditions stated above is not satisfied, provide additional curing or testing of the affected portion as directed by the Engineer:
         1) The costs of such curing or testing shall be at the Contractor's expense.

3.13 ADJUSTING

A. Remove and replace or repair defective work as directed by the Engineer:
   1. Do not patch, repair, or cover defective work before observation by the Engineer.
   2. Make no repairs until Engineer has accepted proposed methods for preparation and repair.

END OF SECTION

SECTION 03366

TOOLED CONCRETE FINISHING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Tooled concrete finishes.

1.02 QUALITY ASSURANCE

A. Mock-ups:
   1. Test panels for concrete finishes:
      a. Prepare test panels for F4 finishes and tie-hole repairs for review by Engineer.
      b. Accepted test panels serve as standard of quality and workmanship for project.
   2. Prepare test panel showing horizontal and vertical joints proposed for project for review by the Engineer. Refer to finishes specified in this Section.
   3. Test panels indicating methods for making concrete repairs: Prepare test panels for proposed repairs at beginning of project for review by Engineer:
      a. Accepted test panels serve as standard for repairs during the project.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
   1. Deliver and store packaged materials in original containers until ready for use.

PART 2 PRODUCTS

2.01 MIXES

A. Mortar mix for F4 finish: Consist of 1 part cement and 1-1/2 parts of fine sand passing Number 100 screen. Mix with enough water and emulsified bonding agent to have consistency of thick cream.

PART 3 EXECUTION

3.01 CONCRETE FINISHES

A. Cement for finishes:
   1. Addition of white cement may be required to produce finish which matches color of concrete to be finished.

B. Finish vertical concrete surfaces with one of the following finishes as indicated in the Finish Schedule:
   1. F3 finish: Repair defective work, remove fins, offsets, and grind projections smooth. Fill depressions 1/4 inch or larger in depth or width and tie holes with mortar after removal of curing compound.
   2. F4 finish: Receive same finish as specified for F3 finish, and, in addition fill depressions and holes 1/16 inch or larger in width with mortar:
      a. "Brush-Off" sandblast surfaces prior to filling holes to expose all holes near surface of the concrete.
      b. Thoroughly wet surfaces and commence filling of pits, holes, and depressions while surfaces are still damp.
      c. Perform filling by rubbing mortar over entire area with clean burlap, sponge rubber floats, or trowels.
      d. Do not let any material remain on surfaces, except that within pits and depressions.
      e. Wipe surfaces clean and moist cure.

C. Finish horizontal concrete surfaces with one of the following finishes as indicated in the Finish Schedule after proper and adequate vibration and tamping:
   1. S1 finish: Screeded to grade and leave without special finish.
   2. S2 finish: Smooth steel trowel finish.
   3. S3 finish: Steel trowel finish free from trowel marks. Provide smooth finish free of all irregularities.

D. Finish concrete floor surfaces to which surfacing material is applied: Finish smooth with tolerance within 1/8 inch in 10 feet in any direction from lines indicated on the Drawings.

3.02 CONCRETE FINISH SCHEDULE

A. Finish concrete surfaces as follows:
   1. F4 finish for following vertical surfaces:
      a. Concrete surfaces specified or indicated to be painted.
      b. Concrete surfaces, interior or exterior, exposed to view.
   2. S1 finish for following surfaces:
      a. Projecting footings which are to be covered with dirt.
      b. Slab surfaces which are to be covered with concrete fill.
   3. S2 finish for following surfaces:
      a. Tops of corbels.
      b. Tops of walls and beams not covered above in this Section.
      c. Tops of slabs not covered above in this Section.
      d. All other surfaces not specified to be finished otherwise.
   4. S3 finish for following surfaces:
      a. Building and machine room floors which are not covered with surfacing material: Provide floors that are free from trowel marks.

END OF SECTION

SECTION 03600

GROUTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cement grout.
   2. Dry-pack mortar.
   3. Non-shrink grout.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-inch cube specimens).
   2. C230 - Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
   3. C531 - Standard Test Method for Liner Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   4. C579 - Standard Test Method for Compressive Strength of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacings and Polymer Concretes.
   5. C939 - Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
   6. C942 - Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.
   7. C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
   8. C1181 - Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.

B. International Concrete Repair Institute (ICRI):
   1. 310.2R - Selecting and specifying Concrete Surface Preparations for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

1.03 SUBMITTALS

A. Cement grout:
   1. Mix design.
   2. Material submittals.

B. Non-shrink grout:
   1. Manufacturer's literature.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to jobsite in their original, unopened packages or containers, clearly labeled with manufacturer's product identification and printed instructions.

B. Store materials in cool dry place and in accordance with manufacturer's recommendations.

C. Handle materials in accordance with the manufacturer's instructions.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Non-shrink grout:
   1. Manufacturers: One of the following or equal:
      a. Five Star Products, Inc., Five Star Grout.
      b. BASF Construction Chemicals, Masterflow 928.
      c. L&M Construction Chemicals, Inc., CRYSTEX.
   2. In accordance with ASTM C1107.
   3. Preportioned and prepackaged cement-based mixture.
   4. Contain no metallic particles such as aluminum powder and no metallic aggregate such as iron filings.
   5. Require only addition of potable water.
   6. Water for pre-soaking, mixing, and curing: Potable water.
   7. Free from emergence of mixing water from within or presence of water on its surface.
   8. Remain at minimum flowable consistency for at least 45 minutes after mixing at 45 degrees Fahrenheit to 90 degrees Fahrenheit when tested in accordance with ASTM C230:
      a. If at fluid consistency, verify consistency in accordance with ASTM C939.
   9. Dimensional stability (height change):
      a. In accordance with ASTM C1107, volume-adjusting Grade B or C at 45 degrees Fahrenheit to 90 degrees Fahrenheit.
      b. Have 90 percent or greater bearing area under bases.
   10. Have minimum compressive strengths at 45 degrees Fahrenheit to 90 degrees Fahrenheit in accordance with ASTM C1107 for various periods from time of placement, including 5,000 pounds per square inch at 28 days when tested in accordance with ASTM C109 as modified by ASTM C1107.

2.02 MIXES

A. Cement grout:
   1. Use same sand-to-cementitious materials ratio for cement grout mix that is used for concrete mix.
   2. Use same materials for cement grout that are used for concrete.
   3. Use water-to-cementitious materials ratio that is no more than that specified for concrete.
   4. For spreading over surfaces of construction or cold joints.
   5. Make color of finished patch match that of surrounding concrete.

B. Dry-pack mortar:
   1. Proportions by weight: 1 part portland cement to 2 parts concrete sand:
      a. Portland cement: As specified in Section 03301 - Concrete Work.
      b. Concrete sand: As specified in Section 03301 - Concrete Work.

C. Non-shrink grout:
   1. Mix in accordance with manufacturer's installation instructions such that resulting mix has flowable consistency and is suitable for placing by pouring.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect concrete surfaces to receive grout or mortar and verify that they are free of ice, frost, dirt, grease, oil, curing compounds, paints, impregnations, and loose material or foreign matter likely to reduce bond or performance of grout or mortar.

3.02 PREPARATION

A. Surface preparation for grouting other baseplates:
   1. Remove grease, oil, dirt, dust, curing compounds, laitance, and other deleterious materials that may affect bond to concrete and bottoms of baseplates.
   2. Roughen concrete surfaces in contact with grout to ICRI CSP-6 surface profile or rougher:
      a. Remove loose or broken concrete.
   3. Metal surfaces in contact with grout: Grit blast to white metal surface.

3.03 INSTALLATION

A. Mixing:
   1. Cement grout:
      a. Use mortar mixer with moving paddles.
      b. Pre-wet mixer and empty out excess water before beginning mixing.
   2. Dry-patch mortar:
      a. Use only enough water so that resulting mortar will crumble to touch after being formed into ball by hand.
   3. Non-shrink grout:
      a. May be drypacked, flowed, or pumped into place. Do not overwork grout.
      b. Do not retemper by adding more water after grout stiffens.

B. Placement:
   1. Cement grout:
      a. Exercise care in placing cement grout because it is required to furnish structural strength, impermeable water seal, or both.
      b. Do not use cement grout that has not been placed within 30 minutes after mixing.
      c. is uniformly wetted. Over mixing will cause air entrapment in mix.
   2. Non-shrink grout:
      a. Add non-shrink cement grout to premeasured amount of water that does not exceed the manufacturer's maximum recommended water content.
      b. Mix in accordance with manufacturer's instructions to uniform consistency.

C. Curing:
   1. Cement based grouts and mortars:
      a. Keep continuously wet for minimum of 7 days. Use wet burlap, soaker hose, sun shading, ponding, and in extreme conditions, combination of methods.
      b. Maintain above 40 degrees Fahrenheit until it has attained compressive strength of 3,000 pounds per square inch, or above 70 degrees Fahrenheit for minimum of 24 hours to avoid damage from subsequent freezing.
   2. Epoxy based grouts:
      a. Cure grouts in accordance with manufacturers' recommendations:
         1) Do not water cure epoxy grouts.
      b. Do not allow any surface in contact with epoxy grout to fall below 50 degrees Fahrenheit for minimum of 48 hours after placement.

D. Grouting equipment bases, baseplates, soleplates, and skids: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

E. Grouting other baseplates:
   1. General:
      a. Use non-shrink grout as specified in this Section.
      b. Baseplate grouting shall take place from one side of baseplate to other in continuous flow of grout to avoid trapping air in grout.
      c. Maintain hydrostatic head pressure by keeping level of grout in headbox above bottom of baseplate. Fill headbox to maximum level and work grout down.
      d. Vibrate, rod, or chain non-shrink grout to facilitate grout flow, consolidate grout, and remove trapped air.
   2. Forms and headboxes:
      a. Build forms using material with adequate strength to withstand placement of grouts.
      b. Use forms that are rigid and liquidtight. Caulk cracks and joints with elastomeric sealant.
      c. Line forms with polyethylene for easy grout release. Coating forms with 2 coats of heavy-duty paste wax is also acceptable.
      d. Headbox shall be 4 to 6 inches higher than baseplate and shall be located on one side of baseplate.
      e. After grout sets, remove forms and trim back grout at 45 degree angle from bottom edges of baseplate.

3.04 FIELD QUALITY CONTROL

A. Non-shrink grout:
   1. Test for 24-hour compressive strength in accordance with ASTM C942.

END OF SECTION

SECTION 04055

ADHESIVE BONDING REINFORCING BARS AND ALL THREAD RODS IN MASONRY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Bonding reinforcing bars and all thread rods in masonry using injectable, 2-component adhesive.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. Standard B212.15 - Carbide Tipped Masonry Drills and Blanks for Carbide Tipped Masonry Drills.

B. ICC Evaluation Service, Inc. (ICC-ES):
   1. AC58 - Acceptance Criteria for Adhesive Anchors in Masonry Elements.

C. Society for Protective Coatings (SSPC):
   1. Surface Preparation Standards (SP):
      a. SP-1 - Solvent Cleaning.

1.03 DEFINITIONS

A. Evaluation Report: Report prepared by ICC-ES, or by other testing agency acceptable to the Engineer and to the Authority Having Jurisdiction, that documents testing and review of the adhesive product to confirm that it conforms to the requirements of ICC-ES AC58.

1.04 SUBMITTALS

A. Product data: Furnish technical data for adhesives, including:
   1. Independent testing laboratory results indicating allowable loads in tension and shear for masonry walls of the types included in the Work, with load modification factors for temperature, spacing, edge distance, and other installation variables.
   2. Handling and storage instructions.
   3. Installation instructions.

B. Quality control submittals:
   1. Special inspection: Detailed instructions for special inspection to comply with the building code specified in Section 01410 - Regulatory Requirements.
   2. Evaluation Report confirming that the product complies with the requirements of ICC-ES AC58.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store and protect as follows, unless manufacturer has more stringent requirements:
   1. Store adhesive components on pallets or shelving in a covered-storage area protected from weather:
   2. Control temperature to maintain storage within manufacturer's recommended temperature range:
      a. If products are stored at temperatures outside manufacturer's recommended range, test components prior to use by methods acceptable to the Engineer to determine if the products still meet specified requirements.
   3. Dispose of products that have passed their expiration date.

1.06 PROJECT CONDITIONS

A. Seismic design category: As specified in Section 01612 – Seismic Design Criteria

PART 2 PRODUCTS

2.01 GENERAL

A. Like items of materials: Use end products of one manufacturer to achieve structural compatibility and single-source responsibility.

2.02 ADHESIVE FOR SELF-CONTAINED CARTRIDGE SYSTEM

A. Adhesive shall have a current Evaluation Report demonstrating compliance with the requirements of ICC-ES AC58.

B. Materials:
   1. 2-component structural adhesive, insensitive to moisture, and gray in color.
   2. Cure temperature, pot life, and workability: Compatible with intended use and environmental conditions.

C. Packaging:
   1. Furnished in disposable, side-by-side cartridges with resin and hardener components isolated until mixing through manufacturer's static mixing nozzle:
      a. Nozzle designed to thoroughly blend the components, in the proper mixing ratio, for injection from the nozzle directly into prepared hole.
      b. Provide nozzle extensions as required to allow full-depth insertion and filling from the bottom of the hole.
   2. Container markings: Include manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

D. For installation in solid masonry and solid-grouted masonry (concrete or brick):
   1. Manufacturers: One of the following or equal:
      a. Hilti, Inc., HY-270 Adhesive Anchor System.
      b. Simpson Strong-Tie Co., Inc., ET-HP Anchoring Adhesive.
      c. USP Structural Connectors, CIA-GEL 7000 Masonry Epoxy Adhesive.

2.03 ALL THREAD RODS

A. Materials: As specified in Section 05120 - Structural Steel.

2.04 REINFORCING BARS

A. As specified in Section 04090 - Masonry Accessories.

PART 3 EXECUTION

3.01 GENERAL

A. Unless otherwise required for “conditions of use” in the Evaluation Report submitted, prepare, and install holes, adhesive, and inserts (all thread rods or reinforcing bars) in accordance with the manufacturer’s recommendations and this Section:
   1. In the event of conflicts, the more restrictive provisions shall govern.

B. Do not install adhesive-bonded all-thread rods or reinforcing bars in upwardly inclined and overhead applications.

3.02 PREPARATION

A. Prior to completing manufacturer’s on-site training specified in this Section, do not:
   1. Drill holes for reinforcing bars or all thread rods.
   2. Mix or install adhesive in holes.

B. Review manufacturer’s installation instructions and “conditions of use” stipulated in the Evaluation Report before beginning work.

C. Confirm that adhesive and substrate receiving adhesive are within manufacturer’s recommended temperature range, and will remain so during the cure time for the product.

3.03 HOLE LAYOUT AND INSTALLATION

A. Drilling holes:
   1. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device. Mark locations with on the surface of the masonry using removable construction crayon, or other method acceptable to the Engineer.
   2. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the masonry without prior acceptance by Engineer.

B. Hole drilling equipment:
   1. Electric or pneumatic rotary impact type:
      a. Set drill to “rotation only” mode, or to “rotation plus hammer” mode in accordance with manufacturer’s installation instructions and the requirements of the Evaluation Report.
   2. Where edge distances are less than 2 inches and “rotation plus hammer” mode is permitted, use lighter impact equipment to prevent micro-cracking and spalling from drilling.

3. Drill bits: Carbide-tipped in accordance with ANSI B212-15.
4. Hollow drill bits with flushing air systems are preferred. Air supplied to hollow drill bits shall be free of oil, water, or other contaminants that will reduce bond.

C. Hole diameter: As recommend in the manufacturer's installation instructions and the Evaluation Report.

D. Hole depth: As recommended by the manufacturer's installation instructions to provide minimum effective embedment indicated on the Drawings.

E. Obstructions in drill path:
1. If an existing reinforcing bar or other obstruction is hit while drilling hole, stop drilling and fill the hole with dry-pack mortar. Relocate the hole to miss the obstruction and drill to the required depth:
   a. Allow dry-pack mortar to cure to strength equal to that of the surrounding masonry before resuming drilling in that area.
   b. Epoxy grout may be substituted for dry-pack mortar when acceptable to the Engineer.
2. Avoid drilling an excessive number of adjacent holes that would weaken the structural member and endanger the stability of the structure. Obtain Engineer's acceptance of distance between abandoned and relocated holes.

F. Cleaning holes:
1. Insert air nozzle to bottom of hole and blow out loose dust:
   a. Use compressed air that is free of oil, water, or other contaminants.
   b. Provide minimum air pressure of 90 pounds per square inch for not less than 4 seconds.
2. Using a stiff bristle brush of diameter that provides contact around the full perimeter of the hole, vigorously brush the hole to dislodge compacted drilling dust:
   a. Insert brush to the bottom of the hole and withdraw using a simultaneous twisting motion.
   b. Repeat at least 4 times.
3. Repeat the preceding steps as required to remove drilling dust or other material that will reduce bond, and as required by the manufacturer and the Evaluation Report.
4. Leave prepared hole clean and dry.

3.04 INSTALLATION OF ADHESIVE AND INSERTS

A. Clean and prepare inserts:
1. Prepare embedded length of reinforcing bars and all thread rods by cleaning to bare metal. The inserts shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.
2. Solvent-clean prepared reinforcing bars and all thread rods over their embedment length in accordance with SSPC SP-1. Provide an oil and grease-free surface for bonding of adhesive to steel.

B. Fill holes with adhesive: Solid or solid-grouted masonry:
1. Starting at the bottom of the hole, fill hole with adhesive before inserting the reinforcing bar or all thread rod.
2. Fill hole without creating air voids as nozzle is withdrawn.

3. Fill hole with sufficient adhesive so that excess is extruded out of the hole when the reinforcing bar or all thread rod is inserted into the hole.
4. Where metal or plastic screens are required for use in masonry (units with hollow cells or holes, and multi-wythe brick walls), fill screen with adhesive and insert into hole in accordance with manufacturer's recommendations.

C. Install reinforcing bars and all thread rods:
1. Install to depth, spacing, and locations as indicated on the Drawings.
2. Insert bars and all thread rods into hole in accordance with manufacturer's recommended procedures. Confirm that insert has reached the designated embedment in the hole and that adhesive completely surrounds the embedded portion.
3. Clean excess adhesive from the mouth of the hole.

D. Curing and loading:
1. Provide curing conditions recommended by the adhesive manufacturer for the period required to fully cure the adhesive at the actual temperature of the masonry.
2. Do not disturb or load anchors until manufacturer's recommended cure time has elapsed.

3.05 FIELD QUALITY CONTROL

A. Contractor shall provide field quality control as specified in Section 01450 - Quality Control.

B. Manufacturers' services:
1. Before beginning installation, furnish adhesive manufacturer's representative to conduct on-site training in proper storage and handling of adhesive, drilling and cleaning of holes, and preparation and installation of reinforcing bars and all thread rods:
a. Provide notice of training to Engineer and Special Inspector not less than 10 working days before training occurs. Engineer and Special Inspector may attend training sessions:
2. Submit record, signed by the Engineer, listing Contractor's personnel who completed the training. Only qualified personnel who have completed manufacturer's on-site training shall perform installations.
3. Do not install holes or adhesive until training is complete.

3.06 FIELD QUALITY ASSURANCE

A. Owner's Engineer will provide on-site inspection and field quality assurance.

B. Special inspection:
1. As specified in Section 01455 - Regulatory Quality Assurance.
2. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the "Conditions of Use" in the Evaluation Report for the product installed.
3. Provide a written record of each inspection using form acceptable to the Engineer and the Authority Having Jurisdiction.

4. Preparation:
    a. Review drawings and specifications for the Work being observed.
    b. Review adhesive manufacturer's recommended installation and evaluation report's special inspection procedures.
5. Provide an initial inspection by for each combination of masonry type and reinforcing bar or all thread rod being installed. During initial inspection, observe the following for compliance with installation requirements. Furnish report of inspection that includes the following items:
    a. Masonry construction: Type and thickness; whether fully or partially grouted; locations and types of voids and holes in units.
    b. Environment: Temperature and moisture conditions of masonry base material and work area.
    c. Holes: Locations, spacing, edge distances; verification of drill bit compliance with ANSI B212.15; cleaning equipment and procedures; cleanliness of hole. Before placing adhesive, confirm that depth and preparation of holes conforms to requirements of the Contract Documents, installation recommendations of the manufacturer, and "conditions of use" specified in the Evaluation Report.
    d. Adhesive: Product manufacturer and name; lot number and expiration date; temperature of product at installation; installation procedures. Note initial set times observed during installation.
    e. Embedded reinforcing bars and all thread rods: Material diameter and length; steel grade and/or strength; cleaning and preparation; cleanliness at insertion; minimum effective embedment.
6. Subsequent installations of the same reinforcing bars or threaded rods in the same masonry may be performed without the presence of the special inspector, provided that:
    a. There is no change in the personnel performing the installation, the type or details of the masonry receiving the insert, the adhesive or the reinforcing bars and all thread rods being used. Changes in any of these items shall require a new initial inspection.
    b. For ongoing installations over a period of time, the special inspector visits the site at least once per day during each day of installation to observe the work for compliance with material requirements and installation procedures.

END OF SECTION

SECTION 04090

MASONRY ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Control joint filler.
   2. Reinforcing bars.
   3. Water repellent.

1.02 REFERENCES

A. American Welding Society (AWS):
   1. D1.4 - Structural Welding Code - Reinforcing Steel.

B. ASTM International (ASTM):
   1. A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   2. A951 - Standard Specification for Masonry Joint Reinforcement.
   3. A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
   4. C549 - Standard Specification for Perlite Loose Fill Insulation.
   5. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
   6. D2287 - Standard Specification for Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds.

1.03 SYSTEM DESCRIPTION

A. The Drawings contain general notes concerning amount of reinforcement and placing, details of reinforcement at wall corners and intersections, and details of extra reinforcement around openings in masonry.

1.04 SUBMITTALS

A. Reinforcing bars:
   1. Changes to reinforcing steel contract drawing requirements:
      a. Indicate in separate letter submitted with shop drawings any changes of requirements indicated on the Drawings for reinforcing steel.
      b. Such changes will not be acceptable unless the Engineer has accepted such changes in writing.
      c. Reinforcement detail drawings:
         1) Review of reinforcement shop drawings by the Engineer will be limited to general compliance with the Contract Documents.
      d. Welding procedures.

B. Product data.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
   1. Deliver bars bundled and tagged with identifying tags.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Anchor bolts:
   1. Cast-in/built-in steel anchors: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry:
      a. Includes: anchor bolts, anchor rods, deformed bar anchors, and welded studs.
   2. Post-installed steel anchors: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry:
      a. Includes concrete anchors for concrete masonry, and screw anchors for concrete masonry.

B. Control joint filler: The key shall be of the width and shape as indicated on the Drawings. In accordance with ASTM D2000 or ASTM D2287:
   1. Manufacturers: One of the following or equal:
      a. Hohmann & Barnard, VS Standard.
      b. Wire-Bond, No. 2901.
      c. Southern Metals and Plastics, No. CJ1.

C. Reinforcing bars:
   1. Deformed bars in accordance with ASTM A615, Grade 60.
   2. Provide reinforcing steel that is of quality specified, free from excessive rust or scale or any defects affecting its usefulness.

D. Water repellent: Water based, methacrylate polymer with aqueous polysiloxane.

2.02 FABRICATION

A. Reinforcing bars:
   1. Cut and bend bars in accordance with building code as specified in Section 01410 - Regulatory Requirements.
   2. Bend bars cold.
   3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:
   1. Reinforcing bars:
      a. Verify that bars are new stock free from rust scale, loose mill scale, excessive rust, dirt, oil, and other coatings which adversely affect bonding capacity when placed in the work.

3.02 PREPARATION

A. Reinforcing bars:
   1. Thin coating of red rust resulting from short exposure will not be considered objectionable. Thoroughly clean any bars that have rust scale, loose mill scale, or thick rust coat.
   2. Remove concrete or other deleterious coatings from dowels and other projecting bars by wire brushing or sandblasting before bars are embedded in subsequent masonry placement.

3.03 INSTALLATION

A. Reinforcing bars:
   1. No field bending of bars will be allowed.
   2. Welding:
      a. Weld reinforcing bars where indicated on the Drawings or acceptable to the Engineer.
      b. Perform welding in accordance with AWS D1.4.
      c. Submit welding procedures.
      d. Do not tack weld reinforcing bars.

B. Placing reinforcing bars:
   1. Accurately place bars and adequately secure them in position.
   2. Overlap bars at splices as indicated on the Drawings or specified.
   3. If not indicated on the Drawings, lap splice bars in masonry in accordance with the building code as specified in Section 01410 - Regulatory Requirements.

END OF SECTION

SECTION 04100

MORTAR AND MASONRY GROUT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Mortar and grout for masonry construction.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C144 - Standard Specification for Aggregate for Masonry Mortar.
   2. C150 - Standard Specification for Portland Cement.
   3. C207 - Standard Specification for Hydrated Lime for Masonry Purposes.
   4. C270 - Standard Specification for Mortar for Unit Masonry.
   5. C404 - Standard Specification for Aggregates for Masonry Grout.
   6. C476 - Standard Specification for Grout for Masonry.
   7. C780 - Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry.
   8. C1019 - Standard Test Method for Sampling and Testing Grout.

1.03 DEFINITIONS

A. Alkali: Sum of sodium oxide and potassium oxide calculated as sodium oxide.

1.04 PERFORMANCE REQUIREMENTS

A. Compressive strength:
   1. Mortar: Minimum 1,800 pounds per square inch at 28 days.
   2. Grout: Minimum 2,000 pounds per square inch at 28 days.

B. Mortar color:
   1. To match existing CMU buildings.

1.05 SUBMITTALS

A. Product data.

B. Shop drawings.

C. Design Mixes for mortar and grout.

D. Test reports:
   1. Mortar Strength Test Results.
   2. Grout Strength Test Results.

1.06 QUALITY ASSURANCE

A. Materials for mortar and grout: Do not change source of materials which will affect the appearance of finished work after the work has started unless acceptable to Engineer.

1.07 PROJECT CONDITIONS

A. Environmental requirements:
   1. Cold weather requirements:
      a. Cold Weather Construction: In accordance with the building code as specified in Section 01410 - Regulatory Requirements.
      b. Provide adequate equipment for heating mortar and grout materials when air temperature is below 40 degrees Fahrenheit:
         1) Temperatures of separate materials, including water, shall not exceed 140 degrees Fahrenheit when placed in mixer.
         2) Maintain mortar temperature on boards above freezing.
   2. Hot weather requirements:
      a. Wet mortar board before loading and cover mortar to retard drying when not being used.

PART 2 PRODUCTS

2.01 MATERIALS

A. Portland cement:
   1. Type II, low alkali, containing maximum 0.6 percent total alkali in accordance with ASTM C150.

B. Hydrated lime:
   1. Type S in accordance with ASTM C207.

C. Aggregate for mortar:
   1. Fine aggregate: Sand in accordance with ASTM C144.

D. Aggregate for grout:
   1. Fine aggregate: Size Number 2 in accordance with ASTM C404.
   2. Coarse aggregate: Size Number 8 in accordance with ASTM C404.

E. Admixtures:
   1. Grout admixture:
      a. Manufacturers: The following or equal:
         1) Sika Corp., Sika Grout Aid, Type II.
   2. Mortar water repellent admixture:
      a. Manufacturers: One of the following or equal:
         1) Sika Corp., Sikaproof A.
         2) W.R. Grace, Dry Block Mortar.
         3) BASF, Rheopel Plus Mortar Admixture.
   3. Other admixtures:
      a. Prohibited, unless accepted by the Engineer.

F. Water: Clean, clear, potable, free of oil, soluble salts, chemicals, and other deleterious substances.

G. Other materials:
   1. Prohibited, unless acceptable to Engineer.

2.02 MIXES

A. Mortar mix:
   1. Portland cement-lime mortar.
   2. Mortar mix proportions by volume: As indicated in the following table:

MORTAR TYPE	PARTS BY VOLUME OF PORTLAND CEMENT	PARTS BY VOLUME OF HYDRATED LIME	AGGREGATE MEASURED IN A DAMP LOOSE CONDITION
S	1	Greater than 1/4 to 1/2	Not less than 2-1/4 and not more than 3 times the sum of the separate volumes of cementitious materials
N	1	Greater than 1/2 to 1 ¼	Not less than 2-1/4 and not more than 3 times the sum of the separate volumes of cementitious materials

   3. Mortar mixing:
      a. Mix on jobsite in accordance with ASTM C270.
      b. Mix in mechanical mixer and only in quantities needed for immediate use.
      c. Mix for minimum 3 minutes, and maximum of 5 minutes after materials have been added to mixer.
   4. Measurement by volume: Measurement of constituents shall be accomplished by the use of a container of known capacity.
   5. Water shall be mixed with the dry ingredients in sufficient amount to provide a workable mixture which will adhere to the vertical surfaces of masonry units:
      a. Use no mortar which has been standing for more than 1 hour after being mixed.
   6. Whenever 90 minutes has elapsed since last batch was mixed, completely empty mixer drum of materials and wash down before placing next batch of materials.

B. Grout mix:
   1. Grout mix proportions by volume: As indicated in the following table:

TYPE OF GROUT	PARTS BY VOLUME OF PORTLAND CEMENT	PARTS BY VOLUME OF HYDRATED LIME	AGGREGATE MEASURED IN A DAMP LOOSE CONDITION	
			Fine Aggregate	Coarse Aggregate
Fine grout	1	0-1/10	2-1/4 to 3 times the sum of the volumes of the cementitious materials	-
Coarse grout	1	0-1/10	2-1/4 to 3 times the sum of the volumes of the cementitious materials	1 to 2 times the sum of the volumes of the cementitious materials

2. Grout mixing:
    a. Mix on jobsite or in a transit mix in accordance with ASTM C476
    b. Slump: 8 to 11 inches, unless otherwise accepted by the Engineer.
    c. Use within 90 minutes after addition of mixing water.
    d. Mix for minimum of 5 minutes after ingredients are added and until uniform mix is attained. Grout shall have sufficient water added to produce pouring consistency without segregation.
3. Use coarse grout for hollow cell masonry units with minimum 4-inch cell dimensions in both horizontal directions:
    a. Calculate cell dimension for this criterion by subtracting diameter(s) of any horizontal reinforcement crossing the cell from clear cell dimensions of the masonry unit.

2.03 SOURCE QUALITY CONTROL

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Testing of grout and mortar:
1. During progress of construction, the Owner will have tests made to determine whether the grout and mortar, as being produced, complies with Specifications.
2. Compressive strength tests for mortar: In accordance with ASTM C780, Annex A7 as modified in the following paragraphs:
    a. Spread mortar on the masonry units in a layer 1/2 to 5/8 inch thick.
    b. Allow mortar to stand for one minute, then remove and place in a 2-inch by 4-inch cylinder mold. Place mortar in two layers compressing the mortar using the flat end of a stick or fingers. Lightly tap the mold on opposite sides. Level off and immediately cover molds, keeping them damp until taken to the laboratory.
    c. After 48 hour set, remove mortar specimens from molds and store in a fog room until tested. Water curing (curing in tanks) is not permitted.
    d. Test specimens in damp condition.
3. Compressive strength test for grout: In accordance with ASTM C1019.

4. Owner's Representative will make and deliver test specimens to the laboratory and testing expense will be borne by the Owner.
5. Required number of tests:
    a. At least 2 test specimens of grout will be made per week.
6. Do not use grout and mortar that does not meet specification:
    a. Remove such mortar and grout from Project site.
7. Make provisions for and furnish grout and mortar for test specimens, and provide manual assistance to the Engineer in preparing test specimens.
8. Assume responsibility for care of and providing proper curing conditions for test specimens.

3.02 ADJUSTING

A. Repair of defective masonry:
    1. Remove and replace or repair defective work.
    2. Do not patch, repair, or cover defective work without inspection by the Engineer.
    3. Provide repairs having strength equal to or greater than specified strength for areas involved.

END OF SECTION

SECTION 04220

CONCRETE UNIT MASONRY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Concrete masonry units and accessories.

1.02 REFERENCES

A. The Masonry Society (TMS):
   1. TMS 402/602 - Building Code Requirements and Specification for Masonry Structures.

B. ASTM International (ASTM):
   1. C90 - Standard Specification for Loadbearing Concrete Masonry Units.
   2. C140 - Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
   3. C426 - Standard Test Method for Linear Drying Shrinkage of Concrete Masonry Units.

1.03 DEFINITIONS

A. Mortar Smears: Mortar paste smeared across the permanent masonry construction during construction and absorbed into the masonry pores.

B. Mortar Splash: Mortar dropped splashed onto the permanent masonry construction at the base of the wall or off the scaffolding.

C. Mortar Tag: Excess mortar between masonry units worked out of the joints during tooling or striking.

D. Mortar Stains: Mortar paste left after mortar tags are removed.

1.04 SUBMITTALS

A. Product data:
   1. Submit manufacturer’s product data for proposed cleaning agent.

B. Shop drawings: Include elevations of each wall indicating type and layout of units, including type of mortar joints, bond pattern, reinforcing steel, connecting dowels, joint reinforcement, grouted cells, and control joints.

C. Samples: Include samples of stretcher units in sufficient quantity to illustrate color range.

D. Test reports:
   1. Compressive strength.
   2. Linear shrinkage.

3. Moisture content as a percentage of total absorption.
4. Total absorption.
5. Unit weight.

E. Manufacturer's instructions:
   1. Submit printed or written recommendations from the masonry unit manufacturer of the cleaning procedures and cleaning agents appropriate for each type of masonry unit included in the work.

F. Quality assurance submittals:
   1. If requested by the Engineer, submit a record of the Installer's evidence of qualifications.
   2. If requested by the Engineer, submit a record of the Masonry Cleaner's evidence of qualifications.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Installer qualifications:
      a. The mason shall hold an appropriate contractor's license in the State where the work will be constructed.
      b. The mason shall have not less than 5 years' experience and completed a minimum of 20 projects and at least 5 of which included the type of masonry units specified for this Work.
      a. The mason shall hold current certification demonstrating successful completion of the quality certification program administered by the Rocky Mountain Masonry Institute or the Mason Contractors Association of America.
   2. Masonry cleaner qualifications:
      a. The masonry cleaner shall have not less than 5 years' experience and completed a minimum of 20 projects

B. Pre-installation conference: Conduct as specified in Section 01312 - Project Meetings.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Transport and handle concrete masonry units as required to prevent discoloration, chipping, and breakage.

B. Store masonry units off the ground in a dry location, covered and protected from absorbing moisture:
   1. Locate storage piles, stacks, and bins to protect materials from heavy traffic.
   2. If masonry units are delivered in shrink-wrapped packaging and condensation develops, remove shrink-wrap packaging.

C. Remove chipped, cracked, and otherwise defective units from jobsite upon discovery.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Cold weather requirements:
   1. In accordance with building code as specified in Section 01410 - Regulatory Requirements, provide adequate equipment for heating masonry materials when air temperature is below 40 degrees Fahrenheit.

B. Hot weather requirements:
   1. In accordance with building code as specified in Section 01410 - Regulatory Requirements, when ambient air temperature exceeds 100 degrees Fahrenheit, or when ambient air temperature exceeds 90 degrees Fahrenheit and wind velocity is greater than 8 miles per hour, implement hot weather protection procedures.
   2. Wet mortarboard before loading and cover mortar to retard drying when not being used.
   3. Do not spread mortar beds more than 48 inches ahead of placing masonry units.
   4. Place masonry units within one minute of spreading mortar.

1.08 SEQUENCING AND SCHEDULING

A. Order concrete masonry units well before start of installation to ensure adequate time for manufacturing and minimum 28 days for curing and drying before start of installation. Protect from weather after curing period to avoid moisture increase.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Hollow load bearing concrete masonry units:
   1. Class: Class 1 in accordance with ASTM C90, Standard Level of Quality with minimum compressive strength of 1,500 pounds per square inch.
   2. Surface texture: Standard and split face.
   3. Color: Integral, Natural gray of concrete or Match existing. Coordinate color selection with Veolia.
   4. Typical size: 12 inches wide by 8 inches high by 16 inches long, unless otherwise indicated on the Drawings, or other sizes as needed to minimize cutting.
   5. Special sizes and shapes: As required for window and door openings, bond beams, piers, lintels, control joints, and other special applications to minimize cutting.

B. Anchor bolts: As specified in Section 05120 - Structural Steel.

C. Steel reinforcement: As specified in Section 04090 - Masonry Accessories.

PART 3 EXECUTION

3.01 PREPARATION

A. Protection:
   1. Protect adjacent construction with appropriate means from mortar droppings and other effects of laying of concrete masonry units.

B. Surface preparation:
   1. Thoroughly clean foundations of laitance, grease, oil, mud, dirt, mortar droppings, and other matter that will reduce bond.

3.02 INSTALLATION

A. Forms and shores:
   1. Where required, construct forms to the shapes indicated on the Drawings:
      a. Construct forms sufficiently rigid to prevent deflection which may result in cracking or other damage to supported masonry and sufficiently tight to prevent leakage of mortar and grout.
      b. Do not remove supporting forms or shores until the supported masonry has acquired sufficient strength to support safely its weight and any construction loads to which it may be subjected:
         1) Wait at least 24 hours after grouting masonry columns or walls before applying uniform loads.
   2. Wait at least 72 hours before applying concentrated loads.

B. Concrete masonry units:
   1. Provide Standard Level of Quality. Comply with the requirements of ACI 530.1 unless more restrictive requirements are contained in this Section.
   2. Lay concrete masonry units dry.
   3. Lay units in uniform and true courses, level, plumb, and without projections or offset of adjacent units.
   4. Lay units to preserve unobstructed vertical continuity of cells to be filled with grout or insulation.
   5. Align vertical cells to be filled with grout to maintain clear, unobstructed continuous vertical cell measuring not less than 2 by 3 inches.
   6. Place mortar with full coverage of joints at webs of all cells and face shells.
   7. Butter vertical head joints for thickness equal to face shell thickness of units, and shove joints tightly together so that mortar bonds to both masonry units.
   8. Solidly fill joints from face of units to inside face of cells.
   9. Lay units to desired height with joints of uniform thickness.
   10. Bond shall be plumb throughout.
   11. Lay units to avoid formation of cracks when units are placed. Keep cells of units as free of mortar as possible as masonry wall height increases.
   12. When positions of units shift after mortar has stiffened, bond is broken, or cracks are formed, relay units in new mortar.
   13. Remove mortar, mortar droppings, debris, and other obstructions and materials from inside of cell walls.
   14. Remove mortar tags and smears daily with a non-metallic tool:
      a. Mortar tags and smears shall be removed after they initially set, but shall not be permitted to remain more than 24 hours.

15. Where practical, protect completed work from mortar splash by placing thin plastic sheeting around the base of walls:
    a. Place sand, straw, sawdust, or other similar material on the floor around the base of walls to protect floors and walls.
16. Turn scaffold planks over at the end of the workday to avoid mortar splashes from wet weather:
    a. Cover tops of walls at the end of the workday and other work stoppages to prevent entry of water into the partially completed masonry.
17. Seal cleanouts after inspection and before grouting.

C. Bond pattern:
    1. Lay concrete masonry units in running bond pattern, unless otherwise indicated on the Drawings.

D. Mortar joints:
    1. Make joints straight, clean, smooth, and uniform in thickness.
    2. Tool exposed joints, slightly concave. Strike concealed joints flush.
    3. Make vertical and horizontal joints 3/8-inch thick.
    4. Where fresh masonry joins totally or partially set masonry, clean, and roughen set masonry before laying new units.
    5. Remove mortar that protrudes more than 1/2 inch into the cells of units that are to be grouted.

E. Grouting and reinforcement:
    1. Where horizontal and vertical bars are spliced and adjacent lap splices are separated by more than 3 inches, the lap splice length shall be 72 bar diameters. Where adjacent lap splices are separated by 3 inches or less, the lap splice length shall be increased by 1.3 times or the lap splices shall be staggered at least 24 bar diameters with no increase in length.
    2. Hold vertical reinforcing bars in position at top and bottom and at intervals not exceeding 200 bar diameters. Use steel wire bar positioners to position bars. Tie reinforcing bars to dowels with wire ties.
    3. Obtain acceptance of reinforcement placement before grouting.
    4. Fill all spaces and cells solidly with grout:
        a. Low-lift grouting:
            1) Hollow unit masonry to be grouted by the low lift method shall be constructed and grouted in lifts not exceeding 4 feet.
            2) Slushing with mortar will not be permitted.
    5. Grout in cells shall have full contact with surface of concrete footings.
    6. When grouting stops for 1 hour or longer, form horizontal construction joints by stopping grout placement 1-1/2 inches below top of uppermost unit containing grout.
    7. After placement, consolidate grout using mechanical immersion vibrators designed for consolidating grout.
    8. Placement:
        a. Use a hand bucket, concrete hopper, or grout pump.
        b. Place grout in final position within 1-1/2 hours after mixing. Place grout so as to completely fill the grout spaces without segregation of the aggregates.
        c. Do not insert vibrators into lower grout placements that are in a semi-solidified state.

d. Remove grout spills immediately by hand washing with a bucket and brush.

F. Cutting concrete masonry units:
1. When possible, use full units of the proper size in lieu of cut units. Cut units as required to form chases, openings, for anchorage, and for other appurtenances.
2. Cut and fit units with power-driven carborundum or diamond disc blade saw.

G. Control joints:
1. Provide in masonry walls at locations indicated on the Drawings.
2. Make full height and continuous in appearance.
3. Run bond beams and bond beam reinforcing bars continuously through control joints.
4. Insert control joint filler in joints as wall is constructed.
5. Apply sealant as specified in Section 07900 - Joint Sealants.

H. Steel door frames:
1. Anchor and fully grout jambs and head of steel doorframes connected to concrete unit masonry.
2. Fill frames with grout as each 2 feet of concrete unit masonry is laid.

I. Anchor bolts:
1. Hold anchor bolts in place with template during grouting to ensure precise alignment.
2. Do not cut or ream members being anchored or use other means to accommodate misaligned anchor bolts in roof deck support angles.

J. Enclosures:
1. Where concrete masonry units enclose conduit, pipes, stacks, ducts, and similar items, construct chases, cavities, and similar spaces as required, whether or not such spaces are indicated on the Drawings.
2. Point openings around flush mounted electrical outlet boxes with mortar, including flush joints above boxes.
3. Do not cover enclosures until inspected and when appropriate, tested.

K. Other embedded items:
1. Build in wall plugs, accessories, flashings, pipe sleeves, and other items required to be built-in as the masonry work progresses.

L. Patching:
1. Patch exposed concrete masonry units at completion of the Work and in such manner that patching will be indistinguishable from similar surroundings and adjoining construction.

M. Water curing:
1. Protect concrete masonry units from drying too rapidly by frequently fogging or sprinkling so walls will always be visibly damp for minimum 3 days.

N. Miscellaneous:
   1. Build in required items, such as anchors, flashings, sleeves, frames, structural steel, lintels, anchor bolts, and metal fabrications, as required for complete installation.

O. Water repellent:
   1. Apply water repellent as specified in Section 07190 - Water Repellents.

P. Grouting equipment:
   1. Grout pumps:
      a. Do not pump grout through aluminum tubes.
      b. Operate pumps to produce a continuous stream of grout without air pockets.
      c. Upon completion of each days pumping, eject grout from pipeline without contamination or segregation of the grout:
         1) Remove waste materials and debris from the equipment.
         2) Dispose of waste materials, debris, and all flushing water outside the masonry.
   2. Vibrators:
      a. Internal vibrators shall maintain a speed of not less than 5,000 impulses per minute when submerged in the grout.
      b. Maintain at least 1 spare vibrator, at the site at all times.
      c. Apply vibrators at uniformly spaced points not further apart than the visible effectiveness of the machine.
      d. Limit duration of vibration to time necessary to produce satisfactory consolidation without causing segregation.

3.03 CONSTRUCTION

A. Site tolerances: Lay masonry plumb, true to line, and with courses level. Keep bond pattern plumb throughout. Lay masonry within the following tolerances:
   1. Maximum variation from the plumb in the lines and surfaces of columns, walls, and in the flutes and surfaces of fluted or split faced blocks:
      a. In adjacent masonry units: 1/8 inch.
      b. In 10 feet: 1/4 inch.
      c. In any story or 20 feet maximum: 3/8 inch.
      d. In 40 feet or more: 1/2 inch.
   2. Maximum variations from the plumb for external corners, expansion joints, and other conspicuous lines:
      a. In any story or 20 feet maximum: 1/4 inch.
      b. In 40 feet or more: 1/2 inch.
   3. Maximum variations from the level or grades indicated on the Drawings for exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines:
      a. In any bay or 20 feet maximum: 1/4 inch.
      b. In 40 feet or more: 1/2 inch.
   4. Maximum variations of the linear building lines from established position in plan and related portion of columns, walls, and partitions:
      a. In any bay or 20 feet maximum: 1/2 inch.
      b. In 40 feet or more: 3/4 inch.

5. Maximum variation in cross sectional dimensions of columns and in thickness of walls:
    a. Minus: 1/4 inch.
    b. Plus: 1/2 inch.

3.04 FIELD QUALITY CONTROL

A. Site tests:
    1. Owner will have tests performed by an independent laboratory.
    2. Have minimum 3 concrete masonry units of each type proposed for Project tested in accordance with ASTM C90, C140, and C426 to verify conformance to Specifications.
    3. Tests shall include compressive strength, linear shrinkage, moisture content as percent of total absorption, total absorption, and unit weight.

B. Special inspection:
    1. Special inspection shall be as specified in Section 01455 - Regulatory Quality Assurance.
    2. Owner will employ a qualified masonry special inspector for continuous special inspection of the masonry work. Acceptance by a state or municipality having a program of examining and certifying masonry inspectors will be considered adequate qualifications. The masonry inspector shall be at the site during all masonry construction and perform the following duties:
        a. Review Drawings and Specifications and meet with the Contractor to discuss requirements before work commences.
        b. Before masonry work commences, Contractor and the Contractor's Quality Control Representative shall attend meeting with Engineer to review the requirements for surveillance and quality control of the masonry work.
        c. Check brand and type of cement, lime (if used), and source of sand.
        d. Verify that foundation is clean, rough, and ready to receive units.
        e. Check reinforcing steel dowels for correct location, straightness, proper alignment, spacing, size, and length.
        f. Observe field proportioning of mortar. Visually check aggregate to determine uniformity of grading, cleanliness, and moisture.
        g. Verify that joints are full of mortar and kept tight during work. Inspect grout cells to verify that fins will not interfere with grouting. Verify that masons keep grout cells clean of mortar droppings and inspect to determine compliance.
        h. Continuously observe placing of grout.
        i. Perform or supervise performance of required sampling and testing.
    3. Keep complete record of inspections. Report daily to the Building Official, Contractor's Quality Control Representative, Engineer, and Owner the progress of the masonry inspection.

3.05 FINAL CLEANING

A. General:
    1. Final cleaning shall be performed within 7 to 14 days after construction of masonry work.
    2. Protect adjacent materials and equipment that may be damaged by cleaning.
    3. Pre-wet masonry before applying cleaning agent, but do not saturate masonry.

4. Remove mortar stains, smears, and splash, efflorescence, and grout stains on exposed surfaces with the submitted cleaning agent as directed by the masonry unit manufacturer's recommendations.
5. Do not use muriatic acid as cleaning agent.
6. Cleaning agents shall be applied when the masonry surface and air temperatures are at least 50 degrees Fahrenheit:
    a. Dilute cleaning agents in accordance with manufacturer's recommendations.
    b. Do not allow cleaning agents to dry on the masonry.
7. Clean wall from the top to the bottom, without overlapping areas being cleaned for consistency.
8. If pressure cleaning equipment is used, the following limitations shall be observed:
    a. Apply cleaning agent to pre-wetted wall with low pressure (less than 50 pounds per square inch).
    b. Use a 25° to 50° flared-tip nozzle (not a pointed tip).
    c. Maintain a consistent distance from the spray nozzle to the masonry surface no closer than 12 inches:
        1) Masonry cleaner shall use a combination of pressure, nozzle, and distance from tip to masonry that does not damage the masonry surface.
9. Rinse cleaning agents off the wall with potable water.
10. Dispose of debris, refuse, and surplus material offsite legally.

3.06 PROTECTION

A. Provide temporary protection for exposed masonry corners subject to damage.

B. Bracing:
1. Unless wall is adequately supported by permanent supporting elements so wall will not overturn or collapse, adequately brace masonry walls over 8 feet in height to prevent overturning and to prevent collapse.
2. Keep bracing in place until permanent supporting elements of structure are in place.

C. Limited access zone:
1. Establish limited access zone prior to start of masonry wall construction.
2. Zone shall be immediately adjacent to wall and equal to height of wall to be constructed plus 4 feet by entire length of wall on unscaffolded side of wall.
3. Limit access to zone to workers actively engaged in constructing wall. Do not permit other persons to enter zone.
4. Keep zone in place until wall is adequately supported or braced by permanent supporting elements to prevent overturning and collapse.

END OF SECTION

SECTION 05120

STRUCTURAL STEEL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Structural steel shapes and plate.
   2. Fasteners and structural hardware:
      a. All thread rods.
      b. High-strength bolts.
   3. Welding.
   4. Bolting.

1.02 REFERENCES

A. American Institute of Steel Construction (AISC):
   1. 303 - Code of Standard Practice for Steel Buildings and Bridges.
   2. 360 - Specification for Structural Steel Buildings.

B. American Iron and Steel Institute (AISI):
   1. Steel alloys (“types”) as indicated.

C. American Welding Society (AWS):
   1. A5.1 - Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.
   2. A5.17 - Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding.
   3. A5.20 - Specification for Carbon Steel Electrodes for Flux Cored Arc Welding.
   4. D1.1 - Structural Welding Code - Steel.

D. ASTM International (ASTM):
   1. A6 - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
   2. A36 - Standard Specification for Carbon Structural Steel.
   3. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   4. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   6. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   7. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
   8. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   9. A992 - Standard Specification for Structural Steel Shapes.
   10. F436 - Standard Specification for Hardened Steel Washers.

11. F959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
12. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
13. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

E. Research Council on Structural Connections (RCSC):
1. Specification for Structural Joints Using High-Strength Bolts (RCSC Specification).

1.03 DEFINITIONS

A. Snug-tight: At bolted joints, the tightness attained with a few impacts of an impact wrench, or by the full effort of an ironworker using a spud wrench to bring the connected plies into firm contact.

1.04 SUBMITTALS

A. Product data:

B. Shop drawings:
1. Fabrication and erection drawings.

C. Quality control submittals:
1. Welding procedure specifications (WPS) in accordance with AWS D1.1
   a. Submit WPS for each type of welded joint used, whether prequalified or qualified by testing:
      1) State electrode manufacturer and specific electrodes used.
      2) Indicate required AWS qualification for joint.
   b. Submit WPS with shop drawings that indicate those welds.
   c. Submit Procedure Qualification Record (PQR) in accordance with AWS D1.1for welding procedures qualified by testing.
2. Welder qualifications: For each welding process and position:
   a. Welder's qualification certificates.
   b. Contractor's statement that certificate will be "in effect" at the time(s) welding will be performed based on the "Period of Effectiveness" provisions of AWS D1.1.

D. Test reports:
1. Certified copies of mill tests and analyses made in accordance with applicable ASTM standards, or reports from a recognized commercial laboratory, including chemical and tensile properties of each shipment of structural steel or part thereof having common properties.

1.05 QUALITY ASSURANCE

A. Welding:
1. Perform welding of structural metals in accordance with AWS D1.1 using welders who have current AWS qualification certificate for the process, position, and joint configuration to be welded.

2. Make Welding Procedure Specifications available at the locations where welding is performed.
3. Notify Engineer at least 24 hours before starting shop or field welding.
4. Engineer may check materials, equipment, and qualifications of welders.
5. Remove welders performing unsatisfactory Work, or require requalification.
6. Engineer may use gamma ray, magnetic particle, dye penetrant, trepanning, or other aids to visual inspection to examine any part of welds or all welds.
7. Contractor shall bear costs of retests on defective welds.
8. Contractor shall also bear costs in connection with qualifying welders.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping: Deliver structural steel free from mill scale, rust, and pitting.

B. Storage and protection: Until erection and painting, protect from weather items not galvanized or protected by a shop coat of paint.

PART 2 PRODUCTS

2.01 MATERIALS

A. Unless otherwise specified or indicated on the Drawings, materials shall conform to the following:

Item	ASTM Standard	Class, Grade, Type, or Alloy Number
Carbon Steel		
Plate, bars, rolled shapes (except W and WT shapes), and miscellaneous items	A36	--
Rolled W and WT shapes	A992	Grade 50
Hollow structural sections/HSS: Round, square, or rectangular (including “pipe” where indicated for structural members and supports)	A500	Grade C

2.02 FASTENERS AND STRUCTURAL HARDWARE

A. General:
1. Materials: Of domestic manufacture.
2. Where fasteners and hardware are specified to be galvanized, hot-dip galvanize in accordance with ASTM A153 or ASTM F2329, unless otherwise specified.

B. All thread rods:
1. Carbon steel:
   a. In accordance with ASTM A36 unless otherwise indicated on the Drawings.
   b. Nuts: ASTM A194.
   c. Washers: ASTM F436.

2. Galvanized carbon steel:
    a. In accordance with ASTM A36 unless otherwise indicated on the Drawings, and hot dip galvanized in accordance with ASTM A153.
    b. Nuts: ASTM A194, hot-dip galvanized in accordance with ASTM A153.
    c. Washers: ASTM F436, hot-dip galvanized in accordance with ASTM A153.
3. Stainless steel:
    a. Units descaled, pickled, and passivated as specified in “Fabrication” in this Section.
    b. Threaded rods and nuts to be the products of a single manufacturer/fabricator to ensure proper fit without galling. Ship all thread rods with properly fitting nuts attached.
    c. Type 304:
        1) Rod: ASTM F593, Group 1, Condition CW, coarse threads.
        2) Nuts: ASTM F594. Match alloy of rod (group and UNS designation).
        3) Washers: Type 304 stainless steel.

C. Anchor bolts, anchor rods, and post-installed steel anchors: As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

D. High-strength bolts:
1. Provide high-strength bolt assembly, with nuts, hardened flat washers, and compressible-washer-type direct tension indicators.
2. Carbon steel - Uncoated:
    a. Bolts: Plain heavy hex structural bolts in accordance with ASTM F3125, Grade A325, Type 1.
    b. Nuts: Heavy hex nuts in accordance with ASTM A563, Grade C.
    c. Washers:
        1) Adjacent to normal, oversized, and short-slotted holes: Circular, square or rectangular beveled, clipped, or extra thick washers in accordance with ASTM F436, Type 1. Flat circular washers unless otherwise indicated on the Drawings.
        2) Adjacent to long slotted holes: Fabricated from 5/16-inch thick plate conforming to ASTM A36.
    d. Load indicator devices: At slip critical connections, provide one of the following devices at each bolt:
        1) Compressible washer type direct tension indicators (“DTI”): In accordance with ASTM F959, Type 325-1.
        2) Twist-off type tension-control bolt assemblies: ASTM F3125, Grade F1852.
3. Welded studs: As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.03 ISOLATING SLEEVES AND WASHERS

A. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.04 GALVANIZED SURFACE REPAIR

A. Manufacturers: The following or equal:
   1. Jelt, Galvinox.

2.05 THREAD COATING

A. Manufacturers: One of the following or equal:
   1. Bostik, Never-Seez.
   2. Oil Research, Inc., WLR No. 111.

2.06 SUPPLEMENTARY PARTS

A. Furnish as required for complete structural steel erection, whether or not such parts and Work are specified or indicated on the Drawings.

2.07 FABRICATION

A. Shop assembly:
   1. Fabricate structural steel in accordance with AISC 360 and AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
   2. Where anchors, connections, or other details of structural steel are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.
   3. Round off sharp and hazardous projections and grind smooth.
   4. Take measurements necessary to properly fit work in the field. Take responsibility for and be governed by the measurements and proper working out of all the details.
   5. Take responsibility for correct fitting of metalwork.
   6. Welded connections:
      a. Comply with AWS requirements for the metals to be welded.
      b. Weld only in accordance with approved Welding Procedure Specifications.
      c. Keep Welding Procedure Specifications readily available for welders and inspectors during fabrication processes.

B. Galvanized carbon steel:
   1. Where galvanizing is required, hot-dip structural steel after fabrication in accordance with ASTM A123:
   2. Do not electro-galvanize or mechanically-galvanize unless specified or accepted by Engineer.
   3. Re-straighten galvanized items that bend or twist during galvanizing.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 ERECTION

A. General:
   1. Fabricate structural and foundry items to true dimensions without warp or twist.
   2. Form welded closures neatly, and grind off smooth where weld material interferes with fit or is unsightly.
   3. Install structural items accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
   4. Do not shift out of alignment, re-drill, re-shape, or force fit fabricated items.
   5. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and level.
   6. Rigidly support and brace structural items needing special alignment to preserve straight, level, even, and smooth lines. Keep structural items braced until concrete, grout, or dry pack mortar has hardened for 48 hours minimum.
   7. Erect structural steel in accordance with AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
   8. Where anchors, connections, and other details of structural steel erection are not specifically indicated on the Drawings or specified, form, locate, and attach with equivalent in quality and workmanship to items specified.
   9. Round off sharp or hazardous projections and grind smooth.
   10. Paint or coat steel items as specified in Sections 09960 - High-Performance Coatings.

B. Welding: General:
   1. Make welds full penetration type, unless otherwise indicated on the Drawings.
   2. Remove backing bars and weld tabs after completion of weld. Repair defective welds observed after removal of backing bars and weld tabs.

C. Welding: Carbon steel:
   1. General: In accordance with AWS D1.1:
      a. Weld ASTM A36 and A992 structural steel, and ASTM A500 and A501 structural tubing with electrodes in accordance with AWS A5.1, using E70XX electrodes; AWS A5.17, using F7X-EXXX electrodes; or AWS A5.20, using E7XT-X electrodes:
      b. Field repair cut or otherwise damaged galvanized surfaces to equivalent original condition using a galvanized surface repair.

D. Interface with other products:
   1. Where steel members and fasteners come in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

E. Fasteners: General:
   1. Install bolts to project 2 threads minimum, but 1/2 inch maximum beyond nut.
   2. Anchor bolts and anchor rods: Install as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry:
      a. Unless otherwise specified, tighten nuts on anchor bolts and anchor rods specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry to the "snug-tight" condition.

3. All thread rods in drilled holes bonded to concrete with adhesive: Install as specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.
4. All thread rods in drilled holes bonded to masonry with adhesive: Install as specified in Section 04055 - Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry**.**

F. Fasteners: High-strength carbon steel bolts:
1. Connections with high-strength bolts shall in accordance with RCSC Specification for Structural Joints Using High-Strength Bolts.
2. Joints: Slip-critical:
   a. Confirm that faying surfaces at connections are free of dirt and other foreign material, have been blast cleaned, and are free of coatings and inadvertent overspray in accordance with RCSC Specification.
   b. Furnish hardened flat washers in accordance with ASTM F436:
      1) On outer plies with slotted holes.
      2) When 1 or more plies of the connected material has a yield strength less than 40 ksi.
      3) Under element, nut, or bolt head, turned in tightening.
   c. Install tension indicator washers, placed in accordance with ASTM F959 Figure X1, to confirm adequate tightening of bolts.
   d. Tighten bolts to full pretension.

3.03 FIELD QUALITY CONTROL

A. Provide quality control as specified in Section 01450 - Quality Control.

3.04 FIELD QUALITY ASSURANCE

A. Provide quality assurance as specified in Section 01450 - Quality Control.

B. Special inspections, special tests, and structural observation:
1. Provide as specified in Section 01455 - Regulatory Quality Assurance.

END OF SECTION

SECTION 05190

MECHANICAL ANCHORING AND FASTENING TO CONCRETE AND MASONRY

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PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cast-in anchors and fasteners:
      a. Anchor bolts.
   2. Post-installed steel anchors and fasteners:
      a. Concrete anchors.
   3. Appurtenances for anchoring and fastening:
      a. Isolating sleeves and washers.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 355.2 - Qualification of Post-Installed Mechanical Anchors in Concrete & Commentary.

B. American National Standards Institute (ANSI):
   1. B212.15 - Cutting Tools - Carbide-tipped Masonry Drills and Blanks for Carbide-tipped Masonry Drills.

C. American Welding Society (AWS):
   1. D1.1 - Structural Welding Code - Steel.
   2. D1.6 - Structural Welding Code - Stainless Steel.

D. ASTM International (ASTM):
   1. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   2. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold Finished.
   3. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   4. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   5. A240 - Standard Specification for Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   6. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   7. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   8. B633 - Standard Specification for *Electrodeposited* Coatings of Zinc on Iron and Steel.
   9. B695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
   10. E488 - Standard Test Methods for Strength of Anchors in Concrete Elements.
   11. F436 - Standard Specification for Hardened Steel Washers.
   12. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
   13. F594 - Standard Specification for Stainless Steel Nuts.
   14. F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength.

15. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

E. International Code Council Evaluation Service, Inc. (ICC-ES):
   1. AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.

1.03 DEFINITIONS

A. Built-in anchor: Headed bolt or assembly installed in position before filling surrounding masonry units with grout.

B. Cast-in anchor: Headed bolt or assembly installed in position before placing plastic concrete around.

C. Overhead installations: Fasteners installed on overhead surfaces where the longitudinal axis of the fastener is more than 60 degrees above a horizontal line so that the fastener resists sustained tension loads.

D. Passivation: Chemical treatment of stainless steel with a mild oxidant for the purpose of enhancing the spontaneous formation of the steel's protective passive film.

E. Post-installed anchor: Fastener or assembly installed in hardened concrete or finished masonry construction, typically by drilling into the structure and inserting a steel anchor assembly.

F. Terms relating to structures or building environments as used with reference to anchors and fasteners:
   1. Corrosive locations: Describes interior and exterior locations as follows:
      a. Locations used for delivery, storage, transfer, or containment (including spill containment) of chemicals used for plant treatment processes.
   2. Wet and moist locations: Describes locations, other than "corrosive locations," that are submerged, are immediately above liquid containment structures, or are subject to frequent wetting, splashing, or wash down. Includes:
      a. Exterior portions of buildings and structures.
      b. Liquid-containing structures:
         1) Locations at and below the maximum operating liquid surface elevation.
         2) Locations above the maximum operating liquid surface elevation and:
            a) Below the top of the walls containing the liquid.
            b) At the inside faces and underside surfaces of a structure enclosing or spanning over the liquid (including walls, roofs, slabs, beams, or walkways enclosing the open top of the structure).
      c. Liquid handling equipment:
         1) Bases of pumps and other equipment that handles liquids.
      d. Indoor locations exposed to moisture, splashing, or routine wash down during normal operations, including floors with slopes toward drains or gutters.
      e. Other locations indicated on the Drawings.

3. Other locations:
    a. Interior dry areas where the surfaces are not exposed to moisture or humidity in excess of typical local environmental conditions.

1.04 SUBMITTALS

A. General:
1. Submit as specified in Section 01330 - Submittal Procedures.
2. Submit information listed for each type of anchor or fastener to be used.

B. Action submittals:
1. Product data:
    a. Cast-in anchors:
        1) Manufacturer's data including catalog cuts showing anchor sizes and configuration, materials, and finishes.
    b. Post-installed anchors:
        1) For each anchor type, manufacturer's data including catalog cuts showing anchor sizes and construction, materials and finishes, and load ratings.
2. Samples:
    a. Samples of each type of anchor, including representative diameters and lengths, if requested by the Engineer.
3. Certificates:
    a. Cast-in anchors:
        1) Mill certificates for steel anchors that will be supplied to the site.
    b. Post-installed anchors:
        1) Manufacturer's statement or certified test reports demonstrating that anchors that will be supplied to the site comply with the materials properties specified.
4. Test reports:
    a. Post-installed anchors: For each anchor type used for the Work:
        1) Current ICC-ES Report (ESR**)** demonstrating:
            a) Acceptance of that anchor for use under the building code specified in Section 01410 - Regulatory Requirements.
5. Manufacturer's instructions:
    a. Requirements for storage and handling.
    b. Recommended installation procedures including details on drilling, hole size (diameter and depth), hole cleaning and preparation procedures, anchor insertion, and anchor tightening.
    c. Requirements for inspection or observation during installation.
6. Qualification statements:
    a. Post-installed anchors: Installer qualifications:
        1) Submit list of personnel performing installations and include date of manufacturer's training for each.

1.05 QUALITY ASSURANCE

A. Qualifications:
1. Post installed anchors shall be in accordance with building code specified in Section 01410 - Regulatory Requirements.

B. Special inspection:
   1. Provide special inspection of post-installed anchors as specified in Section 01455 - Regulatory Quality Assurance and this Section.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver post-installed anchors in manufacturer's standard packaging with labels visible and intact. Include manufacturer's installation instructions.

B. Handle and store anchors and fasteners in accordance with manufacturer's recommendations and as required to prevent damage.

C. Protect anchors from weather and moisture until installation.

1.07 PROJECT CONDITIONS

A. As specified in Section 01610 - Project Design Criteria.

B. Seismic Design Category (SDC) for structures is indicated on the Drawings.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. General:
   1. Furnish threaded fasteners with flat washers and hex nuts fabricated from materials corresponding to the material used for threaded portion of the anchor:
      a. Cast-in anchors: Provide flat washers and nuts as listed in the ASTM standard for the anchor materials specified.
      b. Post-installed anchors: Provide flat washers and nuts supplied for that product by the manufacturer of each anchor.
   2. Size of anchors and fasteners, including diameter and length or minimum effective embedment depth: As indicated on the Drawings or as specified in this Section. In the event of conflicts, contact Engineer for clarification.
   3. Where anchors and connections are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.

B. Materials:
   1. Provide and install anchors of materials as in this Section.

2.02 CAST-IN ANCHORS AND FASTENERS

A. Anchor bolts:
   1. Description:
      a. Straight steel rod having one end with an integrally forged head, and one threaded end. Embedded into concrete with the headed end cast into concrete at the effective embedment depth indicated on the Drawings or specified, and with the threaded end left to project clear of concrete face as required for the connection to be made.

b. Furnish anchor bolts with heavy hex forged head or equivalent acceptable to Engineer:
    1) Rods or bars with angle bend for embedment in concrete (i.e., “L” or “J” shaped anchor bolts) are not permitted in the Work.

2. Materials:
    a. Type 316 stainless steel:
        1) Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
        2) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
        3) Washers: Type 316 stainless steel.
    b. Type 304 stainless steel:
        1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
        2) Bolts: ASTM F593, Group 1, Condition CW, coarse threads.
        3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
        4) Washers: Type 304 stainless steel**.**
    c. Galvanized steel:
        1) Hot-dip galvanized coating in accordance with ASTM F2329.
        2) Bolt: ASTM F1554, Grade 36, heavy hex, coarse thread.
        3) Nuts: ASTM A563, Grade A heavy hex, threads to match bolt.
        4) Washers: ASTM F436, Type 1.

2.03 POST-INSTALLED ANCHORS AND FASTENERS - ADHESIVE

A. Epoxy bonding of reinforcing bars, all thread rods, and threaded inserts in concrete: As specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.

B. Epoxy bonding of reinforcing bars, all thread rods, and threaded inserts in masonry: As specified in Section 04055 - Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry**.**

2.04 POST-INSTALLED ANCHORS AND FASTENERS - MECHANICAL

A. General:
1. Post-installed anchors used for the Work shall hold a current ICC Evaluation Service Report demonstrating acceptance for use under the building code specified in Section 01410 - Regulatory Requirements:
    a. Conditions of use: The acceptance report shall indicate acceptance of the product for use under the following conditions:
        1) In regions of concrete where cracking has occurred or may occur.
        2) To resist short-term loads due to wind forces.
        3) To resist short-term loading due to seismic forces for the Seismic Design Category of the structure where the product will be used.
2. Substitutions: When requesting product substitutions, submit calculations, indicating the diameter, effective embedment depth and spacing of the proposed anchors, and demonstrating that the substituted product will provide

load resistance that is equal to or greater than that provided by the anchors listed in this Section:

a. Calculations shall be prepared by and shall bear the signature and seal of a Civil or Structural Engineer licensed in the State of California.
b. Decisions regarding the acceptability of proposed substitutions shall be at the discretion of the Engineer.

B. Concrete anchors:
   1. Description. Post-installed anchor assembly consisting of a threaded stud and a surrounding wedge expansion sleeve that is forced outward by torquing the center stud to transfer loads from the stud to the concrete through bearing, friction, or both. (Sometimes referred to as “expansion anchors” or “wedge anchors.”):
      a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials to develop holding power.
   2. Concrete anchors for anchorage to concrete:
      a. Acceptance criteria:
         1) Concrete anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and with ICC-ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
         2) Concrete anchor performance in the current ICC-ES Report shall be “Category 1” as defined in ACI 355.2.
      b. Manufacturers: One of the following or equal:
         1) Hilti, Kwik Bolt TZ Expansion Anchor.
         2) DEWALT/Powers, PowerStud.
         3) Simpson Strong-Tie, Strong Bolt 2 Wedge Anchor.
      c. Materials. Integrally threaded stud, wedge, washer, and nut:
         1) Stainless steel: Type 304 or 316.
         2) Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).
   3. Concrete anchors for anchorage to concrete masonry (fully grouted cells):
      a. Acceptance criteria: Concrete anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified in accordance with ICC-ES AC01, including all mandatory tests and optional seismic tests.
      b. Manufacturers: One of the following or equal:
         1) Hilti, Kwik Bolt 3 Expansion Anchor.
         2) DEWALT/Powers, Power-Stud+ SD1.
         3) Simpson Strong-Tie, Wedge-All Anchor.
      c. Materials. Integrally threaded stud, wedge, washer, and nut:
         1) Stainless steel: Type 304 or 316.
         2) Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5) or mechanically galvanized in accordance with ASTM B695, Class 55, Type 1.

C. Flush shells:
   1. Description: Post-installed anchor assembly consisting of an internally threaded mandrel that is forced into a pre-drilled concrete hole with a setting tool until the top of the anchor is flush with the face of the concrete. Once installed, a removable threaded bolt is installed in the mandrel.
   2. Flush shell anchors are not permitted in the Work.

2.05 APPURTENANCES FOR ANCHORING AND FASTENING

A. Anchor bolt sleeves:
   1. Having inside diameter approximately 2 inches greater than bolt diameter and minimum 10-bolt diameters long.
   2. Plastic sleeves:
      a. High-density polyethylene, corrugated sleeve, threaded to provide adjustment of location on the anchor bolt.
      b. Manufacturers: The following or equal:
         1) Portland Bolt & Manufacturing Co.
   3. Fabricated steel sleeves: Construct as specified in Section 05500 - Metal Fabrications:
      a. At galvanized carbon steel anchor bolts, provide galvanized carbon steel sleeves.
      b. At stainless steel anchor bolts, provide stainless steel sleeves of same Type (304 or 316) as bolt, except that sleeves shall be constructed from low carbon stainless steel for welding (Type 304L or 316L.

B. Isolating sleeves and washers:
   1. Manufacturers: One of the following or equal:
      a. Central Plastics Co.
      b. Allied Corrosion Industries.
   2. Sleeves: Mylar, 1/32-inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending half way into both steel washers.
   3. One sleeve required for each bolt.
   4. Washers: The inside diameter of all washers shall fit over the isolating sleeve, and both the steel and isolating washers shall have the same inside diameter and outside diameter:
      a. Proper size to fit bolts.
      b. Two 1/8-inch thick steel washers for each bolt.
      c. G3 Phenolic: 2 insulating washers are required for each bolt:
         1) Thickness: 1/8 inch.
         2) Base material: Glass.
         3) Resin: Phenolic.
         4) Water absorption: 2 percent.
         5) Hardness (Rockwell): 100.
         6) Dielectric strength: 450 volts per mil.
         7) Compression strength: 50,000 pounds per square inch.
         8) Tensile strength: 20,000 pounds per square inch.
         9) Maximum operating temperature: 350 degrees Fahrenheit.

C. Coating for repair of galvanized surfaces:
   1. Manufacturers: The following or equal:
      a. Jelt, Galvinox.

D. Thread coating: For use with threaded stainless steel fasteners:
   1. Manufacturers: One of the following or equal:
      a. Bostik, Never-Seez.
      b. Oil Research, Inc., WLR No. 111.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 INSTALLATION: GENERAL

A. Where anchors and fasteners are not specifically indicated on the Drawings or specified, make attachments with materials specified in this Section.

B. Substitution of anchor types:
   1. Post-installed anchors may not be used as an alternative to cast-in/built-in anchors at locations where the latter are indicated on the Drawings.
   2. Cast-in/built-in anchors may be used as an alternative to post-installed mechanical anchors at locations where the latter are indicated on the Drawings.

C. Protect products from damage during installation. Take special care to protect threads and threaded ends.

D. Accurately locate and position anchors and fasteners:
   1. Unless otherwise indicated on the Drawings, install anchors perpendicular to the surfaces from which they project.
   2. Install anchors so that at least 2 threads, but not more than 1/2 inch of threaded rod, projects past the top nut.

E. Interface with other products:
   1. Where steel anchors come in contact with dissimilar metals (aluminum, stainless steel, etc.), use stainless steel anchors and separate or isolate dissimilar metals using isolating sleeves and washers.
   2. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.

3.03 INSTALLATION: CAST-IN ANCHORS

A. General:
   1. Accurately locate cast-in and built-in anchors:
      a. Provide anchor setting templates to locate anchor bolts and anchor rods. Secure templates to formwork.
      b. Brace or tie off embedments as necessary to prevent displacement during placement of plastic concrete or of surrounding masonry construction.
      c. Position and tie cast-in and built-in anchors in place before beginning placement of concrete or grout. Do not “stab” anchors into plastic concrete, mortar, or grout.

d. Do not allow cast-in anchors to touch reinforcing steel. Where cast-in anchors are within 1/4 inch of reinforcing steel, isolate the metals by wrapping the anchors with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.

2. For anchoring at machinery bases subject to vibration, use 2 nuts, with 1 serving as a locknut.

3. Where anchor bolts or anchor rods are indicated on the Drawings as being for future use, thoroughly coat exposed surfaces that project from concrete or masonry with non-oxidizing wax. Turn nuts down full length of the threads, and neatly wrap the exposed thread and nut with a minimum of 4 wraps of 10-mil waterproof polyvinyl tape.

B. Anchor bolts:

1. Minimum effective embedment: 10-bolt diameters, unless a longer embedment is indicated on the Drawings.

2. Where indicated on the Drawings, set anchor bolts in plastic, galvanized steel or stainless steel sleeves to allow for adjustment.

3. Ensure that butt weld develops full strength of the stud.

3.04 INSTALLATION: POST-INSTALLED ADHESIVE ANCHORS

A. Epoxy and acrylic adhesive bonding of reinforcing bars, all thread rods, and internally threaded inserts in concrete: As specified in Section 03055 – Adhesive - Bonded Reinforcing Bars and All Thread Rods in Concrete.

B. Epoxy and acrylic adhesive bonding of reinforcing bars, all thread rods, and internally threaded inserts in masonry: As specified in Section 04055 - Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry.

3.05 INSTALLATION: POST-INSTALLED MECHANICAL ANCHORS

A. General:

1. Install anchors in accordance with the manufacturer's instructions, ACI 355.2, the anchor's ICC-ES Report. Where conflict exists between the ICC-ES Report and the requirements in this Section, the requirements of the ICC-ES Report shall control.

2. Where anchor manufacturer recommends the use of special tools and/or specific drill bits for installation, provide and use such tools.

3. After anchors have been positioned and inserted into concrete or masonry, do not:

a. Remove and reuse/reinstall anchors.

b. Loosen or remove bolts or studs.

B. Holes drilled into concrete and masonry:

1. Do not drill holes in concrete or masonry until the material has achieved its minimum specified compression strength (f'c or f'm).

2. Accurately locate holes:

a. Before drilling holes, use a reinforcing bar locator to identify the position of all reinforcing steel, conduit, and other embedded items within a 3-inch radius of each proposed hole.

b. If the hole depth exceeds the range of detection for the rebar locator, the Engineer may require radiographs of the area designated for investigation before drilling commences.

3. Exercise care to avoid damaging existing reinforcement and other items embedded in concrete and masonry:
    a. If embedments are encountered during drilling, immediately stop work and notify the Engineer. Await Engineer's instructions before proceeding.
4. Unless otherwise indicated on the Drawings, drill holes perpendicular to the concrete surface into which they are placed.
5. Drill using anchor manufacturer's recommended equipment and procedures:
    a. Unless otherwise recommended by the manufacturer, drill in accordance with the following:
        1) Drilling equipment: Electric or pneumatic rotary type with light or medium impact. Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.
        2) Drill bits: Carbide-tipped in accordance with ANSI B212-15. Hollow drills with flushing air systems are preferred.
6. Drill holes at manufacturer's recommended diameter and to depth required to provide the effective embedment indicated.
7. Clean and prepare holes as recommended by the manufacturer and as required by the ICC-ES Report for that anchor:
    a. Unless otherwise recommended by anchor manufacturer, remove dust and debris using brushes and clean compressed air.
    b. Repeat cleaning process as required by the manufacturer's installation instructions.
    c. When cleaning holes for stainless steel anchors, use only stainless steel or non-metallic brushes.

C. Insert and tighten (or torque) anchors in full compliance with the manufacturer's installation instructions:
    1. Once anchor is tightened (torque), do not attempt to loosen or remove its bolt or stud.

D. Concrete anchors: Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Concrete Anchors			
Nominal Diameter	**Minimum Effective Embedment Length**		**Minimum Member Thickness**
	In Concrete	**In Grouted Masonry**	
3/8 inch	2 1/2 inch	2 5/8 inch	8 inch
1/2 inch	3 1/2 inch	3 1/2 inch	8 inch
5/8 inch	4 1/2 inch	4 1/2 inch	10 inch
3/4 inch	5 inch	5 1/4 inch	12 inch

E. Flush shell anchors:
    1. Flush shell anchors are not permitted in the Work.
    2. If equipment manufacturer's installation instructions recommend the use of flush shell anchors, contact Engineer for instructions before proceeding.

3.06 FIELD QUALITY CONTROL

A. Contractor shall provide quality control over the Work of this Section as specified in Section 01450 - Quality Control:
   1. Expenses associated with work described by the following paragraphs shall be paid by the Contractor.

B. Post-installed anchors:
   1. Review anchor manufacturer's installation instructions and requirements of the Evaluation Service Report (hereafter referred to as "installation documents") for each anchor type and material.
   2. Observe hole-drilling and cleaning operations for conformance with the installation documents.
   3. Certify in writing to the Engineer that the depth and location of anchor holes, and the torque applied for setting the anchors conforms to the requirements of the installation documents.

3.07 FIELD QUALITY ASSURANCE

A. Owner's Representative will provide on-site observation and field quality assurance for the Work of this Section:
   1. Expenses associated with work described by the following paragraphs shall be paid by the Owner.

B. Field inspections and special inspections:
   1. Required inspections: Observe construction for conformance to the approved Contract Documents, the accepted submittals, and manufacturer's installation instructions for the products used.
   2. Record of inspections:
      a. Maintain record of each inspection.
      b. Submit copies to Engineer upon request.
   3. Statement of special inspections: At the end of the project, prepare and submit to the Engineer and the authority having jurisdiction inspector's statement that the Work was constructed in general conformance with the approved Contract Documents, and that deficiencies observed during construction were resolved.

C. Special inspections: Anchors cast into concrete and built into masonry.
   1. Provide special inspection during positioning of anchors and placement of concrete or masonry (including mortar and grout) around the following anchors:
      a. Anchor bolts.
   2. During placement, provide continuous special inspection at each anchor location to verify that the following elements of the installation conform to the requirements of the Contract Documents:
      a. Anchor:
         1) Type and dimensions.
         2) Material: Galvanized steel, Type 304 stainless steel, or Type 316 stainless steel as specified in this Section or indicated on the Drawings.
         3) Positioning: Spacing, edge distances, effective embedment, and projection beyond the surface of the construction.

4) Reinforcement at anchor: Presence, positioning, and size of additional reinforcement at anchors indicated on the Drawings.

3. Following hardening and curing of the concrete or masonry surrounding the anchors, provide periodic special inspection to observe and confirm the following:
   a. Base material (concrete or grouted masonry):
      1) Solid and dense concrete or grouted masonry material within required distances surrounding anchor.
      2) Material encapsulating embedment is dense and well-consolidated.

D. Special Inspections: Post-installed mechanical anchors placed in hardened concrete and in grouted masonry:
   1. Provide special inspection during installation of the following anchors:
      a. Concrete anchors.
   2. Unless otherwise noted, provide periodic special inspection during positioning, drilling, placing, and torquing of anchors:
      a. Provide continuous special inspection for post-installed anchors in "overhead installations" as defined in this Section.
   3. Requirements for periodic special inspection:
      a. Verify items listed in the following paragraphs for conformance to the requirements of the Contract Documents and the Evaluation Report for the anchor being used. Observe the initial installation of each type and size of anchor, and subsequent installation of the same anchor at intervals of not more than 4 hours:
         1) Any change in the anchors used, in the personnel performing the installation, or in procedures used to install a given type of anchor shall require a new "initial inspection."
      b. Substrate: Concrete or masonry surfaces receiving the anchor are sound and of a condition that will develop the anchor's rated strength.
      c. Anchor:
         1) Manufacturer, type, and dimensions (diameter and length).
         2) Material (galvanized, Type 304 stainless steel, or Type 316 stainless steel).
      d. Hole:
         1) Positioning: Spacing and edge distances.
         2) Drill bit type and diameter.
         3) Diameter, and depth.
         4) Hole cleaned in accordance with manufacturer's required procedures. Confirm multiple repetitions of cleaning when recommended by the manufacturer.
         5) Anchor's minimum effective embedment.
         6) Anchor tightening/installation torque.
   4. Requirements for continuous special inspection:
      a. The special inspector shall observe all aspects of anchor installation, except that holes may be drilled in his/her absence provided that he/she confirms the use of acceptable drill bits before drilling, and later confirms the diameter, depth, and cleaning of drilled holes.

E. Field tests:
   1. Owner's Representative may, at any time, request testing to confirm that materials being delivered and installed conform to the requirements of the Specifications:
      a. If such additional testing shows that the materials do not conform to the specified requirements, the Contractor shall pay the costs of these tests.
      b. If such additional testing shows that the materials do conform to the specified requirements, the Owner shall pay the costs of these tests.

3.08 NON-CONFORMING WORK

A. Remove misaligned or non-performing anchors.

B. Fill empty anchor holes and repair failed anchor locations using high-strength, non- shrink, non-metallic grout.

C. If more than 10 percent of all tested anchors of a given diameter and type fail to achieve their specified torque or proof load, the Engineer will provide directions for required modifications. Make such modifications, up to and including replacement of all anchors, at no additional cost to the Owner.

3.09 SCHEDULES

A. Stainless steel. Provide and install stainless steel anchors at the following locations:
   1. "Corrosive locations" as defined in this Section: Type 316 stainless steel
   2. "Wet and moist locations" as defined in this Section: Type 316 stainless steel.
   3. "Other locations:"
      a. For connecting steel members to concrete or masonry: Type 304 stainless steel.
      b. For connecting aluminum members to concrete or masonry**.**
   4. At locations indicated on the Drawings.

END OF SECTION

SECTION 05216

OPEN WEB STEEL JOIST FRAMING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Open web steel joists, joist girders, and accessories.
   2. Welding and bolts for connections at joists and joist girders.

1.02 REFERENCES

A. American Welding Society (AWS):
   1. A2.4 - Standard Symbols for Welding, Brazing, and Non-Destructive Examination.
   2. B2.1 - Specification for Welding Procedure and Performance Qualification.
   3. D1.1 - Structural Welding Code - Steel.

B. ASTM International (ASTM):
   1. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   2. F436 - Standard Specification for Hardened Steel Washers.
   3. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

C. Occupational Safety and Health Administration (OSHA):
   1. Code of Federal Regulations, Title 29 – Labor, Chapter XVII.
      a. Part 1926.757 - Steel Erection; Open Web Steel Joists.

D. Society for Protective Coatings (SSPC):
   1. Paint 15 - Steel Joist Shop Primer/Metal Building Primer.
   2. SP-15 - Commercial Grade Power Tool Cleaning.

E. Steel Joist Institute (SJI):
   1. Code of Standard Practice:
      a. COSP - Code of Standard Practice for Steel Joists and Joist Girders.
   2. Standard Specifications:
      a. K Series - Standard Specifications for Open Web Steel Joists.
      b. LH/DLH Series - Standard Specifications for Longspan Steel Joists, LH-Series and Deep Longspan Steel Joists, DLH-Series.
      c. JG Series - Standard Specification for Joist Girders.
   3. Standard Load Tables:
      a. Standard Specification Load Tables and Weight Tables for Steel Joists and Joists Girders.
   4. Technical Digests:
      a. TD 8 - Welding of Open-Web Steel Joists and Joist Girders.
      b. TD 9 - Handling and Erection of Steel Joists and Joist Girders.

1.03 DEFINITIONS

A. Steel joists: As referred to in this Section, includes joists, K series joist substitutes, joist girders, and joist headers.

B. SJI Standard Specifications: Refers to one or more of the following documents corresponding to the joist type indicated on the Drawings:
   1. K Series - Standard Specifications for Open Web Steel Joists.

C. SJI Standard Load Tables: Refers to one of the following documents corresponding to the joist type indicated on the Drawings:
   1. Standard Load Tables, Open Web Steel Joists, K-Series (LRFD & ASD).

1.04 SUBMITTALS

A. General: Submit as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Manufacturer's specifications and installation instructions for each type of joist and accessories.
   2. Coatings:
      a. Shop coating. Manufacturer’s product data sheets indicating type and characteristics of applied coatings, and recommendations for preparation and materials for finished coatings.

C. Shop drawings:
   1. General:
      a. Provide fabrication drawings/schedules, and erection/layout drawings for all joists and related miscellaneous metal work.
      b. Clearly indicate portion of the Work covered by each submittal, and location of each member in the work.
      c. Mark number or tags on joists and fabrications shall be the same mark numbers indicated on fabrication schedules and erection drawings.
      d. Indicate shop and field welds using symbols in accordance with AWS A2.4. Indicate net weld lengths.
   2. Fabrication drawings/schedules:
      a. Detail each piece or assembly to be incorporated into the work.
      b. For each joist type and size, and for each accessory, indicate:
         1) SJI standard designations including depth and chord size.
         2) Identification mark number.
         3) Loading criteria and camber.
         4) Configuration and details including joist elevation view; bearing seats; end conditions; chord extensions; and details of internal joints, welds, and splices (if any).
         5) Dimensions, both overall and internal.
         6) Methods of connecting, anchoring, fastening, bracing, bridging, and attaching.
         7) Coatings and surface preparation.
   3. Erection/layout drawings:
      a. Indicate placement of each piece shown in the fabrication drawings/schedules or listed in the bill of materials.

b. Show layout of joists with mark numbers; methods of framing at openings; locations, types, and connection details for bridging; details of connections between joists and supporting joist girders, joist headers, framing, or structures; and accessories.
c. Indicate erection sequence and requirements for temporary bracing.
d. Show requirements for field welding and bolting.
e. Show profiles and deflection criteria under live and total loads for joist configurations not specifically listed in SJI Standard Load Tables.
f. List loads used in the design of steel joists:
1) Show loads and position of loads from all mechanical and electrical equipment supported by the joists and framing.

D. Calculations:
1. Submit calculations for each joist type and span, documenting adequacy to resist uniform and concentrated loads indicated on the Drawings; locations, sizes and types of bridging for resisting downward and uplift loads; and adequacy of connections of joists and bridging.
2. Provide calculation cover letter sealed and signed by the joist manufacturer's qualified registered design professional licensed in the state where the Project is located.

E. Certificates/certifications:
1. SJI membership. Submit evidence of manufacturer’s current membership in SJI and of manufacturer's qualifications to produce members of the types specified and required for the Work.
2. SJI compliance. At the completion of manufacturer, for each joist type and load case provided, submit manufacturer’s certificate of compliance stating that design and fabrication of members was performed in accordance with SJI Standard Specifications and the approved shop drawings. Include manufacturer's statements that:
a. Welders performing shop welding for joists hold current qualification for the types of welding and welding positions required for the Work.
b. Manufacturer has completed in-plant before shipment to verify compliance of materials and workmanship with the requirements of SJI Standard Specifications for the products produced.
3. Quality control program: Submit evidence of active participation in a nationally recognized program for quality control of steel fabrication.
4. Field welding. Submit welder qualification certificates in accordance with AWS D1.1 for the types of welding and welding positions required for the Work.

F. Test and inspection reports:
1. Mill test reports: Submit manufacturer's certificates, indicating ASTM standards, structural strength, and material properties for steel used in the joists and bridging.
2. Inspections:
a. Source quality control:
1) Submit reports of manufacturer's in-plant inspections for compliance with SJI Standard Specifications.

b. Field quality control:
    1) Report of erection inspection.
    2) Report of welding inspection.
c. Field quality assurance:

1.05 SYSTEM DESCRIPTION

A. Pre-engineered, pre-fabricated open-web steel joists, joist girders, and accessories designed and fabricated to the requirements of the Steel Joist Institute and details as specified in this Section and indicated on the Drawings.

B. Design requirements:
1. Design joists and bridging in accordance with current SJI Specifications and load tables to support loads indicated based on the depth, spacing, and deflections, indicated:
    a. Maximum deflection under live load:
        1) Roof joists: Span divided by 240 (L/240).
    b. Minimum design loads as indicated on the Drawings:
        1) Dead load.
        2) Live load.
        3) Wind load (net uplift).
        4) Axial tension and compression forces applied to the truss at end connections.
    c. Camber: Provide standard camber based on SJI Standard Specifications unless otherwise indicated on the Drawings:
        1) In no case shall joists be manufactured with negative (downward) camber.
        2) Where a joist will be installed parallel to and within 6 feet of a wall, decrease camber in that joist nearest the wall to one-half of the standard camber.
2. Bridging: Provide horizontal and diagonal bridging as required by the SJI Standard Specifications, as indicated on the Drawings, and as required to maintain stability under gravity, uplift, erection, and construction loadings.
3. End anchorage: Provide end anchorage details to secure and/or stabilize joists at supports, and to transfer any loads indicated on the Drawings.
4. Header units: Provide header units to support joists at openings in floor or roof framing not framed with structural steel shapes.
5. Accessories:
    a. Provide miscellaneous items including splice plates, reinforcing angles, and bolts required to complete the installation.
    b. Provide supplemental steel framing to support steel deck where normal deck bearing is precluded by other framing members and minor openings.

1.06 QUALITY ASSURANCE

A. Design and fabricate joists in compliance with the following and as specified in this Section:
1. SJI Standard Specifications.
2. SJI Standard Load Tables.
3. SJI Code of Standard Practice.

B. Qualifications:
   1. Manufacturers:
      a. Holding current membership in the Steel Joist Institute and a recognized fabricator of structural steel joists conforming to the SJI Standard Specifications, the SJI Standard Load Tables, and the SJI Code of Practice.
   2. Installer/Erector:
      a. Field Welding: Qualified procedures and welders in accordance with AWS D1.1. Provide welders qualified within the last 12 months preceding the date of joist erection.

C. Regulatory requirements:
   1. In accordance with OSHA requirements for steel erection, including specific requirements for joists and framing.

D. Inspection:
   1. Inspect joists in accordance with SJI Standard Specifications.
   2. Inspect fabrication as specified in Part 2, Source Quality Control.
   3. Provide inspections for Field Quality Control and Field Quality Assurance as specified in Part 3, Execution.

E. Pre-installation conference: Steel joists and deck:
   1. Schedule and conduct pre-installation conference at least 2 weeks prior to installation of joists:
      a. Provide additional conferences if necessary to discuss or coordinate specific conditions of installation.
   2. Required attendees:
      a. Contractor.
      b. Steel joist manufacturer’s technical representative.
      c. Steel joist installer’s job superintendent.
      d. Subcontractor(s) providing and installing coatings under Division 9.
   3. Agenda:
      a. Joist submittals.
      b. Manufacturer’s recommended inspections and inspection procedures.
      c. Requirements and coordination for quality control inspections and quality assurance (including special inspections).
      d. Other Specification requirements requiring coordination between parties to the work.
   4. Prepare and submit minutes of the pre-installation conference as specified in Section 01312 - Project Meetings.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Transport, deliver, store, and handle steel joists as recommended in SJI specifications, and as required to avoid stresses and to prevent damage to materials and coatings.

B. Observe delivered materials for damage before and after unloading, and note any permanent bends, deformations, broken welds, or other damage on the receiving documents.

C. Store joists off the ground, protected from weather and corrosion, and under watertight covering sloped to drain:
   1. Support by means that will protect members from distortion and damage.
   2. Store joists with top chord down and with plane of joist vertical.

1.08 WARRANTY

A. Special warranty:
   1. Duration: 5 years warranty on joists.

PART 2 PRODUCTS

2.01 MATERIALS

A. Steel joists:
   1. Provide joist type, chord configuration, depth, and bearing as indicated on the Drawings.
   2. Comply with SJI Standard Specifications for joist series
   3. Details: Provide the following:
      Chord members: Rolled double angle sections only. Rod or bar members are not permitted.

B. Bridging:
   1. In accordance with SJI Standard Specifications for type of joist, chord size, spacings, spans and uplift loads indicated on the Drawings.
   2. Anchored to walls, girders, and roof deck as indicated.

C. Coatings:
   1. Shop paint. In accordance with SSPC Paint 15.

D. Fasteners:
   1. Anchor bolts and anchor rods to concrete and masonry: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   2. Bolts: pre-tensioned bolted connections.
      a. Provide high-strength bolt assembly with hardened flat washers and nuts. Provide uncoated components unless galvanized coating is indicated on the Drawings.
      b. Uncoated:
         1) Bolts: Plain, heavy hex structural bolts conforming to ASTM F3125, Grade A325, Type 1.
         2) Nuts: Heavy hex nuts conforming to ASTM A563, Grade C.
         3) Washers: Circular flat washers conforming to ASTM F436.

E. Accessories:
   1. Bearing plates: Material as specified in Section 05120 - Structural Steel.

2.02 FABRICATION

A. Open web steel joists:
   1. Fabricate steel joist in accordance with SJI Standard Specifications to details indicated on the Drawings.

B. Cross bridging: Provide horizontal or diagonal type bridging for joists.

C. End anchorage: Provide end anchorage, including bearing plates, to secure joists to adjacent construction as indicated on the Drawings.

D. Coatings:
   1. Shop primer:
      a. Clean and prime joists and accessories in accordance with SSPC Paint 15 for delivery.
      b. After delivery, remove shipping primer and prepare joists and accessories for re-priming and finish coating specified in Section 09960 - High-Performance Coatings.

2.03 SOURCE QUALITY CONTROL

A. Tests and inspections:
   1. Provide joist manufacturer's inspection as required by SJI Standard Specifications. Submit inspection results.
   2. Special Inspection - Fabrication. Requirements of the building code specified in Section 01450 - Regulatory Requirements for special inspection of fabricated structural items shall be considered to be satisfied when the manufacturer is registered and approved to perform steel fabrication work in accordance with a quality control program that is certified by the Steel Joist Institute (SJI), the American Institute of Steel Construction (AISC), the City of Los Angeles Department of Building and Safety (COLA), or similar program acceptable to building official and the Engineer.

PART 3 EXECUTION

3.01 GENERAL

A. Furnish and erect steel joists accordance with the requirements of SJI’s Code of Standard Practice for Steel Joists and Joist Girders.

3.02 PREPARATION

A. Field verify dimensions and elevations of structural elements supporting the joists and joist girders:
   1. Establish lines and elevations within tolerances before beginning erection.
   2. Make bearing surfaces true and uniform.
   3. Do not begin placement of steel joists until supporting work is in place and secured.

B. Clean bearing surfaces of joists and supporting members before erection and as required during erection to maintain solid contact between members.

3.03 INSTALLATION

A. Erection:
   1. Place and secure steel joists in accordance with SJI Standard Specifications, approved erection drawings, and these Specifications.
   2. Allow for loads from erection procedures, but do not load joists until all fastening is complete.
   3. Provide sufficient temporary bracing to maintain joists and supporting framing safe, plumb, and in true alignment until completion of erection and installation of permanent bridging and bracing.

B. Installation of joists and bridging:
   1. Do not start placement of steel joists until supporting work is in place, adjusted to specified tolerances, and secured.
   2. Do not field modify, alter, or repair joists unless specific written instructions have been received from the joist manufacturer and submitted to the Engineer. Such instructions shall bear the seal and signature of the joist manufacturer's registered design professional licensed in the state where the joists are installed.
   3. Place joists on supporting surfaces, adjust, and accurately align to required elevation, location and spacing before permanently fastening:
      a. Set joists plumb and level (with indicated allowances for camber).
      b. Set "tag end" of joists at location shown on the erection plans.
      c. Adjust bearing shoe elevations to provide full bearing after joists and supporting members have been plumbed and positioned, but before final tightening of connections and before any loads are imposed.
      d. Solidly pack areas under bearing plates using materials and procedures indicated on the Drawings.
   4. Install bridging in accordance with OSHA 29CFR-1926.757d and SJI Standard Specifications to provide lateral stability for the joists before slacking of hoisting lines. Quantity of bolted diagonal erection bridging shall be in accordance with SJI Standard Specifications.
   5. Install bridging simultaneously with joist erection and before construction loads are applied. Anchor ends of bridging lines at top and bottom chords where terminating at walls or beams. Quantity, size, and sequence for installing bridging shall be in accordance with SJI Standard Specifications.
   6. Erection stability and handling shall be in accordance with SJI Standard Specifications.

C. Fastening joists:
   1. Each joist must be attached at a minimum of one end immediately upon placement in the final erection position and before additional joists are placed.
   2. When field welding joists, weld to supporting steel framework in accordance with SJI Standard Specifications and as indicated on the Drawings:
      a. Coordinate welding sequence and procedure with placing of joists.
      b. In accordance with AWS D1.1.
      c. Length of field welds applied to the top and bottom chords of joists shall not exceed 1/2 of the width of the steel member.
   3. When bolting joists, bolt to supporting steel framework in according with SJI Standard Specifications.

D. Coating:
   1. Deliver joists coated or uncoated as specified.
   2. Where members are painted or coated in place, do not begin preparation or coating until all units are in place; properly, completely, and permanently fastened, and accepted by the Engineer.
   3. Prepare, prime, and finish as specified in Section 09960 - High-Performance Coatings.
   4. Perform surface preparation and coating application under environmentally controlled field conditions, or in an off-site paint shop.

3.04 TOLERANCES

A. As indicated in SJI Standard Specifications, unless otherwise noted.

B. Deviation from straight line between opposite ends of any installed joist: Maximum 3/8 inch in 10 feet.

3.05 REPAIR

A. Do not install damaged joists or accessories. Remove such materials from the site and replace with sound materials at no additional cost to the Owner.

B. Repair rust spots and coatings damaged by handling, welding, or other erection and fastening processes.

C. After erection, touch-up rust spots, connections, field welds, and abraded areas of members using specified coatings. Clean and prepare damaged areas. Apply coating at the same thickness as that applied before erection. Feather edges of repairs to provide a uniform appearance after repair:
   1. Clean and prepare surfaces using SSPC-SP 15 procedures.
   2. Apply coating of same product and color as member. Apply primer and finish coat(s).

3.06 FIELD QUALITY CONTROL

A. Provide field quality control over the Work of this Section as required by Section 01450 - Regulatory Requirements.

B. Field tests and inspections:
   1. High-strength bolting:
      a. Confirm use of specified bolts and nuts.
      b. Pre-tensioned connections:
         1) Confirm that all plies of the connected elements have been brought into firm contact by the tightened connection.
         2) Confirm bolts pretension using turn-of-the nut method, twist-off type tension controlled nut, or direct-tension indicator washer. Do not use calibrated wrench.
   2. Welding - Field welds:
      a. Perform observations and testing in the presence of the Engineer.
      b. Visual observation:
         1) Visually examine all welds in accordance with AWS D1.1.

2) Quality of welds and standards for acceptance shall be in accordance with AWS D1.1, "Visual Inspection Acceptance Criteria" Table.

c. Test results:

1) Submit records of testing to Engineer within 24 hours after testing.

3. After erection, observe installation for conformance with this specification.

3.07 FIELD QUALITY ASSURANCE

A. Provide field quality assurance over the Work of this Section as required by Section 01450 - Regulatory Requirements.

B. Special inspections, special tests and structural observation:

1. Provide as required by Section 01455 - Regulatory Quality Assurance.

C. Field inspections:

1. Required inspections:

a. Observe construction for conformance to the Contract Documents and the accepted Shop Drawings:

1) Confirm that joist and accessory locations and tags (marks) match those indicated on the erection drawings.

2) Confirm that joists are installed in vertical alignment and without lateral sweep.

3) Confirm that joist spacing conforms to erection drawings.

4) Confirm that bridging lines, spacing, and connections/anchoring conform to erection drawings.

b. Visually inspect field bolting, including bolt tightness.

c. Visually inspect field welding using AWS certified welding inspectors in accordance with AWS D1.1:

1) In accordance with AWS D1.1.

2) Mark welds observed.

2. Records of inspections:

a. Provide record of each inspection.

b. Submit copies to Engineer upon request.

D. Field testing.

3.08 NON-CONFORMING WORK

A. Remove and replace damaged and non-conforming work to the satisfaction of the Engineer.

END OF SECTION

ELEMENTS INSPECTED	REF[1]	CONFORMS?		
		Yes	No	Comments [2]
Member Installation:				
Joist and accessory locations, tags, and tagged end locations conform to erection drawings.	1			
Joist spacing conforms to erection drawings.	1			
Joists and accessories are installed in horizontal and vertical alignment and without lateral sweep.	1			
Joist bearing length on supporting members conforms to erection drawings and details.	1a			
Joist and accessory installations conform to specified tolerances.				
Bridging:				
Bridging locations, types (horizontal or diagonal), and member sizes conform to erection drawings.	1b			
Bridging connections to joists conforms to erection drawings.	1b			
Bridging connections to and terminations at ends/walls conforms to erection drawings.	1b			
Field Welding:				
Welds at locations indicated on erection drawings.				
Weld size and length as indicated on erection drawings.	1a			
Quality of welds complies with AWS D1.1 - "Visual Inspection Acceptance Criteria" Table	1a			
(Continued, next page)				
Field Bolting:				
Bolts at locations indicated on erection drawings.	1a			
Bolts, nuts and washers of sizes and materials specified.	1a			
Bolts tightened as specified. All plies of connection have been brought into firm contact.	1a			

		CONFORMS?		
Other:				

Notes:

(1) Reference: **2019 CBC .**

(2) Comments: Insert comment number from page 2 this form.

Comments:

Inspector:

Name (printed): _____

Signature: _____ Date: _____

Company (printed): _____

SECTION 05310

STEEL DECKING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Steel deck for floors and roofs, and associated accessories.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

B. American Welding Society (AWS):
   1. D1.3 - Structural Welding Code - Sheet Steel.

1.03 SUBMITTALS

A. Product data.

B. Shop drawings.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection:
   1. Store steel deck at the site stacked on platforms or pallets and covered with tarpaulins or other suitable weathertight covering.
   2. Do not use steel deck for storage or working platform.
   3. Remove damaged, unlabeled, untagged, rusty, and deteriorated steel deck material from the jobsite.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. ASC Profiles (Formerly IMSA Building Products and BHP).
   2. Verco Manufacturing Co.

2.02 MATERIALS

A. Sheet steel: ASTM A653, G 90 minimum coating designation.

2.03 FABRICATION

A. Steel deck shall be formed:
   1. So every sheet is identical and will register perfectly with adjacent sheets.
   2. In accordance with building code as specified in Section 01410- Regulatory Requirements.

B. Decking used with concrete fill shall be deformed to develop composite action between the deck and the concrete.

C. Furnish minimum gauge, deck thickness, section modulus, moment of inertia, and allowable diaphragm shear per foot of deck width that is not less than for type deck sections indicated on the Drawings.

D. Treat exposed roof deck with phosphate.

E. Furnish roof deck ready to receive field painting without further pretreatment. Paint exposed roof deck in accordance with Contract Documents.

F. Accessories:
   1. Furnish all accessories indicated on the Drawings or needed to completed work.
   2. Minimum required gauges:
      a. Sump pans: 14 gauge.
      b. All other accessories: 20 gauge unless otherwise indicated on the Drawings.

G. Welding and electrodes: In accordance with AWS D1.3.

H. Furnish roof decking in lengths to minimize number of splices.

I. Furnish steel deck complete, including cutting, shaping, fitting, drilling, welding, ridge plates, valley plates, reinforcing plates for openings, and miscellaneous pieces necessary for proper installation.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Examine work in place to verify that it is satisfactory to receive the work of this Section. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

3.02 INSTALLATION

A. Decking shall span over at least 3 spans wherever possible.

B. Do not damage or overload roof deck during installation.

C. Do not use steel deck for storage or as a working platform until sheets have been welded in position.

D. Do not exceed maximum uniformly distributed load of 20 pounds per square foot.

E. Install decking in straight and continuous rows as far as practicable, with ribs at right angles to supporting members.

F. For each end of deck section, provide 3 inches minimum bearing on supports. For sections that abut each other, each piece shall bear a minimum of 3 inches on the support. This requires a 6 inch minimum flange width. For cases where the minimum bearing cannot be obtained, notify the Engineer.

G. Electric arc weld deck sections to bearing plates, supports at butt joints, at intermediate supports, side supports, and at end supports as indicated on the Drawings. Do not burn through the deck. Remove all slag.

H. Fasten the longitudinal joints between deck sections together by the method indicated on the Drawings.

I. Neatly cut and fit openings in roof deck, and reinforce with structural steel members as indicated on the Drawings.

J. Paint welds as specified.

K. Install roof deck free of dents and bent members.

L. Reinforce all holes and openings in steel deck as indicated on the Drawings.

M. Piping, conduit, equipment, and other services: Do not hang from decking.

N. Install all accessories required to complete work.

3.03 REPAIR OF GALVANIZING AND COATING

A. Touch-up damage to galvanized surfaces, including cut edges and holes, with zinc rich primer.

B. Repair damage to factory-applied coating system in accordance with the manufacturer's printed recommendations.

3.04 CLEANUP

A. After erection, remove weld spatter, grease, and oil from decking.

END OF SECTION

SECTION 05500

METAL FABRICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Concrete inserts.
   2. Handrails and guardrails.
   3. Metal gratings.
   4. Preformed channel pipe supports.
   5. Miscellaneous metals.
   6. Associated accessories to the above items.

1.02 REFERENCES

A. Aluminum Association (AA):
   1. DAF-45: Designations from Start to Finish.
      a. M12-C22-A41.

B. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

C. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A48 - Standard Specification for Gray Iron Castings.
   3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc- Coated, Welded, and Seamless.
   4. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   5. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels for General Applications.
   6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   7. A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
   8. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   9. A489 - Standard Specification for Carbon Steel Lifting Eyes.
   10. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   11. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
   12. A635 - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for.
   13. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   14. A992 - Standard Specification for Structural Steel Shapes.

15. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
16. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
17. B308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
18. B429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
19. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
20. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

D. American Welding Society (AWS):
   1. A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.

E. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

A. Passivation: Removal of exogenous iron or iron compounds from the surface of a stainless steel by means of chemical dissolution resulting from treatment with an acid solution that removes the surface contamination but does not significantly affect the stainless steel itself.

1.04 SUBMITTALS

A. Product Data:
   1. Handrails and guardrails.
   2. Metal grating.

B. Shop drawings:
   1. Handrails and guardrails:
      a. Including details on connection attachments, gates, kick plates, ladders, and angles.
      b. Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories.
      c. Include erection drawings, elevations, and details where applicable.
      d. Indicate welded connections using standard AWS A2.4 welding symbols. Indicate net weld lengths.
   2. Metal grating.
   3. Miscellaneous metals.

C. Samples:
   1. Guardrails with specified finishes.

D. Quality control submittals:
   1. Design data.
   2. Test reports:
      a. Guardrails: 3 copies of certified tests performed by an independent testing laboratory certifying that guardrails meet current State and OSHA strength requirements.

b. Gratings:
   1) Grating manufacturers' calculations showing that gratings will meet specified design load, stress, and deflection requirements for each size grating for each span.
   2) Reports of tests performed.

PART 2 PRODUCTS

2.01 MATERIALS

A. General: Unless otherwise specified or indicated on the Drawings, structural and miscellaneous metals in accordance with the standards of the ASTM, including the following:

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
Cast Iron		
Cast Iron	A48	Class 40B
Steel		
Galvanized sheet iron or steel	A653	Coating G90
Coil (plate)	A635	--
Structural plate, bars, rolled shapes, and miscellaneous items (except W shapes).	A36	--
Rolled W shapes	A992	Grade 50
Standard bolts, nuts, and washers	A307	--
High strength bolts, nuts, and hardened flat washers	F3125, Grade A325	--
Eyebolts	A489	Type 1
Tubing, cold-formed	A500	--
Tubing, hot-formed	A501	--
Steel pipe	A53	Grade B

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
Stainless Steel		
Plate, sheet, and strip	A240	Type 304* or 316**
Bars and shapes	A276	Type 304* or 316**
Bolts (Type 304)	F593	Group 1 Condition CW
Bolts (Type 316)	F593	Group 2 Condition CW
Aluminum		
Flashing sheet aluminum	B209	Alloy 5005-H14, 0.032 inches minimum thickness
Structural sheet aluminum-	B209	Alloy 6061-T6
Structural aluminum	B209 B308	Alloy 6061-T6
Extruded aluminum	B221	Alloy 6063-T42
* Use Type 304L if material will be welded. ** Use Type 316L if material will be welded.		

1. Stainless steels are designated by type or series defined by ASTM.
2. Where stainless steel is welded, use low-carbon stainless steel.

2.02 MANUFACTURED UNITS

A. Handrails and guardrails:
   1. General:
      a. Design and fabricate assemblies to conform to current local, State, and OSHA standards and requirements.
      b. Coordinate layout of assemblies and post spacings to avoid conflicts with equipment and equipment operators:
         1) Indicate on the shop drawings locations of such equipment.
         2) Highlight locations where railings cannot be made continuous, and obtain Engineer's directions on how to proceed before fabricating or installing railings.

2. Aluminum handrails and guardrails (nonwelded pipe):
    a. Rails, posts, and fitting-assembly spacers:
        1) In accordance with ASTM B429, 6005, 6063 or 6105, minimum Schedule 40, extruded aluminum pipe of minimum 1.89-inch outside diameter and 0.14-inch wall thickness.
    b. Kick plates: 6061 or 6105 aluminum alloy.
    c. Fastenings and fasteners: As recommended or furnished by the manufacturer.
    d. Other parts: 6063 extruded aluminum, or F214 or F514.0 aluminum castings:
        1) Fabrications: In accordance with ASTM B209 or ASTM B221 extruded bars:
            a) Bases: 6061 or 6063 extruded aluminum alloy.
        2) Plug screws or blind rivets: Type 305 stainless steel.
            a) Other parts: Type 300 series stainless steel.
    e. Finish of aluminum components:
        1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
        2) Pretreat aluminum for cleaning and removing markings before anodizing.
    f. Fabrication and assembly:
        1) Fabricate posts in single, unspliced pipe length.
        2) Perform without welding.
        3) Do not epoxy bond the parts.
        4) Maximum clear opening between assembled railing components as indicated on the Drawings.
    g. Manufacturers: One of the following or equal:
        1) Moultrie Manufacturing Co., Wesrail.
        2) Golden Railings, Riveted System.
        3) Craneveyor Corp. Enerco Metals, C-V Rail.
3. Fastenings and fasteners: As recommended or furnished by guardrail manufacturer for use with this system.

B. Metal gratings:
1. General:
    a. Fabricate grating to cover areas indicated on the Drawings.
    b. Unless otherwise indicated on the Drawings, grating over an opening shall cover entire opening.
    c. Make cutouts in grating where required for equipment access or protrusion, including valve operators or stems, and gate frames.
    d. Band ends of grating and edges of cutouts in grating:
        1) End banding: 1/4 inch less than height of grating, with top of grating and top edge of banding flush.
        2) Cutout banding: Full-height of grating.
        3) Use banding of same material as grating.
        4) Panel layout: Enable installation and subsequent removal of grating around protrusions or piping.
        5) Openings 6 inches and larger: Lay out grating panels with edges of 2 adjacent panels located on centerline of opening.

6) Openings smaller than 6 inches: Locate opening at edge of single panel.
7) Where an area requires more than 1 grating section to cover area, clamp adjacent grating sections together at 1/4-points with fasteners acceptable to Engineer.
8) Fabricate steel grating sections in units weighing not more than 50 pounds each.
9) Fabricate aluminum grating sections in units of weighing not more than 50 pounds each.
10) Gaps between adjacent grating sections shall not be more than the clear spacing between bearing bars.

e. When requested by Engineer, test 1 section of each size grating for each span length involved on the job under full load:
1) Furnish a suitable dial gauge for measuring deflections.

f. Grating shall be aluminum, unless otherwise specified or indicated on the Drawings.

2. Aluminum grating:
a. Material for gratings, shelf angles, and rebates: 6061-T6 or 6063-T6 aluminum alloy, except crossbars may be 6063-T5 aluminum alloy.
b. Shelf angle concrete anchors: Type 304 or Type 316 stainless steel.
c. Grating rebate rod anchors: 6061-T6 or 6063-T6 aluminum alloy.
d. Bar size and spacing: As determined by manufacturer to enable grating to support design load.
e. Design live load: A minimum of 100 pounds per square foot uniform live load on entire grating area, but not less than the live load indicated on the Drawings for the area where grating is located.
f. Maximum fiber stress for design load: 12,000 pounds per square inch.
g. Maximum deflection due to design load: 1/240 of grating clear span.
h. Maximum spacing of main grating bars: 1-1/8 inches clear between bars.
i. Minimum grating height: 1-1/2 inches.
j. Manufacturers: The following or equal:
1) Harsco Industrial IKG, Swaged Aluminum I-Bar with striated finish.

C. Miscellaneous aluminum:
1. Fabricate aluminum products, not covered separately in this Section, in accordance with the best practices of the trade and field assemble by riveting or bolting.
2. Do not weld or flame cut.

D. Miscellaneous cast iron:
1. General:
a. Tough, gray iron, free from cracks, holes, swells, and cold shuts.
b. Quality such that hammer blow will produce indentation on rectangular edge of casting without flaking metal.
c. Before leaving the foundry, clean castings and apply 16-mil dry film thickness coating of coal-tar epoxy, unless otherwise specified or indicated on the Drawings.

E. Miscellaneous stainless steel:
    1. Provide miscellaneous stainless steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
        a. Fabricate and install in accordance with the best practices of the trade.
    2. Cleaning and passivation:
        a. Following shop fabrication of stainless steel members, clean and passivate fabrications.
        b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a passive finished surface.
        c. Provide quality control testing to verify effectiveness of cleaning agents and procedures and to confirm that finished surfaces are clean and passivated:
            1) Conduct sample runs using test specimens with proposed cleaning agents and procedures as required to avoid adverse effects on surface finishes and base materials.
        d. Pre-clean, chemically descale (pickle), and final clean fabrications in accordance with the requirements of ASTM A380 to remove deposited contaminants before shipping.
            1) Passivation by citric acid treatment is not allowed:
                a) If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible; however, these treatments shall be followed by inorganic cleaners such as nitric-hydrofluoric acid.
            2) Provide acid descaling (pickling) in accordance with Table A1.1 of Annex A1 of ASTM A380.
            3) After pickling, final cleaning of stainless steel shall conform to Part II of Table A2.1 of Annex A2 of ASTM A380.
        e. After cleaning, inspect using methods specified for “gross inspection” in ASTM A380.
        f. Improperly or poorly cleaned and passivated materials shall not be shipped and will not be accepted at the job site.

F. Miscellaneous structural steel:
    1. Provide miscellaneous steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
        a. Fabricate and install in accordance with the best practices of the trade.

G. Isolating sleeves and washers:
    1. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:
    1. Examine work in place to verify that it is satisfactory to receive the work of this Section.
    2. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

3.02 INSTALLATION

A. General:
   1. Install products as indicated on the Drawings, and in accordance with shop drawings and manufacturer's printed instructions, as applicable except where specified otherwise.
   2. Interface between materials:
      a. Dissimilar metals: Where steel comes in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals:
         1) Make application so that the isolating or protective barrier is not visible in the completed construction.
         2) Isolating sleeves and washers: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
      b. Aluminum in contact with concrete or masonry: Coat aluminum surfaces as specified in Section 09960 - High Performance Coatings.
      c. Aluminum in contact with concrete or masonry.

B. Handrails and guardrails:
   1. General:
      a. Fasten pipe rails to fittings with Series 300 stainless steel pop rivets or flush set screws.
      b. Make pipe cuts clean and straight, free of burrs and nicks, and square and accurate for minimum joint-gap.
      c. Drill and countersink holes to proper size, as required for a tight flush fit of screws and other component parts.
      d. Space attachment brackets as indicated in the manufacturer's instructions.
   2. Aluminum pipe handrails and guardrails:
      a. During construction, keep exterior surfaces of handrails and guardrails covered with minimum 0.4 millimeters of heat shrink polyethylene film.
      b. Do not remove protective film before handrails and guardrails have been accepted by Engineer nor before other work in proximity of handrails and guardrails has been completed.
      c. Discontinue handrails and guardrails at lighting fixtures.
      d. Provide 1/8-inch diameter weep hole at base of each post.
      e. Space posts as indicated on the Drawings.
      f. Anchor posts into concrete by grouting posts into formed holes in concrete, into stainless steel sleeves cast in concrete; or bracket mount to face of concrete surfaces as specified and indicated on the Drawings.
      g. Space rails as indicated on the Drawings.
      h. Make adequate provision for expansion and contraction of kick plates and rails:
         1) Make provisions for removable sections where indicated on the Drawings.
      i. Make lower rails a single, unspliced length between posts, or continuous.
      j. Make top rails continuous whenever possible, and attach single, unspliced lengths to 3 posts minimum.
      k. Draw up fasteners tight with hand wrench or screw driver.
      l. Space attachment brackets as indicated on shop drawings or in manufacturer's installation instructions.
      m. Completed installation shall have handrails and railings rigid and free of play at joints and attachments.

n. Protect handrail and guardrail finish from scratches, gouges, dents, stains, and other damage.
o. Replace damaged or disfigured handrails and guardrails with new.
p. Shortly before final acceptance of the work, and after removal of protective polyethylene film, clean handrails, and guardrails with mild detergent or with soap and water:
1) After cleaning, thoroughly rinse handrails and guardrails and wipe with soft cloth.
q. Erect guardrail straight, level, plumb, and true to the positions as indicated on the Drawings. Correct deviations from true line of grade, which are visible to the eye.

C. Metal gratings:
1. General:
a. Allow 1/8-inch maximum clearance between ends of grating and inside face of vertical leg of shelf angles.
b. Horizontal bearing leg of shelf angles shall be 2 inches minimum.
c. Install aluminum plate or angles where necessary to fill openings at changes in elevation and at openings between equipment and grating.
d. Install angle stops at ends of grating.
e. Installed grating shall not slide out of rebate or off support.
f. Weld stops in place, unless otherwise specified or indicated on the Drawings.
g. Top surfaces of grating sections adjacent to each other shall lie in same plane.
2. Aluminum grating:
a. Aluminum grating: Support on aluminum shelf angles or rebates.

D. Stainless Steel:
1. Welding:
a. Passivate field-welded surfaces:
1) Provide cleaning, pickling and passivating as specified in this Section.
2) Clean using Derustit Stainless Steel Cleaner, or equal.

END OF SECTION

SECTION 07190

WATER REPELLENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Water repellent for concrete masonry.

1.02 DEFINITIONS

A. Water repellent: Resistance to penetration of water from rainfall.

1.03 REFERENCES

A. International Union of Testing and Research Laboratories for Materials and Structures (RILEM):
   1. RILEM Test Method No. 11.4, Measurement of Water Absorption Under Low Pressure.

B. South Coast Air Quality Management District (SCAQMD):
   1. Rule 1168 – Adhesive and Sealant Applications.

1.04 SUBMITTALS

A. Product Data.

B. Samples: Water repellent applied on 8-inch by 8-inch substrates to receive water repellent, marked with application date and application rate.

C. Manufacturer's Application Instructions.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of water repellents for minimum 5 years with satisfactory performance record.

B. Applicator qualifications: Trained, approved, and accepted by water repellent manufacturer.

C. Spray personnel qualifications: Minimum 2 years of experience spraying exotic coatings.

D. Regulatory requirements: Comply with volatile organic compound regulations.

E. Mock-ups:
   1. Apply water repellent on 8-foot by 8-foot mock-up walls. Use same equipment and procedures that will be used in applying material on walls.
   2. Test mock-up for water penetration 30 days after applying water repellent in accordance with field quality control.

3. When accepted by the Engineer, mock-up walls will be standard for walls.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to site in manufacturer's original containers with seals unbroken and labeled with manufacturer's batch number.

B. Store materials in original, unopened containers in compliance with manufacturer's printed instructions.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Sealants in compliance with SCAQMD Rule 1168.

B. Apply water repellent under temperature and relative humidity conditions before, during, and after application in accordance with manufacturer's instructions.

C. Allow surfaces to dry for minimum 5 days after rains.

1.08 PROJECT CONDITIONS

A. Make proper material allowance based upon substrate material and surface configuration when determining quantities of material.

1.09 WARRANTY

A. Warrant to furnish and apply water repellent on walls that experience water penetration because of failure of water repellent for minimum **5** years.

1.10 MAINTENANCE

A. Extra materials: Deliver water repellent in manufacturer's original unopened containers to Owner that equals minimum 1 percent of material supplied.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Water repellent sealer:
   1. One of the following or equal:
      a. Rainguard Products.
      b. ProSoCo, Inc.

2.02 SYSTEM DESCRIPTION

A. Performance requirements: Surfaces with water repellent shall be uniform in color with unaltered texture.

2.03 MATERIALS

A. Water repellent sealer for concrete and concrete masonry: Silane/Siloxane; Volatile Organic Compound compliant; free of silicone oils, paraffin wax, or urethanes:
   1. Manufacturers: The following or equal:
      a. Rainguard, BLOK-LOK.

2.04 EQUIPMENT

A. Spray equipment: High-volume, low-pressure, airless, with maximum 60 pounds per square inch pressure:
   1. Pump: Non-atomizing, able to flow material on walls at minimum 1 to 1-1/2 gallons per minute.

PART 3 EXECUTION

3.01 EXAMINATION

A. Carefully inspect installed construction. Verify that construction is ready for repellent application.

B. Require manufacturer's representative to verify that water repellent may be installed.

3.02 PREPARATION

A. Allow concrete or masonry walls to cure at least 30 days before applying water repellent.

B. Clean wall surfaces of soil, mud, efflorescence, or other detrimental materials.

C. Tuck-point or caulk cracks, other than hairline cracks.

D. Route out defective mortar joints, point with mortar and tool.

E. Moisture content: Apply water repellent sealer when moisture content of substrate is 15 percent or less.

3.03 APPLICATION ON CONCRETE MASONRY

A. Apply water repellent in accordance with manufacturer's printed instructions.

B. Apply flood coat using low-pressure spray equipment.

C. Start at top of wall and work down using overlapping horizontal passes.

D. Hold spray head 8 to 10 inches from surface so saturation coat runs freely down wall 6 to 10 inches below point of application on most substrates.

E. Spray by traveling horizontally to ensure uniform coverage.

F. Overlap each following pass by centering spray head on bottom line of the previous pass.

G. Trigger gun off at end of each pass to avoid applying excessive amount of material. Do not over apply.

H. Avoid application in hot or windy weather as premature drying can cause whitish residue on walls.

3.04 FIELD QUALITY CONTROL

A. 20 days after application, test water repellent on CMU surfaces using RILEM Test Method No. 11.4:
   1. Contractor shall perform a 20-minute RILEM baseline test on dry untreated CMU units of each type to receive water repellent. Test results (water loss in milliliter) shall be compared to CMU units in walls after water repellent application.
   2. On water repellant coated CMU, a RILEM tube test resulting in 5 milliliter or less after 20 minutes is necessary to qualify for 5-year warranty.

B. Notify the Engineer and manufacturer at least 72 hours in advance of test.

C. Where tested wall areas fail to pass RILEM tube test, apply additional coat of water repellent on entire wall from corner to corner.

D. Test all locations where directed by the Engineer.

3.05 CLEANING

A. Concrete masonry: Clean drips, runs, and overspray residue while still wet, using detergent and water. Clean application and spray equipment with detergent and water immediately following use.

B. Clean application and spray equipment according to the manufacturer's recommendations.

C. Remove excess materials, equipment, and debris incidental to water repellent application upon completion.

3.06 PROTECTION

A. During application, protect water repellent treated and adjacent surfaces from damage.

B. Protect glass, aluminum, and other surfaces from overspray.

C. Protect concrete sidewalks from runoff. Soak with water immediately prior to application on adjacent walls.

D. Repair damaged areas promptly.

END OF SECTION

SECTION 07220

ROOF AND DECK INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Roof and deck insulation and associated accessories.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. D41- Standard Specification for Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing.
   3. D312 - Standard Specification for Asphalt Used in Roofing.

B. National Roofing Contractors Association (NRCA).

C. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Product data.

B. Samples. Include 6-inch square samples of each type and thickness of insulation required.

C. State thickness and R-value of insulation to be provided at each building.

D. Manufacturer's installation instructions: Include the following:
   1. Indicate special environmental conditions required for installation.
   2. Indicate adhesive recommendations.
   3. Indicate fastener recommendations and attachment pattern to meet specified requirements.
   4. Indicate installation techniques.

E. Certificates:
   1. Certify that products meet or exceed specified requirements.
   2. Certify that insulation is approved by manufacturer for use with specified roofing materials.

F. Manufacturer's field reports.

G. Warranty.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed product for minimum 5 years with satisfactory performance record.

B. Installer qualifications:
   1. Manufacturer-approved installer of products similar to specified products on minimum 5 projects of similar scope as Project with satisfactory performance record.
   2. Committed to complying with manufacturer's specifications and NRCA recommendations.
   3. Committed to assuming undivided responsibility for roof insulation, roofing membrane and sheet metal flashing, and trim associated with roofing.

C. Product compatibility: Provide roofing manufacturer approved roof insulation.

D. Pre-installation conference: Conduct as specified in Section 01312 - Project Meetings.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with manufacturer's instructions.

B. Label asphalt containers with certification of full compliance with requirements of ASTM D312, Table 1, and indicating equiviscous temperature, finished flowing temperature, and flash point.

C. Store roof system materials on pallets or dunnage at least 4 inches above ground and suitably covered to protect from weather.

1.06 SEQUENCING AND SCHEDULING

A. Apply no more insulation than can be completely covered with roofing membrane on the same day.

B. When installation of insulation and roof membrane cannot be completed within same day, install temporary water cutoffs at end of day's work and remove cutoffs prior to resumption of work.

1.07 WARRANTY

A. Furnished by roof membrane manufacturer, as specified in Section 07540 – Thermoplastic Polyolefin (TPO) Membrane Roofing.

PART 2 PRODUCTS

2.01 MATERIALS

A. Roof insulation system: As follows with UL Class C meeting wind up-lift requirements:
   1. Where 5-inch rigid foam roof insulation is indicated on the Drawings, insulation shall be as follows:
      a. First layer: 1.5-inch thick foam insulation having an R-Value of 9.0.
      b. Second layer: 3.4-inch thick foam insulation having an R-Value of 21.1.
      c. Total system thickness shall be 4.9 inches and have a minimum R-Value of 30.0.

B. Mineral board: Factory fabricated, 1/2-inch thick, glass mat faced, noncombustible, moisture resistant, silicone treated, gypsum core panel:
   1. Manufacturers: The following or equal:
      a. Georgia-Pacific, Dens-Deck Roof Board.

C. Roof crickets and saddles: Tapered Perlite Roof Insulation or as otherwise recommended by roofing manufacturer to meet warranty requirements.

D. Primer: ASTM D41, asphalt primer.

2.02 ACCESSORIES

A. Screw fastener system for steel decks:
   1. Self-drilling and self-tapping, zinc plated or stainless steel screws, sized for 1/2- to 3/4-inch exposure on exposed to view underside of deck, with minimum 3-inch square or diameter ribbed steel stress plates, hot-dip galvanized with minimum G-60 coating in accordance with ASTM A123.
   2. Manufacturers: One of the following or equal:
      a. Tru Fast.
         TW Buildex.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that deck is properly graded to outlets.

B. Verify that deck surfaces are clean, dry, and where required, coated with primer.

3.02 PREPARATION

A. Embed 1 ply of roofing felt over roof drains and minimum 6 inches over adjacent surface in solid uniform layer of plastic cement.

3.03 INSTALLATION OVER STEEL DECK

A. Install roof insulation in accordance with manufacturer's specifications.

B. Secure wood nailers to roof deck adjoining eaves, at roof curbs for attachment of flashing and counterflashing, and at other locations indicated on the Drawings:
   1. Nailers shall be built up of pressure treated wood to match the thickness of the insulation.

C. Apply first layer of roof insulation with long joints continuous, either parallel or at right angles to ribs of deck.

D. Form joints parallel to ribs over solid bearing.

E. Stagger end joints.

F. Secure with approved mechanical fasteners in FM I-90 pattern:
   1. Space fasteners as recommended by insulation manufacturer.
   2. Drive fasteners through tin caps or plastic fastener/cap assemblies, unless they are provided with integral flat cap not less than 1 inch across.
   3. Install screw fastener system in top rib of steel deck in accordance with manufacturer's instructions. Where underside of metal deck is exposed to view, size fasteners to penetrate deck from 1/2- to 3/4-inch, unless otherwise recommended by fastener manufacturer.

G. Apply second layer of roof insulation with both long and short joints offset from joints of first layer.

H. Install cant strips at curbs, parapets, and intersections of roofs and vertical walls, when recommended by membrane manufacturer. Place on top of insulation and set in solid mopping of asphalt.

I. Roof crickets:
   1. Install as required to achieve drainage pattern indicated on the Drawings, and as otherwise required to obtain roof warranty. Set in full mopping of hot asphalt. Feathered edges of crickets and tapered insulation shall be formed of perlite or fiber board.
   2. Mop 12-inch wide felt strip into solid asphalt at valley formed by installation of roof crickets to provide additional membrane reinforcement.

J. Before application of roofing, turn over and solidly mop projecting felt to insulation at vertical surfaces and edges.

K. Do not leave insulation exposed to weather.

3.04 FIELD QUALITY CONTROL

A. Roof insulation which becomes wet or damaged shall be removed and replaced with solid, dry insulation, unless installer provides written acceptance of the damaged insulation from the roofing manufacturer, whose warranty shall cover the system.

B. Inspections: Roof membrane manufacturer, whose warranty shall cover complete roof assembly, shall provide supervision and inspection necessary to secure warranty.

END OF SECTION

SECTION 07540

THERMOPLASTIC POLYOLEFIN (TPO) MEMBRANE ROOFING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Fully-adhered, 60 mil thermoplastic polyolefin membrane, white, scrim-reinforced roofing system.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D751 - Standard Test Methods for Coated Fabrics.

B. American Society of Civil Engineers (ASCE):
   1. ASCE 7 – Minimum Design Loads and Associated Criteria for Buildings and Other Structures.

C. Single Ply Roofing Industry (SPRI):
   1. SPRI WD-1 - Wind Design Standard Practice for Roofing Assemblies.

D. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Product data: Include specifications, outline of roof and size, deck type, location of all penetrations, and plan identifying high and low points and field verified elevations, fastener type and flashing details.

B. Samples: Membrane material, 4 by 4 inches square.

C. Manufacturer's Installation Instructions.

D. Certificates:
   1. UL Listed.
   2. Letter of certification from the manufacturer certifying the roofing contractor is authorized to install the manufacturer's roofing system, include certified foreman and training dates.
   3. Indicating membrane thickness from the membrane manufacturer.

E. Maintenance manual: Include repair instructions.

F. Warranties by installer and manufacturer.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed product for minimum 5 years with satisfactory performance record.

B. Installer qualifications: Manufacturer-approved installer of products similar to specified products on minimum 5 projects of similar scope as Project with satisfactory performance record.

C. Pre-installation conference: Conduct prior to beginning work. Installer, Owner, Manufacturer's Representative and Engineer shall be in attendance.

D. Verify existing roof, deck insulation, and roof specialties and accessories in Section 07700 - Roof Specialties and Accessories are compatible with membrane roofing.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with manufacturer's recommendations.

B. Deliver materials with appropriate labels indicating warnings, storage conditions, lot numbers, and usage instructions.

1.06 WARRANTY

A. Special warranty:
   1. Manufacturer's warranty:
      a. Minimum 20 years to correct defective roofing materials, including installation.

   2. Roof Installer's warranty: Minimum 2 years to correct defective workmanship.

PART 2 PRODUCTS

2.01 MANUFACTURER AND TYPE

A. Type: Fully-adhered, 60 mil, white, reinforced thermoplastic polyolefin (TPO) membrane assemblies.

B. Manufacturers: One of the following or equal:
   1. Carlisle Corp., Sure-Weld Roofing System.
   2. Johns Manville, JM TPO Roofing Systems.

2.02 DESIGN CRITERIA

A. Fire Hazard Classification: Minimum Roof Covering is C.

B. UL Class C.

C. Design uplift pressures:
   1. In accordance with building code: As specified in Section 01410 - Regulatory Requirements.
   2. In accordance with SPRI WD-1.
   3. In accordance with ASCE 7 – Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE.SEI 7-16).

2.03 COMPONENTS

A. Scrim-Reinforced Thermoplastic Polyolefin (TPO) Sheet: 60 mil, scrim-reinforced, white, membrane 10-feet wide maximum by appropriate length conforming to following minimum physical properties:
   1. Tensile strength: Minimum of 300 pounds per foot as tested in accordance with ASTM D751.
   2. Tear strength: Minimum 45-60 pounds when tested in accordance with ASTM D751.

B. Flashing, bonding adhesive, sealant, primer, seam caulk, insulation replacement, and fasteners: Membrane manufacturer approved.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify the following:
   1. Maximum 1/4-inch insulation joint widths.
   2. Proper installation of nailers and cants.
   3. Dry, clean, and smooth substrate without sharp edges and debris.

3.02 INSTALLATION

A. Install roofing system in conformance with manufacturer's instructions.

B. Install perimeter sheets.

C. Lay field sheets with long edges perpendicular to roof slope, with edge of roll aligned with perimeter sheets.

D. Fully adhered membrane shall be bonded to the substrate with manufacturer's approved adhesives. Overlap fastened edges of installed membrane by approximately 5-1/2 inches at fastening plates and 2 inches at end roll sections.

E. Seal non-factory cut edges with seam caulk.

F. Fasten and finish perimeter in accordance with membrane manufacturer's standard termination details.

3.03 FIELD QUALITY CONTROL

A. Arrange for manufacturer's warranty supervision and inspection. Notify Owner and Engineer 48 hours in advance of date and time of inspection.

END OF SECTION

SECTION 07700

ROOF SPECIALTIES AND ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Manufactured roof specialties and accessories, including the following:
   1. Metal coping.

1.02 REFERENCES

A. SPRI ES-1 - Wind Design Standard for Edge Systems Used with Low-Slope Roofing Systems.

1.03 SUBMITTALS

A. Product data: Include finish and color options.

B. Shop drawings: Include equipment curbs and supports details.

C. Certifications: Certify that curbs are capable of supporting the specified equipment as specified in Section 01612 - Seismic Design Criteria.

D. Samples: Include finish and color samples.

E. Manufacturer's Installation Instructions.

F. Warranties.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed product for minimum 5 years with satisfactory performance record.

B. Installer qualifications: Installer of products similar to specified products on minimum 5 projects of similar scope as Project with satisfactory performance record.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with manufacturer's recommendations.

1.06 WARRANTY

A. Provide manufacturers' standard warranties that warranty against defects for longer than 1 year.

PART 2 PRODUCTS

2.01 METAL COPINGS

A. Manufacturers: One of following or equal:
   1. Peterson Aluminum Corp., Pac-Lok.
   2. MM Systems Corp., Snap-Lok.
   3. OMG Roofing Products, Permasnap.

B. Characteristics:
   1. Capable of direct attachment to top of masonry walls.
   2. In accordance with SPRI ES-1.
   3. In accordance with codes as specified in Section 01410 - Regulatory Requirements.
   4. Capable of counterflashing roofing.

C. Copings:
   1. Material: Aluminum, minimum 0.063 inch thick.
   2. Width: To suit wall thickness.
   3. Length: 144 inches.
   4. Face Heights: Sufficient to conceal nailers or roof decking.
   5. Corners: Mitered and welded with minimum 24-inch legs.
   6. Finish: Kynar® 500, resin-base color coating. Color as selected from manufacturer's standard color line.

D. Splice plates: Same materials, width, face heights, and finish as coping, 6 inches long.

E. Seal strips: Extruded Butyl with protective paper.

F. Anchor plate: Galvanized steel. Same width, face height as coping, approximately 12 inches long.

G. Fasteners and anchors: Manufacturer's recommendation.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install roof accessories and specialties accordance with manufacturers' instructions.

3.02 INSTALLATION OF METAL COPINGS

A. Accurately align and install metal copings with uniformly smooth vertical faces.

B. Attach anchor plate to top of wall at 72 inches on center.

C. Install splice plates on anchor plates at splice joints of coping. Install seal strips on top of plate and down face approximately 1/2 inch. Apply slight pressure on sealant to incur adherence to clean, dry splice plate. Remove protective paper from sealant.

D. Fully engage hook on front face of coping with front leg of anchor plates, pivot coping into position pressing firmly at rear over each anchor plate until hook on rear face of coping snaps into place.

E. Leave 1/4-inch joint between abutting ends at splice plates.

END OF SECTION

SECTION 07900

JOINT SEALANTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Acrylic-Latex sealant.
   2. Precast concrete joint sealant.
   3. Silicone sealant.
   4. Synthetic rubber sealing compound.
   5. Synthetic sponge rubber filler.
   6. Related materials.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. M198 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

B. ASTM International (ASTM):
   1. C920 - Standard Specification for Elastomeric Joint Sealants.
   2. C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
   3. C1330 - Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants.
   4. C1521 - Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints.
   5. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension.
   6. D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomer.

1.03 SUBMITTALS

A. Product data.

B. Samples, include color selections.

C. Manufacturer's Installation Instructions.

D. Warranty.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed product for minimum 5 years with satisfactory performance record.

B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 5 projects of similar scope as Project with satisfactory performance record.

1.05 PROJECT/SITE CONDITIONS

A. Environmental requirements: Do not apply sealant on wet or frosty surfaces or when surface temperature is higher than 100 degrees Fahrenheit or lower than recommended by the manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with manufacturer's recommendations.

B. Code date packages. Do not use material older than manufacturer’s published shelf life. Store materials at temperatures lower than 80 degrees Fahrenheit. Condition materials in accordance with manufacturer’s instructions prior to installation.

1.07 SEQUENCING AND SCHEDULING

A. Caulk joints prior to painting.

1.08 WARRANTY

A. Warrant to correct defective products for minimum 1 year in accordance with manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 SEALANTS

A. General:
   1. Provide colors matching materials being sealed.
   2. Where compound is not exposed to view in finished work, provide manufacturer's color which has best performance.
   3. Nonsagging sealant for vertical and overhead horizontal joints.
   4. Sealants for horizontal joints: Self-leveling pedestrian/traffic grade.
   5. Joint cleaner, primer, bond breaker: As recommended by sealant manufacturer.
   6. Sealant backer rod and/or compressible filler made from closed cell polyethylene, polyethylene jacketed polyurethane foam, or other flexible, nonabsorbent, non-bituminous material recommended by sealant manufacturer to:
      a. Control joint depth.
      b. Break bond of sealant at bottom of joint.
      c. Provide proper shape of sealant bead.
      d. Serve as expansion joint filler.

2.02 SILICONE SEALANT

A. ASTM C920, Type S, Grade NS, Class 25, single component silicone sealant:
   1. Manufacturers: One of the following or equal:
      a. Tremco, Proglaze.
      b. Pecora Corp., Number 864.
      c. Dow Corning, Number 795.
      d. General Electric, Number 1200 Series.

2.03 SYNTHETIC RUBBER SEALING COMPOUND

A. Manufacturer: One of the following or equal:
   1. Sika Corporation, Sikaflex 2c NS or SL.
   2. Sika Corporation, Sikaflex 2c NS EZ Mix.
   3. Pacific Polymers, Elastothane 227R.

B. Material: In accordance with ASTM C920 Type M, Grade P (pourable), Class 25 and Type M, Grade NS (non-sag), Class 25; multi-part polyurethane; able to cure at room temperature to firm, highly resilient polymer; able to perform satisfactory when continuously submerged in water or sewage and exposed to direct sunlight in dry condition; with the following properties determined at 75 degrees Fahrenheit and 50 percent relative humidity:
   1. Base: Polyurethane rubber.
   2. Application time: Minimum 2 hours.
   3. Cure time: Maximum 3 days.
   4. Tack free time: Maximum 24 hours.
   5. Ultimate hardness: Non-sag 25, Pourable/SL 40, within 5 Shore A.
   6. Tensile strength: Non-sag 95 pounds per square inch minimum and self-leveling minimum 170 pounds per square inch when tested in accordance with ASTM D412.
   7. Ultimate elongation: Minimum 340 percent when tested in accordance with ASTM D412.
   8. Tear resistance: Non-sag 45 pounds per inch minimum and self-leveling minimum 85 pounds per inch when tested in accordance with ASTM D624, Die C.
   9. Service temperature range: Minus 25 degrees to 158 degrees Fahrenheit.

C. Color: Gray to match concrete, unless indicated on the Drawings.

2.04 SYNTHETIC SPONGE RUBBER FILLER

A. Closed-cell expanded sponge rubber manufactured from synthetic polymer neoprene base, or resilient polyethylene foam backer rod. In accordance with ASTM C1330, Type C:
   1. Manufacturers: The following or equal:
      a. Presstite, No. 750.3 Ropax Rod Stock.

B. Characteristics:
   1. Suitable for application intended.
   2. Strength: As necessary for supporting sealing compound during application.
   3. Resiliency: Resistance to environmental conditions of installation.
   4. Bonding: No bonding to the sealing compound.
   5. Structure: Cellular, prevents absorption of water.

6. Compatibility with other materials in joint and acceptance by manufacturer of sealing compound.
7. Size: Minimum 25 percent greater than nominal joint width.

2.05 RELATED MATERIALS

A. Primer: Nonstaining type, recommended by sealant manufacturer to suit application.

B. Joint cleaner: Noncorrosive, nonstaining, compatible with joint forming materials and as recommended by sealant manufacturer.

C. Bond breaker tape: Pressure-sensitive tape recommended by sealant manufacturer to suit application.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify acceptability of joint dimensions, physical, and environmental conditions.

B. Verify that surfaces are dry, clean, and free of dirt, grease, curing compound, and other residue which might interfere with adhesion of sealants.

3.02 PREPARATION

A. Allow concrete to cure thoroughly before caulking.

B. Synthetic sponge rubber filler:
1. Prepare surfaces designated to receive filler in accordance with manufacturer's installation instructions.
2. Do not stretch filler beyond its normal length during installation.

C. Caulking:
1. Verify that surfaces are dry, clean, and free of dirt, grease, curing compounds, and other residue that might interfere with adhesion of sealant.
2. Concrete, masonry, wood, and steel surfaces: Clean and prime in accordance with manufacturer's instructions prior to caulking.

D. Synthetic rubber sealing compound:
1. Ensure surfaces to which synthetic rubber must bond are dry and free of dust, dirt, and other foreign residue.
2. Heavy sandblasted caulking groove to sound surface, and prime with manufacturer's recommended primer for particular surface.

E. For sidewalks, pavements, and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, fill joints to depth equal to 75 percent of joint width, but neither more than 5/8 inches deep nor less than 3/8 inches deep.

F. For normal moving building joints sealed with elastomeric sealants not subject to traffic, fill joints to depth equal to 50 percent of joint width, but neither more than 1/2 inch deep nor less than 1/4 inch deep.

G. For joints sealed with acrylic-latex sealants, fill joints to depth in range of 75 percent to 125 percent of joint width.

H. Use joint filler to achieve required joint depths, to allow sealants to perform properly.

I. Prepare surfaces and install synthetic sponge rubber filler in accordance with manufacturer's recommendations.

J. Do not stretch filler beyond normal length during installation.

K. Apply bond breaker when recommended by joint sealer manufacturer.

3.03 INSTALLATION

A. Synthetic sponge rubber filler: Install filler in accordance with manufacturer's installation instructions.

B. Caulking, joints, and sealing:
   1. Construct expansion, contraction, and construction joints as indicated on the Drawings.
   2. Install pipe and conduit in structures as indicated on the Drawings.
   3. Caulk doors, windows, louvers, and other items installed in or over concrete openings inside and out.
   4. Use synthetic rubber sealing compound for caulking where indicated on the Drawings or as specified, except for masonry construction and where specified otherwise.
   5. Complete caulking prior to painting.
   6. Verify that concrete is thoroughly cured prior to caulking.
   7. When filler compressible material is used, use untreated type.
   8. Apply caulking with pneumatic caulking gun.
   9. Use nozzles of proper shape and size for application intended.
   10. Maintain continuous bond between caulking and sides of joint to eliminate gaps, bubbles, or voids and fill joint in continuous operation without layering of compound.
   11. Employ experienced applicators to caulk joints and seams in neat workmanlike manner.
   12. To hasten curing of compound when used on wide joints subject to movement, apply heat with infrared lamps or other convenient means.
   13. Apply synthetic rubber sealing compound with pneumatic caulking tool or other acceptable method.

3.04 CLEANING

A. Clean surfaces adjacent to sealant as work progresses.

B. Remove excess uncured sealant by soaking and scrubbing with sealant cleaning solvent.

C. Remove excess cured sealant by sanding with Number 80 grit sandpaper.

D. Leave finished work in neat, clean condition.

3.05 SCHEDULE

A. Silicone:
   1. Use where indicated on the Drawings.
   2. Joints and recesses formed where window, door, louver and vent frames, and sill adjoin masonry, concrete, stucco, or metal surfaces.
   3. Door threshold bedding.
   4. Moist or wet locations, including joints around plumbing fixtures.
   5. Stainless steel doors and frames, including joints between applied stops and frames, and around anchor bolts.
   6. Plenum joints.

B. Synthetic rubber sealing compound, non-sag Type II:
   1. Use where indicated on the Drawings.
   2. Water-bearing and earth-bearing concrete structures.
   3. Joints in masonry, concrete vertical surfaces, and metal-faced panels in vertical surfaces.
   4. Joints between sheet metal flashing and trim.
   5. Joints between sheet metal flashing and trim, and vertical wall surfaces.
   6. Small voids between materials requiring filling for weathertight performance in vertical surfaces.
   7. Perimeters of frames of doors, windows, louvers, and other openings where bonding is critical to airtight performance.
   8. Expansion and control joints in masonry vertical surfaces.

C. Synthetic rubber sealing compound, self-leveling Type I:
   1. Use where indicated on the Drawings.
   2. Expansion and control joints in masonry, concrete horizontal surfaces, and metal panels in horizontal surfaces.
   3. Small voids between materials requiring filling for weathertight performance in horizontal surfaces.
   4. Pavement joints.
   5. Perimeters of frames of doors, windows, louvers, and other openings in horizontal surfaces where bonding is critical to airtight performance.

3.06 FIELD QUALITY CONTROL

A. Adhesion testing:
   1. Perform adhesion tests in accordance with ASTM C1521 per the following criteria:
      a. Water bearing structures: 1 test per every 1,000 LF of joint sealed.
      b. Exterior precast concrete wall panels: 1 test per every 2,000 LF of joint sealed.
      c. Chemical containment areas: 1 test per every 1,000 LF of joint sealed.
      d. Building expansion joints: 1 test per every 500 LF of joint sealed.
      e. All other type of joints except butt glazing joints: 1 test per every 3,000 LF of joint sealed.
      f. Manufacturer's authorized factory representative provide written recommendations for remedial measures on failing tests.

END OF SECTION

SECTION 08110

HOLLOW METAL DOORS AND FRAMES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Steel Non-Fire Resistive Rated:
   1. Doors.
   2. Door frames.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. A250.6 - Hardware on Steel Doors (Reinforcement Application).
   2. A250.8 - Recommended Specification for Standard Steel Doors and Frames.

B. ASTM International (ASTM):
   1. A653 - Standard Specification for Sheet Steel, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   2. A924 - Standard Specification for General Requirements for Steel Sheet, Metallic- Coated by the Hot-Dip Process.
   3. A1008 - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
   4. A1011 - Standard Specification for Steel, Sheet and Strip, Hot Rolled, Carbon, Structural, High Strength Low Alloy, High Strength Low Alloy with Improved Formability, and Ultra High Strength.
   5. E413 - Classification for Rating Sound Insulation.

C. National Association of Architectural Metal Manufacturers (NAAMM)/Hollow Metal Manufacturers Association (HMMA):
   1. HMMA 861 - Guide Specifications for Commercial Hollow Metal Doors and Frames.

D. Steel Door Institute (SDI):
   1. SDI-111 - A Steel Doors and Frame Details.
   2. SDI-117 - Manufacturing Tolerances Standard Steel Doors and Frames.

1.03 SUBMITTALS

A. Product data.

B. Shop drawings: Show the following with references to the Engineer's door marks and hardware groups:
   1. Location of door and frame types.
   2. Details of fabrication, including core construction, glass lights, weatherstripping, and factory finish for each door.
   3. Cutouts and reinforcements for hardware.
   4. Methods of installation and anchorage to adjacent construction.

C. Manufacturer's instructions: Submit manufacturer's installation instructions.

1.04 QUALITY ASSURANCE

A. Testing agency qualifications: Approved by ultimate enforcing authority for the Project; regularly engaged in inspection of materials and workmanship at factory.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Before delivery, identify type and size of each door and frame in such a way that markings will not damage finish.

B. Preassemble doorframes in shop and deliver to Project site with spreader bar at sill or tie them in pairs to form box.

C. Protect doors and frames with resilient packaging sealed with heat shrunk plastic. Break seal on-site to permit ventilation.

D. Protect doors and frames during shipment and storage to prevent warping, bending, and corrosion.

1.06 SEQUENCING AND SCHEDULING

A. Ensure timely delivery of reviewed hardware schedule and hardware templates such that no delay occurs in the work of the Contract.

PART 2 PRODUCTS

2.01 MATERIALS

A. Sheet steel: ASTM A1008, commercial quality, level, cold rolled steel, or ASTM A1011, hot rolled, pickled and oil rolled steel. Galvanize by hot-dip process with zinc-coating in accordance with ASTM A924 or with ASTM A653 and the coating designation A60 or G60.

B. Clips, bolts, screws, and rivets: sized as recommended by manufacturer.

C. Primer: Rust- inhibitive epoxy primer compatible with high-solids epoxy finish coating system as specified in Section 09960 - High-Performance Coatings.

D. Touch-up materials: Primer as recommended by manufacturer.

E. Door hardware: As specified in Section 08710 - Door Hardware.

F. Grout: As specified in Section 04220 - Concrete Unit Masonry.

G. Glass and glazing materials: As specified in Section 08800 - Glazing.

2.02 DOOR AND FRAME TYPES

A. Exterior doors: ANSI 250.8, Grade III, Model 3, or NAAMM HMMA 810 Type A and NAAMM HMMA 861, flush steel rib-stiffened, minimum 16-gauge face sheets.

B. Exterior frames: ANSI 250.8 or NAAMM HMMA 861, fully welded frames HMMA 861, except minimum 14-gauge sizes and shapes as indicated on the Drawings.

2.03 COMPONENTS

A. Door cores:
   1. Stiffeners: Vertical steel ribs formed from minimum 22-gauge plain sheet steel, spaced at maximum 6 inches apart and securely attached to face sheets by spot welds at maximum 5 inches on center.
   2. Core fillers: Insulation, minimum 0.60 pound density noncombustible type, installed in spaces between stiffeners for full height of door; labeled door core material shall conform to requirements of labeling authority.

B. Glazing stops: Minimum 18-gauge sheet steel, mitered, square, or rectangular:
   1. Outside of exterior doors: Fixed, integral to doors and frames.
   2. Secure side of interior doors: Removable.

C. Removable stop fasteners: Flathead, countersunk, tamperproof, self-tapping sheet metal screws.

2.04 FABRICATION OF FRAMES

A. Galvanize all frames installed in exterior openings.

B. Frames: Sheet steel, integral type, welded continuous to full depth of frames with minimum 5/8-inch deep stops, unless otherwise indicated on the Drawings.

C. Hardware reinforcement: Minimum 7-gauge at hinges; 12-gauge at strikes, bolts, closers, and other applied hardware.

D. Jamb Anchors: As required for adjacent wall construction, minimum 3 per jamb, unless otherwise indicated on the Drawings.

E. Floor anchors: Fixed type, except where adjustable anchors are indicated on the Drawings, 1 per jamb, with minimum 2 holes for anchorage. Where floor fill occurs, terminate bottom of frames at indicated finished floor level and support by adjustable extension clips resting on and anchored to structural slabs.

F. Anchors at masonry: Adjustable strap and stirrup, minimum 16-gauge corrugated or perforated steel at maximum of 30 inches on center and extending minimum 8 inches into masonry.

G. Anchors at previously placed concrete: Countersink machine screws through the frame into expansion devices spaced at maximum 30 inches on center.

H. Masonry angle stiffeners: Factory welded into heads of frames for installation in openings more than 48 inches wide.

I. Removable stops: Fasten at approximately 12 to 16 inches on center.

2.05 FABRICATION OF DOORS

A. Galvanize all doors installed in exterior openings.

B. Reinforce face sheets with steel rib stiffeners, spaced at maximum 6 inches apart, and securely attached to face sheets by spot welds at maximum 5 inches on center.

C. Fill voids between face sheets and stiffeners with fiberglass insulation having a minimum density of 0.8 pounds per cubic foot.

D. Edges: Full weld without visible joints. Bevel striking edge 1/8 inch in 2 inches.

E. Tops and bottoms of doors: Close with continuous recess steel channel of minimum 16-gauge, extending full width of door and spot welded to both faces.

F. Tops and bottoms of exterior doors: Flush closing channels welded to make tops and bottoms waterproof with weep holes for escape of moisture.

G. Hinge reinforcement: 7-gauge.

H. Lock, closer, and flush bolt reinforcement: 12-gauge.

I. Astragals:
   1. Install on active leaf of double doors in accordance with UL listing requirements for fire resistive ratings as indicated on the Drawings, and for exterior pairs of doors.
   2. Do not install on doors swinging in pairs with rating of 90 minutes or less in means of egress where both leaves are required to provide building code required exiting widths.
   3. Do not provide astragal cutouts for hardware operations.

J. Glazing: In accordance with fire labeling.

2.06 HARDWARE PREPARATION

A. Cutout, drill, and reinforce frames and doors for hardware in accordance with hardware templates.

B. Install plaster guards or mortar boxes in back of hardware cutouts in and welded to frames.

C. Prepare fire resistive rated doors for hardware in accordance with requirements of labeling authority.

D. Do not weld hinges to doorframes.

2.07 FINISHING

A. Thoroughly clean surfaces of oil, grease, and other impurities; touch-up abraded galvanizing; and chemically etch.

B. Fill irregularities and sand smooth finish surface. Apply 1 coat of manufacturer's standard rust inhibitive baked-on primer.

C. Finish painting: High solids epoxy polyurethane system:
   1. Exterior doors and interior doors in corrosive environments: As specified in Section 09960 - High-Performance Coatings.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine reviewed hardware schedules and verify proper coordination of hardware and doors and frames.

B. Examine opening locations and verify the following:
   1. Correctness of dimensions, backing, or support conditions.
   2. Absence of defects that would adversely affect frame or door installation.

3.02 INSTALLATION

A. Install doors and frames in accordance with approved shop drawings and manufacturer's instructions.

B. Frames:
   1. Set accurately in position, plumb, align, and attach securely to structure.
   2. Set in place before construction of adjacent masonry or framed walls.
   3. Anchor frames to previously placed concrete.
   4. Set frames before removing spreader bars.
   5. Fully grout frames in masonry as the Work progresses.
   6. Grout frames at concrete through keyways provided at head and jambs.

C. Doors: Install at correct openings, ensure smooth swing and proper closure with frame.

D. Door hardware: Install in accordance with Section 08710 - Door Hardware.

E. Separate or isolate dissimilar metals with neoprene gaskets, sleeves, and washers, or with coatings acceptable to the Engineer.

3.03 TOLERANCES

A. Manufacturing and installation tolerances: As indicated on the Drawings or in conformance to SDI 117 as minimum.

3.04 ADJUSTING AND CLEANING

A. Prime coat touch-up: Immediately after installation, sand smooth and touch-up rust areas, and other areas where primer has been damaged, with prime touch-up paint.

B. Make adjustments as required for correct, proper, and free function and smooth operation without binding of hardware or doors and frames.

C. Protect doors and frames from damage to surface or profile.

END OF SECTION

SECTION 08710

DOOR HARDWARE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Door hardware.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
   2. E283 - Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.

B. Builders Hardware Manufacturers Association (BHMA):
   1. A156.7 - Template Hinge Dimensions.
   2. A156.18 - Materials and Finishes.

C. Underwriters Laboratories, Inc.

1.03 SUBMITTALS

A. Product data.

B. Hardware schedule: Include references to Engineer's hardware group number, door type designations, locations, other pertinent data, and manufacturer names or suitable abbreviation opposite items scheduled.

C. Samples: Include for each different type and manufacturer for review of finish.

D. Construction key distribution list: Submit upon Owner's request.

E. Templates:
   1. Furnish hardware templates to fabricators of doors, frames, and other work to be factory-prepared for hardware.
   2. Check shop drawings of other work to confirm that adequate hardware backing is available.

F. Project record documents: Include corrected hardware schedule.

1.04 REGULATORY REQUIREMENTS

A. Provide State Fire Marshall approved fire-rated cross-corridor assemblies and panic devices.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver hardware where directed in unopened packages with items packed separately, complete and ready for installation with necessary fittings, trim, fasteners, and accessories.

B. Provide packages bearing the manufacturers' labels with each item or group of items identified according to the accepted hardware schedule.

1.06 MAINTENANCE

A. Require lockset manufacturers to deliver permanent removable cylinder cores and keys to Owner directly.

1.07 SCHEDULING AND SEQUENCING

A. Upon receipt of accepted hardware schedule, coordinate accepted hardware schedule, templates, reinforcing units, and template instructions to door and frame sections.

B. Restrict distribution of construction keys to superintendents and foremen. Maintain record of persons who have received keys on construction distribution list.

PART 2 PRODUCTS

2.01 FASTENERS

A. Types:
   1. To concrete, marble, or masonry: Machine screws and flush shells.
   2. To wood: Wood screws.
   3. On gypsum board or plaster: Screws of sufficient length to provide solid connection to framing or backing behind gypsum board or plaster.
   4. To mineral and hollow core doors: Hex bolts.
   5. Of exit devices to doors: Thru-bolts, unless otherwise specified.

B. Screws, exposed: Phillips-head type, full-threaded screws, not combination type.

C. Sizes: Suitable for heavy use.

D. Finish: Stainless steel, unless otherwise required to match material and hardware finish.

2.02 HINGES

A. Manufacturers: One of the following or equal:
   1. Stanley.
   2. Hager.
   3. McKinney.
   4. Ives.

B. Material:
   1. Exterior doors: Stainless steel.

C. Knuckles, number of: Minimum 5.

D. Ball bearings: Concealed with interior self-lubricating bushings.

E. Type for doors with closers: Ball bearing.

F. Pins for interior doors: Non-rising.

G. Pins for exterior doors: Non-removable.

H. Template hinges: BHMA A156.7.

I. Tips: Flat button.

J. Height: As follows, unless otherwise specified:
   1. Doors 1-3/8-inch thick: 3-1/2 inches.
   2. Doors 1-3/4-inch thick and up to 41 inches wide: 4-1/2 inches.
   3. Doors 1-3/4-inch thick and from 41 to 48 inches wide: 4-1/2 inches, extra heavy.
   4. Doors 2 inches thick or over 48 inches wide: 5 inches, extra heavy.

K. Widths: Sufficient to clear trim projection when door swings 180 degrees, unless otherwise specified.

L. Number per door leaf: As follows, unless otherwise specified:
   1. 3 hinges on door to 7 feet, 6 inches in height.
   2. 1 additional hinge for each additional 2 feet, 6 inches of height or fraction thereof.

2.03 CONSTRUCTION KEYING

A. Type: Removable core system.

2.04 CLOSERS

A. Manufacturers:
   1. Features:
      a. Heavy-duty.
      b. Non-handed and non-sized.
      c. Adjustable spring power from size 1 through 4.
      d. Hold open feature where specified.
   2. One of the following or equal:
      a. Sargent, 351 Series.
      b. LCN, Super Smoothee Model 4041 Series.
      c. Norton Door Controls, Multi-Size Door Closers Model 7500BF Series.

B. Type: Full rack and pinion type with steel spring and non-gumming, non-freezing hydraulic fluid.

C. Controls: Separate set for regulating sweep speed, latch speed, backcheck and backcheck positioning, or where schedules, spring power.

D. Sizes: As recommended by accepted manufacturer.

E. Covers: Plastic, capable of being spray painted to match adjacent hardware finishes, unless otherwise specified.

F. Narrow frame provisions: Drop plates.

G. Effort to operate: As follows:
   1. Exterior: Maximum 8-1/2 pounds.
   2. Interior: Maximum 5 pounds.
   3. Fire-resistive rated doors: Maximum 15 pounds.

H. Adjust closers in accordance with manufacturer's directions for size of door.

2.05 EXIT DEVICES

A. Lever design:
   1. Manufacturers: The following or equal:
      a. Von Duprin, Lever Model 06.

B. Rim device, non-fire resistive rated:
   1. Manufacturers: One of the following or equal:
      a. Von Duprin Inc., Model Series 98.
      b. Sargent Essex Ind., Model Series 8800.

C. Material: As scheduled.

D. Corrosive environment provisions: Zinc dichromate coated internal parts.

2.06 MISCELLANEOUS DOOR HARDWARE

A. Manual flush bolts: Mortise, and strikes; materials as scheduled:
   1. Manufacturers: One of the following or equal:
      a. Glynn-Johnson.
      b. Hager Hinge Co.

B. Gasketing systems: As scheduled, self-adhesive silicone seal, continuous at head and jambs, rated for fire and smoke in accordance with ASTM E283, sound rated in accordance with ASTM E90:
   1. Manufacturers: One of the following or equal:
      a. Pemko Mfg. Co.
      b. National Guard Products Inc.
      c. Reese.

C. Weatherstripping for exterior doors and smoke, light, and sound seals for interior doors.

D. Thresholds: As scheduled, extruded aluminum, maximum 1/2-inch high, maximum slope of 1 foot in 2 feet:
   1. Manufacturers: One of the following or equal:
      a. National Guard Products Inc.
      b. Pemko Mfg. Co.

E. Dustproof strike: As scheduled:
   1. Manufacturers: One of the following or equal:
      a. Ives.
      b. Trimco.

F. Door bottoms: As scheduled, extruded aluminum with vinyl insert, surface mounted, length equal to door width minus 2 inches, automatic, recessed in bottom of door.
   1. Manufacturers: One of the following or equal:
      a. Pemko.
      b. Reese.

G. Astragals: As specified in Sections 08110 - Hollow Metal Doors and Frames.

2.07 FINISHES

A. Brass and bronze: BHMA A156.18 626 (US26D), satin chrome.

B. Steel: BHMA A156.18 652 (US26D), satin chrome.

C. Stainless steel: BHMA A156.18 630 (US32D), satin stainless steel.

D. Aluminum: BHMA A156.18 628 (US28).

E. Plastic closer covers: Spray paint to match typical door hardware finish.

F. Metal closer covers: Plate covers to match typical door hardware finish.

G. Electromagnetic hold open devices: Manufacturer's standard brushed zinc finish.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect doors and door frames for damage or defects and examine hardware for compatibility with receiving conditions and suitable to intended use.

B. Verify that required wall backing has been installed.

3.02 INSTALLATION

A. Install finish hardware in accordance with manufacturer's templates and instructions.

B. Accurately and properly fit hardware.

C. Securely fasten fixed parts for smooth, trouble-free, non-binding operation.

D. Fit faces of mortise parts snug and flush.

E. Ensure that operating parts move freely and smoothly without binding, sticking, or excessive clearance.

F. Protection:
   1. Protect door hardware from damage or marring of finish during construction, use strippable coatings, removable tapes, or other acceptable means.
   2. Ensure door hardware displays no evidence of finish paint after final building cleanup with exception of prime-coated door hardware installed for finish painting.

G. Latch guard and dead bolts: Install so that bolts automatically engage in keeper, whether activated by closer or by manual pressure.

H. Closers:
   1. Mount on opposite sides of corridors or vestibules, except at exterior doors.
   2. Mount for 180-degree swing wherever possible.
   3. Mount with drop plates at narrow top rail doors.
   4. Adjust to operate noiselessly and evenly.
   5. Have closer manufacturer regulate closers prior to final acceptance of project.

I. Gasketing: Mount to provide complete contact between door and frame, finished floor, or both; and weathertight enclosure.

J. Thresholds:
   1. Install immediately before inspection for Substantial Completion or protect from heavy traffic damage during construction.
   2. Cope to fit door frame profile and drill to suit required flush bolts and panic bolts.
   3. Unless indicated on the Drawings to be set in grout, set in double bead of sealant, tightly fit at jambs, and make waterproof.
   4. Fasten to concrete slab with 5/16-inch stainless steel flat head countersunk machine screws and concrete anchors at 8-inch centers.

3.03 CONSTRUCTION KEYING

A. Insert construction inserts in cylinder cores of exterior doors, and doors requiring security and access for workman, unless otherwise directed by the Engineer.

3.04 ADJUSTING

A. Examine hardware in place for complete and proper installation. Lubricate bearing surfaces for proper function.

B. Replace, rework or otherwise correct defective door hardware, including incorrect hand or function.

3.05 CLEANING

A. Remove protective materials and devices and thoroughly clean exposed surfaces of hardware.

B. Check for surface damage prior to final cleaning for acceptance of project.

3.06 HARDWARE SCHEDULE

A. While the Hardware Schedule is intended to cover all doors and other moveable parts of the building and establish a type and standard of quality, it shall be the specific duty and responsibility of the finish hardware supplier to examine the Drawings and Specifications and furnish proper hardware for all openings.

3.07 HARDWARE GROUPS

A. HW 1: Door D-101:

3 EA HingeBBB1191 4 1/2 X 4 1/2US26DHA
1 EAExit Device9875L X 996L-MUS26DVO
1 EACloser 7500 SN-134689NO
1 SETWeatherstripping 303ASPE
1 EADoor Bottom 216AVPE
1 EAThreshold 170 APE
1 EARaindrip346 CPE

B. HW 2: Door D-102:

3 EA	Hinge	BB1191 4 1/2 X 4 1/2	US26D	HA
1 EA	Exit Device	9875L X 996L-M	US26D	VO
1 SET	Auto Flush Bolt	FB31P	630	Ives
1 EA	Dust Proof Strike	DP2	626	Ives
1 EA	Astragal	357C 600		PE
1 EA	Closer	7500 SN-134689		NO
1 SET	Weatherstripping	303AS		PE
1 EA	Door Bottom	216AV		PE
1 EA	Threshold	170 A		PE
1 EA	Raindrip	346 C		PE

END OF SECTION

SECTION 08800

GLAZING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Glass and glazing.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. Z97.1 - Safety Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test.

B. ASTM International (ASTM):
   1. C1036 - Standard Specification for Flat Glass.
   2. C1048 - Standard Specification for Heat-Treated Flat Glass - Kind HS, Kind FT Coated and Uncoated Glass.
   3. E773 - Standard Test Method for Accelerated Weathering of Sealed Insulating Glass Units.

C. Glass Association of North America (GANA):
   1. GANA Glazing Manual.

D. Insulating Glass Certification Council (IGCC):
   1. Certified Products Directory.

E. U.S. Consumer Product Safety Commission (CPSC):
   1. 16 CFR 1201 - Safety Standard for Architectural Glazing Materials.

1.03 DEFINITIONS

A. Full height windows: Windows meeting the following conditions:
   1. Lowest edge is less than 18 inches above floor.
   2. Area is greater than 9 square feet.
   3. Walking surface is on both sides either of which is within 36 inches of window.
   4. Window has no minimum 1-1/2-inch railing or mullion at from 24 to 36 inches above floor.

1.04 SUBMITTALS

A. Product data.

B. Shop drawings: Locations of glass types and typical glazing details.

C. Samples: As follows:
   1. Glazing sealants, 2-inch long beads, for color selection.
   2. Glass, 1 square foot of each type specified.

D. Certificates of compliance: Certification that tempered glass in accordance with ANSI Z97.1 and CPSC 16 CFR 1201.

E. Manufacturer's Installation Instructions.

1.05 REGULATORY REQUIREMENTS

A. As specified in Section 01410 - Regulatory Requirements.

B. Wind loading: As specified in Section 01614 - Wind Design Criteria.

C. Provide glass and glazing that conforms to CPSC 16 CFR, Part 1201, and exit requirements of the building code.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials in manner to prevent damage.

B. Deliver and store packaged materials in original containers bearing manufacturer's name.

C. Deliver glass affixed with manufacturer's labels showing strength, grade, thickness, type and quality of glass, and for insulating glass, IGCC certification label.

D. Remove labels after installation, inspection, and final acceptance.

1.07 PROJECT CONDITIONS

A. Perform glazing when ambient air temperature is 40 degrees Fahrenheit or above.

1.08 WARRANTY

A. Warrant to replace insulating glass units that exhibit interpane dusting or misting within 10 years with new in accordance with manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 GLASS

A. Clear monolithic: ASTM C1036, Type I, Class 1, Quality q3; minimum 1/4-inch thick.
   1. Manufacturers: One of the following or equal:
      a. PPG Industries, Inc.
      b. Guardian Industries Corp., Sunguard, Clear.

B. Tinted monolithic: ASTM C1036, Type I, Class 2, Quality q3; tinted light bronze; minimum 1/4-inch thick:
   1. Manufacturers: One of the following or equal:
      a. PPG Industries, Inc., Solarbronze.
      b. Guardian Industries Corp., Sunguard, bronze.

C. Tempered: ASTM C1048, Kind FT, Condition A, Type I, Class 1 or Class 2 as scheduled below, Quality q3; tempered without visible tong marks when installed; minimum 1/4-inch thick:
   1. Manufacturers: One of the following or equal:
      a. PPG Industries, Inc., Herculite.
      b. Guardian Industries Corp., equivalent product.

D. Insulating glass units: IGCC Rating Level CBA when tested in accordance with ASTM E773 and E774; hermetically sealed units consisting of minimum 1/4-inch thick, tinted exterior light, minimum 1/4-inch thick, clear interior light, and 1/2-inch wide air space, dehydrated with blended molecular sieve and silica gel desiccant, with metal spacer channel with bent corners and welded splice on 1 vertical side, and polyisobutylene primary and silicone secondary seals.
   1. Manufacturers: One of The following or equal:
      a. PPG Industries, Inc., Twindow.
      b. Guardian Industries Corp., equivalent product.

2.02 GLAZING MATERIALS

A. Setting blocks: Neoprene, 80 to 90 durometer.

B. Spacer blocks: 30 to 40 durometer, thickness equal or greater than insulated window thickness by minimum 6 inches long.

C. Pressure tape: Butyl rubber tape:
   1. Manufacturers: One of the following or equal:
      a. Tremco Mfg. Co., Tremco 440 Tape.
      b. 3-M Co., Weatherban 5422.

D. Sealant: Silicone:
   1. Manufacturers: One of the following or equal:
      a. General Electric Co., Silicone Construction Sealant Series SCS-1200.
      b. Dow Corning Corp., 999-A, Silicone Building and Glazing Sealant.

2.03 SOURCE QUALITY CONTROL

A. Allowable bow and warp tolerances: As measured with glass resting on edge upon two 1 inch wide supports:
   1. Typical: Maximum 1/8 inch in 48 inches.
   2. Tempered glass: Maximum allowed in accordance with ASTM C1048.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine openings to receive glass for defects that would affect glass and glazing work.

B. Verify removal of rivets, screws, bolts, welding fillets, or other projections from clearances in glazing rabbets.

3.02 PREPARATION

A. Examine frames receiving glass and ensure surfaces are clean and dry.

B. Remove dust and oil from glass by wiping clean immediately before installation.

C. Verify that sealants are compatible with glazing materials.

3.03 INSTALLATION OF MONOLITHIC GLASS

A. In accordance with GANA Glazing Manual, manufacturer's instructions, and accepted shop drawings by the Engineer.

B. Glaze doors in closed position after hanging and adjustment.

C. Accurately size and cut glass clean for each glazing condition:
   1. Do not nip edges.

D. Cut and set glass to full fit and play consistent with expansion and contraction requirements and at exterior for absolute security under maximum high velocity wind and vacuum stresses.

E. Maintain edge clearance at least equal to glass thickness from perimeter of glass to inside of rabbet.

F. Maintain 1/8-inch clearance between faces of glass and adjacent stop or bead.

G. Maintain minimum bite of 3/8 inch.

H. Set glass as required to ensure against optical distortion.

3.04 INSTALLATION OF INSULATED GLASS UNITS

A. In accordance with GANA Glazing Manual, manufacturer's instructions, and accepted shop drawings by the Engineer.

B. Use wet and dry glazing method.

C. Cut glazing tape to length and set against permanent stops to project 1/16 inch above sight line.

D. Place setting blocks at quarter points and no closer than 6 inches from corners.

E. Rest glazing on setting blocks and push against tape for full contact at perimeter of unit.

F. Place glazing gasket.

G. Install removable stop with concealed leg notched to accommodate setting blocks.

H. Align top of gasket with stops.

3.05 INSTALLATION OF GASKETS

A. Gaskets: Install in accordance with manufacturer's instructions.

B. Glazing of interior metal frames: Use pressure or foamed tape and sealant as indicated as required to eliminate rattle and reduce sound transmission.

3.06 SEALANT APPLICATION

A. As specified in Section 07900 - Joint Sealants, unless specifically noted otherwise.

B. Ensure protective coatings have been removed from aluminum surfaces.

C. Where setting blocks and spacer shims are required to be set in sealant, butter with sealant, place into position, and allow to set prior to installation of glass.

D. Neatly tool sealant or compound joints to compress material and improve adhesion. Repair or replace pockets exposed by tooling.

3.07 CLEANING

A. After inspection by Engineer, remove labels and marks from glass in accordance with manufacturer's published recommendations.

B. Clean glass and surrounding surfaces from spatter and blemishes resulting from glazing operations.

C. Clean and polish glass inside and outside.

D. Clean glass with a soft, clean, grit-free cloth and mild soap, detergent, or slightly acidic cleaning solution:
   1. Immediately rinse with clean water and remove excess rinse water with a clean squeegee.
   2. Do not use an abrasive cleaner.

E. Remove grease and miscellaneous glazing materials with commercial solvent. Follow with normal wash and rinse:
   1. Be careful not to damage joint sealers.

3.08 GLASS AND LOCATION SCHEDULE

A. Exterior locations: Glass as follows, unless otherwise scheduled or indicated on the Drawings:
   1. Typical: Insulating, tinted, tempered.

END OF SECTION

SECTION 09960

HIGH-PERFORMANCE COATINGS
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PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Coatings, including coating systems, surface preparation, application requirements, and quality control requirements.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
   2. D2200 – Standard Practice for Use of Pictorial Surface Preparation Standards and Guides for Painting Steel Surfaces.
   3. D3359 - Standard Test Methods for Rating Adhesion by Tape Test.
   4. D3960 - Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings.
   5. D4262 - Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces.
   6. D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
   7. D4285 - Standard Test Method for Indicating Oil or Water in Compressed Air.
   8. D4414 - Standard Practice for Measurement of Wet Film Thickness by Notch Gages.
   9. D4417 - Standard Test Methods for Field Measurement of Surface Profile of Blast-Cleaned Steel.
   10. D4541 - Standard Test Methods for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
   11. D4787 - Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.
   12. D5162 - Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates.
   13. D7234 - Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.
   14. E337 - Standard Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures).
   15. F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
   16. F2170 - Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In-situ Probes.

B. International Concrete Repair Institute (ICRI):
   1. 310.2 - Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

C. NACE International (NACE):
   1. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.
   2. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

D. National Association of Pipe Fabricators (NAPF):
   1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

E. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

F. Occupational Safety and Health Administration (OSHA).

G. Society of Protective Coatings (SSPC):
   1. Glossary - SSPC Protective Coatings Glossary.
   2. Guide 6 - Guide for Containing Surface Preparation Debris Generated during Paint Removal Operations.
   3. Guide 15 - Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates.
   4. PA 1 - Shop, Field, and Maintenance Painting of Steel.
   5. PA 2 - Procedure for Determining Conformance to Dry Coating Thickness Requirements.
   6. PA 9 - Measurement of Dry Coating Thickness Using Ultrasonic Gages.
   7. QP 1 - Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors.
   8. SP 1 - Solvent Cleaning.
   9. SP 3 - Power Tool Cleaning.
   10. SP 5 - White Metal Blast Cleaning.
   11. SP 10 - Near-White Metal Blast Cleaning.
   12. SP 11 – Power Tools Cleaning to Bare Metal.
   13. SP 13 - Surface Preparation of Concrete.
   14. SP 16 - Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
   15. SP COM - Surface Preparation Commentary.
   16. SP VIS 1 - Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.
   17. SP WJ-1 - Waterjet Cleaning of Metals -- Clean to Bare Substrate.
   18. SP WJ-2 - Waterjet Cleaning of Metals -- Very Thorough Cleaning.
   19. SP WJ-3 - Waterjet Cleaning of Metals -- Thorough Cleaning.
   20. SP WJ-4 - Waterjet Cleaning of Metals -- Light Cleaning.

1.03 DEFINITIONS

A. Definitions used in this Section are in accordance with definitions referenced in ASTM D16, ASTM D3960, and SSPC Glossary of Definitions.

B. Specific definitions:
   1. Abrasive: Material used for blast cleaning, such as sand, grit, or shot.
   2. Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed.

3. Anchor Pattern: Profile or texture of prepared surface(s).
4. Biogenic Sulfide Corrosion: Corrosion caused by sulfuric acid formed when *Thiobacillus* bacteria metabolizes hydrogen sulfide.
5. Bug Holes: Small cavities resulting when air bubbles are entrapped in the surface of formed concrete during placement and consolidation.
6. System: Protective film with 1 or more coats applied in a predetermined order, including surface preparation and quality control requirements.
7. Coating/Paint/Lining Thickness: Total thickness of primer, intermediate, and/or finish coats after drying or curing.
8. Dew point: Temperature a given air/water vapor mixture starts to condense.
9. Drying Time: Time interval between application and material curing.
10. Dry to Recoat: Time interval between material application and its ability to receive the next coat.
11. Dry to Touch: Time interval between material application and its ability to tolerate a light ouch without coating damage.
12. Exposed Surface: Any indoor or outdoor surface not buried or encased.
13. Feather Edging: Reducing coating thickness at its edge to blend with existing surrounding coating.
14. Feathering: Tapering off a wet edge with a comparatively dry brush.
15. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.
16. Field Coat: Application of a surface coating system at the work site.
17. Finish Coat: Final coat in a paint system, including texture, color, smoothness of surface, and other properties affecting appearance.
18. Hold Point: A defined point, specified in this Section, at which work shall be halted for inspection.
19. Holiday: A discontinuity, skip, void, or pinhole in coating or coating system film that exposes the substrate.
20. Honeycomb: Segregated and porous surface of hardened concrete due to insufficient consolidation.
21. Hydroblast: High or ultra-high pressure water jet surface preparation.
22. Incompatibility: One coating's inability to overlay another coating or surface as evidenced by bleeding, poor bonding, or lifting of old coating; inability of a coating to bond to a substrate.
23. Immersed/Immersion: A service condition in which substrate is submerged, is immediately above liquids, or is subject to frequent wetting, splashing, or washdown.
24. Laitance: A thin, weak, brittle layer of cement and aggregate fines on a concrete surface.
25. Mil: 0.001 inch.
26. Overspray: Dry spray, particularly paint bonded to an unintended surface.
27. Pinhole: A small diameter discontinuity in a coating or coating system film, created by offgassing from a void in a concrete or masonry substrate causing a void between coats or exposing the substrate. Usually caused by coating application while temperature is rising.
28. Pot Life: Time interval after components are mixed and coating can be satisfactorily applied.
29. Prime Coat: First full paint coat applied to a surface when using a multicoat system. Primers adhere to a new substrate, protect the substrate, and promote adhesion of subsequent coats of paint. The prime coat on metal surfaces is the first full coat and does not include solvent wash, grease emulsifiers, or other pretreatment applications.

30. Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-based material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces.
31. Shelf Life: Maximum storage time a material may be stored without losing its usefulness.
32. Shop Coat: 1 or more coats applied in an off-site shop or plant before shipment to work site where field or finishing coat(s) are applied.
33. Spreading Rate: Area covered by a unit volume of paint at a specific thickness.
34. Stripe Coat: A separate brush coat of paint applied to all weld seams, pits, nuts/bolts/washers, and edges. This coat shall not be applied until previous coats have cured. Once applied, the coat shall be allowed to cure before subsequent coats are applied.
35. Tie Coat: An intermediate coat that bonds different types of paint material, improving succeeding coat adhesion.
36. Thick Film Coating System: A coating system applied with a minimum dry film thickness of 25 mils.
37. Touch-Up Painting: Application of paint on previously painted surfaces to repair marks, scratches, and deteriorated or damaged areas to restore the appearance and performance of the coating.
38. Water Blast: An alternative to air abrasive blast cleaning that can be used with or without abrasive injection. Water cleaning at pressures up to 5,000 pounds per square inch is called low-pressure water cleaning or power washing. High- pressure water cleaning uses water pressures between 5,000 and 10,000 pounds per square inch. Water jetting is water blasting with added abrasive at pressures between 10,000 and 25,000 pounds per square inch. Ultra-high-pressure water jetting is water blasting at pressures above 25,000 pounds per square inch.
39. Weld Splatter: Beads of non-structural weld metal that adhere to the surrounding surface, removed as part of surface preparation.

1.04 ABBREVIATIONS

A. CSM - Coating System Manufacturer.

B. CMU - Concrete Masonry Units.

C. CSA - Coating System Applicator. Specialty subcontractor retained by the Contractor to install the coating systems specified in this Section.

D. CTR - Coating System Manufacturer's Technical Representative.

E. DFT - Dry-Film Thickness**.** Thickness of cured film, usually expressed in mils (0.001 inch).

F. SSD - Surface Saturated Dry. Refers to concrete surface condition where the surface is saturated (damp) without the presence of standing water.

G. TPC - Technical Practice Committee.

H. VOC - Volatile Organic Compound. Portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing; expressed in grams per liter (g/l) or pounds per gallon (lb/gal). VOC is determined by EPA Method 24.

I. WFT - Wet Film Thickness. Coating thickness as measured immediately after application. Usually expressed in mils (0.001 inch).

1.05 PERFORMANCE REQUIREMENTS

A. Coating materials shall be formulated for environments encountered in water and wastewater treatment processes.

B. Coating materials that come in contact with water distributed as potable water shall be certified in accordance with NSF 61.

1.06 SUBMITTALS

A. As specified in Section 01330 - Submittal Procedures, submit the following:
   1. Schedule of proposed coating materials.
   2. Schedule of surfaces to be coated with each coating material.
   3. Dehumidification and heating plan.
   4. Product data:
      a. Physical properties of coatings, including the following:
         1) Solids content.
         2) Ingredient analysis.
         3) VOC content.
         4) Temperature resistance.
         5) Typical exposures and limitations.
         6) Manufacturer's standard color chips.
      b. Compliance with regulatory requirements:
         1) VOC limitations.
         2) Lead compounds and polychlorinated biphenyls.
         3) Abrasives and abrasive blast cleaning techniques and disposal.
         4) Methods for tenting blasting areas and methods to protect existing equipment from dust and debris.
         5) NSF certification of coatings for potable water supply systems.
      c. CSM's current printed recommendations and product data sheets for coating systems, including:
         1) Surface preparation recommendations.
         2) Primer type.
         3) Maximum dry and wet-mil thickness per coat and number of coats:
            a) Coating Coverage Worksheets.
         4) Minimum and maximum curing time between coats, including atmospheric conditions for each.
         5) Curing time before submergence in liquid.
         6) Thinner to be used for each coating.
         7) Ventilation requirements.
         8) Minimum and maximum atmospheric conditions during which the paint shall be applied.
         9) Allowable application methods.
         10) Maximum allowable substrate moisture content.
         11) Maximum shelf life.
         12) Requirements for transportation and storage.
         13) Mixing instructions.
         14) Shelf life.
         15) Material pot life.

16) Precautions for applications free of defects.
17) Method of application.
18) Drying time of each coat, including prime coat.
19) Compatible prime coats.
20) Limits of ambient conditions during and after application.
21) Required protection from sun, wind, and other conditions.
22) Touch-up requirements and limitations.
23) Minimum adhesion of each system submitted in accordance with ASTM D4541 and ASTM D7234.

d. Samples: Include 8-inch square drawdowns or brushouts of topcoat finish when requested. Identify each sample as to finish, formula, color name and number, sheen name, and gloss units.
e. Affidavits signed by an officer of the CSM's corporation attesting to full compliance of each coating system component with current federal, state, and local air pollution control regulations and requirements.
f. List of cleaning and thinner solutions allowed by the CSMs.
g. Storage requirements, including temperature, humidity, and ventilation for Coating System Materials as recommended by the CSMs.
h. Thick film coating systems (greater than 25 mils):
1) CSM's detailed written instructions for coating system treatment and graphic details for coating system terminations in coated structures, including pipe penetrations, metal embedments, gate frames, and other terminations encountered.
2) Include detail treatment for coating system at concrete joints.
3) Manufacturer's Representative's (CTR) Field Reports.

5. Quality assurance submittals:
a. Quality assurance plan.
b. Qualifications of CSA, including:
1) List of Similar Projects:
a) Name and address of project.
b) Year of installation.
c) Year placed in operation.
d) Point of contact: Name and phone number.
2) Provide a minimum of 5 project references, each including contact name, address, and telephone number where similar coating work has been performed by their company in the past 5 years.
c. CSA Reports:
1) Written daily quality control inspection reports.
d. CTR Reports:
1) Reports on visits to project site to view and approve surface preparation of structures to be coated.
2) Reports on visits to project site to observe and approve coating application procedures.
3) Reports on visits to coating plants to observe and approve surface preparation and coating application on shop-coated items.

1.07 QUALITY ASSURANCE

A. CSA qualifications:
   1. Minimum of 5 years of experience applying specified type or types of coatings under conditions similar to those of the Work:
      a. Provide qualifications of applicator and references listing 5 similar projects completed in the past 5 years.
   2. SSPC QP 1 certified.
   3. Manufacturer-approved applicator when manufacturer has approved applicator program or when required in these specifications.

B. CTR qualifications:
   1. Certification, one of the following:
      a. NACE Level 2 or 3 Certified Coating Inspector.
      b. SSPC Level 3 Protective Coatings Inspector.
   2. Minimum of 5 years of experience evaluating application of manufacturer's coatings under conditions similar to those of the Work:
      a. Provide CTR qualifications and references listing 5 similar projects completed in the past 5 years.

C. Regulatory requirements: Comply with governing agencies' regulations by using coatings conforming to their VOC limits:
   1. Lead-based coatings are not permitted.
   2. Do not use coal-tar epoxy in contact with drinking water or exposed to ultraviolet radiation.

D. Certification:
   1. Certify that applicable pigments resist deterioration when exposed to hydrogen sulfide and other sewage gases.
   2. Product data shall designate coating as being suitable for wastewater service.

E. Pre-installation conference: Conduct as specified in Section 01312 - Project Meetings:
   1. Coordinate Hold Point schedule.

F. Field samples:
   1. Prepare and coat a minimum 100-square-foot area of each system between corners or limits such as control or construction joints.
   2. Approved field sample may be part of the Work.

G. Obtain approval before coating other surfaces. Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.

H. CSM services:
   1. CSA shall arrange for CTR to attend pre-installation conferences.
   2. Visit the project site periodically to consult on and inspect specified surface preparation and application Hold Points.
   3. Visit coating plants to observe and approve surface preparation procedures and coating application of items to be shop primed and coated.
   4. CTR shall provide written inspection reports.

I. Quality control requirements:
   1. Contractor shall be responsible for the workmanship and quality of the coating system installation:
      a. Inspections by Owner, Engineer, CSA, or CTR will not relieve or limit Contractor’s responsibilities.
   2. Conform to this specification's requirements and the standards referenced in this Section. Changes in the coating system application requirements will be allowed only with the Engineer's written acceptance.
   3. Specially trained crews with experience applying the specified coating system coating are required for:
      a. Coating application using plural component spray equipment or other specialty equipment.
      b. Coating with specialty linings for severe service conditions, including floor coatings, and with linings for corrosive headspaces or secondary containment areas.
   4. CTR shall specially train personnel for coating systems as specified in Appendix B Coating Detail Sheets:
      a. CSM shall approve personnel in writing applying the coating system.
   5. Do not use contaminated, outdated, diluted materials, and/or materials from previously opened containers.
   6. Identify inspection access points used by Owners or Engineers.
   7. Provide ventilation, ingress, egress, or other means as necessary for Owner's or Engineer’s personnel to safely access the work areas.
   8. Conduct and continually inspect work so the coating system is installed as specified. The CSM shall provide written directions to correct coating work not conforming to the specifications or is otherwise unacceptable.
   9. Provide written daily reports summarizing test data, work progress, surfaces covered, ambient conditions, quality control inspection test findings, and other information pertinent to the coating system application:
      a. Determine relative humidity in accordance with ASTM E337. Confirm other conditions, such as proper protective measures for surfaces not to be coated and safety requirements for personnel:
         1) Measure daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
         2) Determine the acceptability of weather and/or environmental conditions within the structure in accordance with the CSM's requirements.
      b. Monitoring surface preparation: Spot check cleanliness, surface profile, and surface pH testing at least 3 times daily. Check each surface at least once. In accordance with:
         1) ASTM D4262.
         2) ASTM D4263.
         3) ASTM D4417.
         4) ICRI 310.2 requirements.
         5) SSPC Surface Preparation Standards.
      c. Confirm that compressed air used for surface preparation or blow-down cleaning is free of oil and moisture.
      d. Monitor surface preparation daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
      e. Do not apply coatings when environmental conditions are outside of the CSM's published limits.

f. Monitoring coatings application: Continuously inspect, measure, and record the wet film thickness and general film quality (visual inspection) for runs, sags, pinholes, holidays, etc. during coating:
   1) Perform WFT measurements in accordance with ASTM D4414.
g. Post cure evaluation: Measure and inspect the overall dry film thickness on all surfaces. Conduct a DFT survey and perform adhesion testing, holiday detection, or cure testing as required in this Section and/or the CSM's written instructions. Perform all applicable tests in accordance with ASTM D4541, ASTM D4787, ASTM D5162, ASTM D7234, SSPC-PA 1, SSPC-PA 2, SSPC-PA 9, and other pertinent standards and recommended practices.

J. Inspection at Hold Points:
1. Conduct inspections at Hold Points during the coating system application and record the results.
2. Coordinate Hold Points with the Engineer so the Engineer can observe Contractor's inspections on a scheduled basis.
3. Provide the Engineer a minimum of 24 hours of notice before conducting Hold Point Inspections.
4. Hold Points shall be as follows:
   a. Conditions before surface preparation: Before starting surface preparation, observe, record, and confirm that oil, grease, and/or soluble salts are gone from the surface.
   b. Post surface preparation: After completing surface preparation, measure and inspect for cleanliness and proper surface profile as specified in this Section and in the CSM's written instructions.
   c. Coatings application: At the beginning of any coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.
   d. Post application inspection: Identify defects in application work on all surfaces, including pinholes, holidays, excessive runs or sags, inadequate or excessive film thickness, and other problems.
   e. Follow-up corrective actions and final inspection: Measure and re-inspect corrective coating work performed to repair defects at prior Hold Points, and repeat until the surface condition is acceptable. Conduct final visual inspection with follow-up tests, such as holiday detection, adhesion tests, and DFT surveys.
   f. Coatings application: At the beginning of coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application:
      1) Observe conditions during the Pre-application Meeting.

1.08 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products as specified in Section 01600 - Product Requirements.

B. Immediately remove unspecified and unapproved coatings from Project site.

C. Deliver new labeled, unopened containers:
   1. Do not deliver materials after manufacturer's expiration date or over 12 months from manufacturing date, whichever is more stringent. Store materials in well-ventilated enclosed structures and protect from weather and excessive heat or cold in accordance with the CSM's recommendations:
      a. Store flammable materials in accordance with federal, state, and local requirements.
      b. Store rags and cleanup materials appropriately to prevent fire and spontaneous combustion.
   2. Store and dispose of hazardous waste in accordance with federal, state, and local requirements. This requirement specifically applies to waste solvents and coatings.
   3. Container labels shall show the following:
      a. Brand name or product title.
      b. CSM's batch number.
      c. CSM's manufacture date.
      d. CSM's name.
      e. Generic material type.
      f. Application and mixing instructions.
      g. Hazardous material identification label.
      h. Shelf life expiration date.
      i. Color.
      j. Mixing and reducing instructions.
   4. Clearly mark containers to indicate safety hazards associated with the use of or exposure to materials.

1.09 PROJECT CONDITIONS

A. Apply coatings to dry surfaces.
   1. Surface moisture: Comply with manufacturer's requirements or as specified in this Section:
      a. Plaster and gypsum wallboard: 12 percent.
      b. Masonry and concrete block: 12 percent.
      c. Interior located wood: 15 percent.
      d. Concrete floors: Moisture vapor transmission rate of no more than 3.0 pounds per 1,000 square feet per 24 hours in accordance with ASTM F1869 or relative humidity no greater than 80 percent if tested in accordance with ASTM F2170 unless the CSM's recommendations are more restrictive.
      e. Concrete structures: Negative results from Plastic Sheet Test in accordance with ASTM D4263, and maximum of 80 percent relative humidity in accordance with ASTM F2170.

B. Do not apply coatings when the following conditions exist. If such conditions exist, provide containment, covers, environmental controls, and other necessary measures:
   1. During rainy, misty, or damp weather, or to surfaces with frost or condensation.
   2. When the surface temperature is below 10 degrees Fahrenheit above the dew point.

3. When ambient or surface temperature:
    a. Is less than 55 degrees Fahrenheit unless manufacturer allows a lower temperature.
    b. Is less than 65 degrees Fahrenheit for clear finishes unless manufacturer allows a lower temperature.
    c. Exceeds 90 degrees Fahrenheit unless manufacturer allows a higher temperature.
    d. Exceeds manufacturer's recommendation.
4. When relative humidity is higher than 85 percent.
5. Under dusty or adverse environmental conditions.
6. When light on surfaces measures less than 15 foot-candles.
7. When wind speed exceeds 15 miles per hour.

C. Apply coating only under evaporation conditions rather than condensation:
    1. Use dehumidification equipment, fans, and/or heaters inside enclosed areas to maintain required atmospheric and surface temperature requirements for proper coating application and cure.
    2. Measure and record relative humidity and air and surface temperatures at the start and end of each shift to confirm proper humidity and temperature levels inside the work area:
        a. Submit test results.

D. Continuously ventilate, dehumidify, and heat enclosed spaces with high humidity during surface preparation, coating application, and curing:
    1. Maintain minimum air temperature of 55 degrees Fahrenheit and 10 degrees Fahrenheit above the dew point.
    2. Maintain dew point of at least 10 degrees Fahrenheit less than the temperature of the coldest part of the structure where work is performed.
    3. Reduce dew point temperature in conditioned space by at least 10 degrees Fahrenheit within 20 minutes.
    4. Seal work areas and maintain positive pressure per dehumidification equipment supplier's recommendations.
    5. Maintain these conditions before, during, and after application to ensure proper adhesion and cure of coatings for no less than:
        a. Entire curing period.
        b. 8 hours after coating.

E. Systems:
    1. Site electrical power availability as specified in Section 01500 - Temporary Facilities and Controls.
    2. Internal combustion engine generators may be used:
        a. Obtain required permits and provide air pollution and noise control devices on equipment as required by permitting agencies require.
        b. Comply with state, federal, and local fire and explosion protection measures when locating and operating generator.
        c. Locate engine generator outside hazardous classified areas per NFPA 820.
        d. Provide daily fuel service for generator for duration of use.
    3. Dehumidification:
        a. Provide desiccant or refrigeration drying.
        b. Use only desiccant types with a rotary desiccant wheel capable of continuous operation.

c. Liquid, granular, or loose lithium chloride drying systems are not acceptable.

4. Heating:
   a. Use electric, indirect combustion, or steam coil.
   b. Direct-fired combustion heaters are not acceptable heat sources during abrasive blasting, coating application, or coating cure.
5. Filters:
   a. Use a filtration system for dust removal designed to not interfere with dehumidification equipment's ability to control dew point and relative humidity inside the reservoir.
   b. Do not allow air from the working area or dust filtration equipment to recirculate through thein dehumidifier during coating application or when solvent vapors are present.
6. Design and submittals:
   a. Prepare and submit dehumidification and heating plan, including all equipment and operating procedures.
   b. Suppliers of services and equipment shall have at least 3 years of experience in similar applications.

F. Provide containment and ventilation system components in accordance with SSPC- Guide 6, Level 3 and as required for hazardous materials.

1.10 MAINTENANCE

A. Provide table of products applied organized by surface type. List coating manufacturer, color, color formulation, distributor name, telephone number, and address.

B. Provide extra materials:
   1. Minimum 1 gallon of each type and color of coating applied or provide additional quantities if specified in the Contract Documents:
   2. Deliver unopened factory-labeled cans when manufacturer packages material in gallon cans.
   3. Deliver material in new gallon containers, properly sealed and identified with permanently affixed, durable, printed labels indicating brand, type, and color, when manufacturer does not package material in gallon cans, deliver.

1.11 CTR RESPONSIBILITIES

A. General:
   1. Attend pre-installation conference.
   2. Perform onsite application training.
   3. Periodically inspect coating system application.

B. Coating system installation training:
   1. Provide a minimum of 8 hours of classroom and off-site training for application personnel and supervisory personnel in one of the following ways:
      a. Train a minimum of 2 supervisory personnel and 2 application personnel.
      b. Submit a letter from the CSM stating that CSM approves the supervisory and application personnel, listed by name and responsibility, and no additional training is required.
   2. CTR can train up to 14 application personnel and 3 supervisory personnel at a time.

3. Minimum training requirements:
    a. Explain in detail the mixing, application, curing, and termination requirements.
    b. Provide hands-on demonstration of coating system mixing.
    c. Explain in detail the ambient condition requirements for temperature and humidity.
    d. Explain in detail the surface preparation requirements.
    e. Explain in detail the re-coat times, cure times, and related ambient condition requirements.
    f. Write a letter stating that training was satisfactorily completed by the personnel, listed by name and responsibility.
4. Provide special training as specified in the Coating Detail Sheets.

C. Coating system inspection:
1. CTR inspection is in addition to the CSA's inspection as specified in this Section.
2. Be on-site to oversee:
    a. Coating application at least once a week.
    b. End of surface preparation.
    c. During coating application.
    d. Post-cure inspection.
3. Routinely inspect and verify in writing that application personnel have successfully performed surface preparation, filler/surfacer application, coating system application, and Quality Control Inspection in accordance with this Section and to warrantable quality.
4. Perform the following activities to confirm conformance with the specifications:
    a. Inspect ambient conditions during coating system installation at Hold Points for conformance with the specified requirements.
    b. Inspect each coated surface type and coating system applied to verify the following:
        1) Cleanliness.
        2) Surface pH for concrete substrates.
        3) Confirm surface preparation of substrates where coating system will terminate or will be applied for conformance to the specified application criteria.
    c. Verify surface profile of substrates by completing the following:
        1) Inspect preparation and application of coating detail treatment at terminations, transitions, metal embedments in concrete, and joints and cracks in substrates.
        2) Inspect application of filler/surfacer materials for concrete and masonry substrates.
        3) Verify proper mixing of coating materials.
        4) Inspect application of primers and finish coats, including wet and dry film thickness.
        5) Inspect coating systems for proper cure times and conditions.
    d. Review adhesion testing of cured coating systems.
    e. Review coating system continuity testing.
    f. Inspect and record representative-localized repairs.
    g. Conduct final review of completed coating system installation.
    h. Prepare and submit site visit reports after each site visit to document that the coating work is in accordance with the CSM’s Recommendations.

D. Final report:
1. Prepare a final report, after coating work ends, summarizing each day's test data, observations, drawings, and photographs. Include substrate conditions, ambient conditions, and application procedures observed during the CTR's site visits. Include a statement that completed work was performed in accordance with the requirements of the CSM's recommendations.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
1. Product requirements as specified in Section 01600 - Product Requirements.

2.02 COATING SYSTEMS IDENTIFICATION

A. Naming Conventions: Coating Systems Identifications contain the elements defined in Table 1.

Table 1 Coating System Identification Elements

First Element	-	Second Element	-	Third Element	-	Fourth Element (optional)
3 or 4 alpha characters		1-3 alpha characters		1 number		3 or 4 alpha characters
Coating Type		Substrate		System Number		Additional Substrate or Special Condition
Example: EPX	-	C	-	6	-	BSC

1) First element identifies the coating type using the following abbreviations:
   a) ACR: acrylic.
   b) CTE: coal tar epoxy.
   c) ELA: elastomeric acrylic.
   d) EPU: epoxy-polyurethane.
   e) EPX: epoxy.
   f) POL: polyurethane.
   g) SIL: silicone.
   h) SILX: siloxane or silane.
   i) VE: vinyl ester.
2) Second element identifies the substrate using the following abbreviations:
   a) C: concrete or masonry.
   b) F: concrete flooring.
   c) FRP: fiber-reinforced plastic.
   d) GM: galvanized metal.
   e) M: metal.
   f) PVC: polyvinyl chloride, chlorinated polyvinyl chloride.
3) Third element identifies the sequential system number:
   a) For example, EPX-C-2 is the second standard epoxy coating system for concrete substrates.

4) Fourth element is optional and identifies the additional substrate or special condition with the following abbreviations:
   a) PWS: Potable water service applications (NSF-61 approved).
   b) BSC: Biogenic sulfide corrosion-resistant applications in wastewater.
   c) BG: Below grade or buried.
   d) OZ: Organic zinc primer, epoxy polyurethane system.
   e) SC: Secondary containment.

2.03 PRODUCTS FOR COATING SYSTEMS

A. Products: As specified in Appendix B Coating Detail Sheets.

B. Cleaning solvents:
   1. Requirements for solvent wash, solvent wipe, or cleaner used, including, but not limited to, those used for surface preparation in accordance with SSPC- SP 1:
      a. Emulsifying type.
      b. Containing no phosphates.
      c. Biodegradable.
      d. Does not damage zinc.
      e. Compatible with the specified primer.
      f. Complying with applicable air-quality control board requirements.
   2. Use clean white cloths and clean fluids in solvent cleaning.

PART 3 EXECUTION

3.01 GENERAL PROTECTION REQUIREMENTS

A. Protect adjacent coated surfaces from coatings and damage associated with coating work. Repair damage resulting from inadequate or unsuitable protection.

B. Use drop cloths and other coverings to protect adjacent surfaces not to be coated against spatter and droppings.

C. Mask off surfaces of items not to be coated or remove items from area.

D. Furnish and deploy sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being coated and, in particular, surfaces within storage and preparation areas.

E. Place coating waste, cloths, and material that may pose a fire hazard in closed metal containers and remove daily from site.

F. Remove electrical plates, surface hardware, fittings, and fasteners before coating application. Carefully store, clean, and replace items after completing coating in each area. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finishes.

G. Erect and maintain protective enclosures in accordance with SSPC- Guide 6.

H. Protect the following surfaces from abrasive blasting by masking or by other means:
   1. Threaded portions of valve and gate stems, grease fittings, and identification plates.
   2. Machined surfaces for sliding contact.
   3. Surfaces to be assembled against gaskets.
   4. Surfaces of shafting where sprockets will be fit.
   5. Surfaces of shafting where bearings will be fit.
   6. Machined bronze surfaces, including slide gates.
   7. Cadmium-plated items, except cadmium-plated, zinc-plated, or sherardized fasteners used to assemble equipment requiring abrasive blasting.
   8. Galvanized items, unless scheduled to be coated.

I. Protect installed equipment, mechanical drives, and adjacent coated equipment from abrasive blasting to prevent damage caused by spent abrasive blast media, dust, or dirt entering such equipment.

J. Schedule cleaning and coating to keep dust and spray from the cleaning process from falling on wet, newly coated surfaces:
   1. Whenever possible, coordinate with other trades and complete surface preparation and coating work before installing hardware, hardware accessories, nameplates, data tags, electrical fixtures, and similar uncoated items that will be in contact with coated surfaces. Mask machined surfaces, sprinkler heads, and other small items that will not be coated.
   2. After completing coating, reinstall removed items.
   3. Disconnect and move equipment adjacent to walls to clean and coat equipment and walls. Replace and reconnect equipment after coating.

3.02 GENERAL SURFACE PREPARATION REQUIREMENTS

A. Prepare surfaces in accordance with CSM's instructions unless more stringent requirements are specified in this Section.

B. Coating detail sheets in Appendix B include additional surface preparation requirements.

C. Follow more stringent requirement if information conflicts.

D. Where required by the Owner’s representative, a NACE International certified coatings inspector, provided by the Owner, will inspect and approve surfaces to be coated before applying a coating:
   1. CSA shall coordinate coating inspections:
      a. Identify coating inspection Hold Points during the pre-installation conference.
      b. Provide at least 2 days notice before inspection.
   2. Contractor shall correct surface defects identified by the inspector at no additional cost to Owner.

3.03 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION

A. Identify equipment, ducting, piping, and conduit as specified in Section 15075 - Equipment Identification and Section 16075 - Identification for Electrical Systems.

B. Remove grilles, covers, and access panels for mechanical and electrical system and coat separately.

C. Prepare and finish coat equipment primed by the manufacturer using specified intermediate and top coats, as applicable, and color selected by the Owner.

D. Prepare, prime, and coat both insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are covered with material not requiring coating, or with a prefinished coating.

E. Replace identification markings on mechanical or electrical equipment when coated over or spattered.

F. Prepare and coat interior surfaces of air ducts and convector and baseboard heating cabinets visible through grilles and louvers with 1 coat of flat black paint to limit of sight line.

G. Prepare and coat dampers exposed immediately behind louvers, grilles, and convector and baseboard heating cabinets to match face panels.

H. Prepare and coat exposed conduit and appurtenances occurring in finished areas with color and texture to match adjacent surfaces.

I. Prepare and coat sides' front, back, and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.

J. Color code equipment, piping, conduit, and exposed ductwork and apply color banding and identification, such as flow arrows, naming, and numbering, in accordance with the Contract Documents.

3.04 CLEANING OF NEW AND PREVIOUSLY COATED OR NEW SURFACES

A. Utilize cleaning agent to remove soluble salts, such as chlorides, from concrete and metal surfaces:
   1. Cleaning agent: Biodegradable non-flammable and containing no VOC.
   2. Manufacturers: The following or equal:
      a. CHLOR*RID International, Inc.:
         1) Complete soluble salt removal with steam or warm water cleaning.
   3. Steam clean and degrease surfaces to be coated to remove oils and grease.
   4. Test cleaned surfaces to ensure removal of soluble salts. Carry out additional cleaning as needed.
   5. Complete final surface preparation before applying new coating system in strict accordance with CSM's printed instructions.

3.05 BLAST CLEANING

A. Surface preparation requirements:
   1. Do not reuse spent blast abrasive.
   2. Ensure that filter compressed air used for blast cleaning is free of condensed water and oil. Clean moisture traps at least once every 4 hours or more frequently, as required, to prevent moisture from entering the abrasive blasting equipment air supply. Check blast air for moisture and oil after each cleaning in accordance with ASTM D4285.

3. Install oil separators just downstream of compressor discharge valves and at the discharge point of blast pot discharges. Check separators on the same frequency as the moisture traps.
4. Keep regulators, gauges, filters, and separators on compressor air lines to blasting nozzles operational at all times.
5. Install an air dryer or desiccant filter drying unit to dry the compressed air before blast pot connections. Use and maintain the dryer throughout surface preparation work.
6. Use a venturi-type, or other high velocity-type, abrasive blast nozzles supplied with at least 100 pounds per square inch gauge air pressure at the nozzle and enough volume to obtain appropriate blast cleaning production rates and surface cleanliness.
7. Provide airborne particulate evacuation and filtering that meets OSHA safety standards. Maintain optimal visibility both to clean and provide the specified surface profile and to allow inspection of the substrate during surface preparation work.
8. If prepared and cleaned metallic substrates become contaminated between final surface preparation work and coating system application, or if the prepared substrate darkens or changes color, re-clean by water blasting, or abrasive blast cleaning as appropriate until the specified degree of cleanliness is restored.

B. Water jetting or water blasting:
1. Use water jetting or water blasting for recoating or relining where an adequate surface profile exists.
2. Perform water jetting or water blasting in accordance with SP 13 and SSPC- WJ-1, WJ-2, WJ-3, WJ-4.

3.06 PREPARATION REQUIREMENTS FOR CONCRETE SURFACES

A. Cure for at least 28 days before coating.

B. Remove degraded concrete using abrasive blast cleaning or high or ultrahigh pressure water jetting, chipping, or other abrading tools until achieving a sound, clean substrate. Remove all bruised or cracked concrete.

C. Prepare substrate cracks and areas requiring resurfacing; perform detail treatment, including, but not limited to, terminating edges per the CSM's recommendations, and as indicated on the Drawings:
1. Prepare concrete surfaces in accordance with SSPC-SP 13.

D. Prepare concrete surfaces in accordance with SSPC-SP 13:
1. Inspect concrete surfaces to select appropriate surface preparation method to provide a suitable substrate for the specified coating system.
2. Use blast cleaning or other means to expose the complete perimeter of air voids or bug holes. Do not leave shelled over, hidden air voids beneath the exposed concrete surface.
3. Repair concrete defects and physical damage.
4. Clean concrete surfaces of dust, mortar, formwork, fins, loose concrete particles, form release materials, oil, and grease.
5. Fill voids to provide surface as specified in Section 03366 - Tooled Concrete Finishing.

E. Provide clean substrate visually free of calcium sulfate, loose, coarse, or fine aggregate, laitance, loose hydrated cement paste, and otherwise harmful substances:
   1. Confirm concrete surface minimum pH of 9.0 with surface pH testing.
   2. If after surface preparation the surface pH remains below 9.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.

F. Prepare concrete surface for coating in accordance with SSPC-SP 13:
   1. Provide ICRI 310.2 minimum No. 3 concrete surface profile (CSP) or as specified on Coating Detail Sheets.
   2. Evaluate profile of the prepared concrete using ICRI 310.2 surface profile replicas.

G. Blast clean cementitious repair mortars or grouts to the same profile and degree of cleanliness requirements required for concrete substrates.

H. Blast clean polymer-based surfacers or waterborne modified cementitious surfaces only if they have exceeded the CSM's recommended recoat time.

I. Vacuum all concrete surfaces before coating application, leaving a dust free, sound concrete substrate:
   1. Thoroughly clean concrete surfaces to be coated to remove loose dirt and spent abrasive.
   2. Remove debris produced by blast cleaning from the structures to be coated, and legally dispose of it off-site.

J. Test moisture content of concrete to be coated:
   1. Conduct ASTM D4263 plastic sheet test at least once for every 500 square feet of surface area to be coated:
      a. Any moisture on plastic sheet after test period constitutes a non-acceptable test, and the concrete must be dried further.
   2. Conduct ASTM F1869 test at least once for every 1,000 square feet of concrete floor surface area to be coated.
   3. Conduct ASTM F2170 one relative humidity moisture test at least once for each 500 square feet of non-floor concrete surface area where the opposite side is exposed to soil or water:
   4. Comply with specified minimum moisture content and CSM’s written recommendations for moisture vapor transmission rates or relative humidity values.

K. Masonry surfaces:
   1. Cure for at least 28 days before coating.
   2. Prepare masonry surfaces to remove chalk, laitance, loose dirt, dried mortar splatter, dust, peeling, or loose existing coatings, or otherwise deleterious substances to leave a clean, sound substrate.
   3. Wash and scrub masonry surfaces with clear water. Do not use muriatic acid.
   4. Seal or fill masonry surfaces with a sealer or block filler compatible with the specified primer after cleaning.
   5. Confirm that masonry surfaces are dry before coating application:
      a. If using pressure washing or low-pressure water blast cleaning for preparation, allow the masonry to dry for at least 5 days under dry

weather conditions or until the minimum ambient temperature is 70 degrees Fahrenheit before coating.

3.07 GENERAL PREPARATION REQUIREMENTS FOR METALLIC SURFACES

A. Remove rust, scale, and welding slag and spatter:
   1. Remove and grind smooth all excessive weld material and weld spatter on metal surfaces before blast cleaning in accordance with NACE SP0178, Appendix C, Level C.
   2. Grind sharp edges on metal substrate to approximately 1/16-inch radius before abrasive blast cleaning.

B. Prepare metallic surfaces in accordance with applicable portions of surface preparation specifications of the SSPC specified for each coating system:
   1. Remove grease and oil in accordance with SSPC-SP 1.
   2. Use solvent as recommended by the CSM.
   3. Measure profile depth of the surface to be coated in accordance with Method C of ASTM D4417. Contractor shall select blast particle size and gradation to produce the specified surface profile.
   4. Constantly monitor and maintain ambient environmental conditions to ensure cleanliness and that no “rust back” occurs before coating material application.

C. Prepare metallic surfaces by blast cleaning in accordance with SSPC-VIS 1 (ASTM D2200). Prepare abrasive blast representative areas for the Owner's representative to inspect on the first day of cleaning.

D. Unless otherwise specified, the requirements for blast cleaning steel, ductile iron, and stainless steel substrates are as follows:
   1. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC-SP 10 unless blasting may damage adjacent surfaces, is prohibited, or is specified otherwise. Where abrasive blasting is not possible, clean surfaces to bare metal with power tools in accordance with SSPC- SP 11.
   2. Ferrous metal surfaces to be submerged: Abrasive blast in accordance with SSPC-SP 5, unless specified otherwise, to clean and provide roughened surface profile with a depth between 2 and 4 mils.
   3. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products, or embedded abrasive from substrate before coating application.
   4. When abrasive blasted surfaces rust or discolor before coating, abrasive blast clean surfaces again.

E. Field preparation of shop-primed surfaces:
   1. Smooth welds and prominences with power tools before applying field-applied coatings.
   2. Clean and dry shop-primed ferrous metal surfaces and fabricated assemblies before applying field coats.
   3. Prepare shop epoxy primed surfaces with light abrasive blasting or abrading and then vacuum before applying finish coats:
      a. Follow CSM instructions for surface preparation when the primer recoat limit has been exceeded.
   4. Non-immersion service: Clean in accordance with SSPC-SP 2 (Hand Tool Cleaning) or SSPC-SP 3 (Power Tool Cleaning) and uniformly roughen.

5. Immersion, BSC, and SC service: Remove shop primer in accordance with SSPC-SP 5 (Near-White Blast Cleaning).

F. Damaged shop primer or rust bleeding:
   1. Ferrous metals: Clean in accordance with SSPC-SP 1 (Solvent Cleaning) and spot blast in accordance with SSPC-SP 10 (Near-White Metal Blast Cleaning) to achieve a uniform surface profile between 2.0 and 2.5 mils before recoating.
   2. Reject galvanized steel with rust bleeding.

G. Damaged coating: Repair by abrasive blast cleaning surfaces as specified for the coating system; feather to a smooth transition before touching up.

3.08 PREPARATION REQUIREMENTS BY SURFACE TYPE

A. Galvanized steel and non-ferrous metal surfaces:
   1. Degrease or solvent clean (SSPC-SP 1) to remove oily residue.
   2. Abrasive blast clean in accordance with SSPC-SP 16:
      a. If abrasive blast cannot be performed, abrade in accordance with SSPC- SP 3 (Power Tool Cleaning).
   3. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded, such as bolts, nuts, or preformed channels.
   4. Test surface for contaminants using copper sulfate solution.

B. Stainless-steel surfaces:
   1. Abrasive blast clean in accordance with SSPC-SP 16 to leave a clean, uniform appearance with surface profile between 1.5 and 2.5 mils.

C. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPF 500-03.

D. Sherardized, aluminum, copper, and bronze surfaces:
   1. Abrasive blast clean in accordance with SSPC-SP 16.
   2. Prepare in accordance with CSM's instructions.

E. Cadmium-plated, zinc-plated, or sherardized fasteners:
   1. Abrasive blast in the same manner as uncoated metal when assembling equipment designated for abrasive blasting.

F. PVC and FRP surfaces:
   1. Lightly sand surfaces to be coated:
      a. Sand to remove gloss and establish uniform surface profile.
   2. Vacuum to remove loose dust, dirt, and other materials.
   3. Solvent clean with clean white rags and allow solvent to evaporate completely before applying coating materials.

3.09 APPLICATION REQUIREMENTS

A. Apply coatings in accordance with manufacturer's instructions.

B. Empty aboveground piping to be coated of contents when applying coatings.

C. Mechanical equipment shop primed by the manufacturer:
   1. Pumps and valves: Shop coat with manufacturer's highest quality coating system meeting the project specifications:
      a. Contractor shall provide CTR shop coating reports.
   2. Non-immersed equipment: Touch up shop primer, and coat in the field with specified coating system after installation:
      a. If project requires equipment removal and reinstallation, complete touch- up coating after final installation.
   3. Immersed equipment not shop coated: Remove shop primer before surface preparation and field apply coating.

D. Verify surface preparation immediately before applying coating in accordance with SSPC SP COM and the SSPC visual standard for the specified surface preparation method.

E. Allow surfaces to dry, except where coating manufacturer requires surface wetting before coating.

F. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with manufacturer's recommended special primer.

G. Do not apply coatings to a surface until it has been prepared as specified.

H. Use equipment designed to apply materials specified:
   1. Use compressors with moisture traps and filters that remove water and oils from the air:
      a. Perform a paper blotter test at the Engineer's request to verify air is sufficiently free of oil and moisture. Do not allow the amount of oil and moisture to exceed CSM-recommended amount.
   2. Equip spray equipment with properly sized mechanical agitators, pressure gauges, pressure regulators, and spray nozzles.

I. Where 2 or more coats are required, tint prime coat intermediate coats as necessary to distinguish each coating and to help indicate coverage:
   1. Do not use color additives with chromium, lead, or lead compounds that hydrogen sulfide, other corrosive gases, might destroy or alter. Apply the specified number of coats.

J. Apply coating by brush, roller, trowel, or spray unless a specific application method is required by coating manufacturer's instructions or these Specifications:
   1. Apply primer or first coat by brush to power tool cleaned ferrous surfaces.
   2. Brush or spray-apply coats for blast-cleaned ferrous surfaces and subsequent coats for non-blast cleaned ferrous surfaces.
   3. After prime coat dries, mark, repair, and retest pinholes and holidays before intermediate or top coats are applied.

K. Spray application:
   1. With a brush, stripe coat edges, welds, corners, nuts, bolts, and difficult-to-reach areas, as necessary, before spray application to ensure specified coating thickness along edges.
   2. When using spray application, apply each coat to thickness no greater than recommended in coating manufacturer's instructions.

3. Use airless spray method unless air spray method is required by CSM's instruction or these Specifications.
4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.

L. Lightly sand and thoroughly clean surfaces to receive high-gloss finishes unless CSM instructs otherwise.

M. Remove all dust on coatings between coats.

N. Shop and field coats:
1. Prime coat: Shop-apply or field-apply prime coats as specified. Use shop- applied primer compatible with the specified field coating system and apply at the minimum dry film thickness recommended by the finish coat CSM:
   a. Provide data sheets identifying the shop primer to on-site coating application personnel.
   b. Perform adhesion tests on the shop primer.
   c. Remove and recoat damaged, deteriorated, and poorly applied shop coatings.
   d. If shop primer coat meets this Section's requirements, spot prime exposed metal of shop-primed surfaces before spray applying primer over the entire surface.
2. Field coats: Apply field coats with 1 or more prime coats and finish coats to build up coating to dry film thickness specified for the coating system:
   a. Do not apply finish coats until other work in the area is complete and previous coats are inspected.
3. Adhesion confirmation: Perform adhesion tests after proper coating cure in accordance with ASTM D3359. Demonstrate that:
   a. Prime coat adheres to the substrate.
   b. Coatings adhere to the prime and intermediate coats:
      1) Coating 5 mils or more DFT: Achieve adhesion test result of 5A on immersed surfaces and 4A or better on other surfaces.
      2) Coating less than 5 mils DFT: Achieve adhesion test results of 5B on immersed surfaces and 4B or better on other surfaces.

O. Brush, roll, trowel, or spray and back roll coats for concrete and masonry.

P. Plural component coating application:
1. Premix contents of component drums if required by the CSM each day.
2. Before starting application:
   a. Verify gauges are working properly.
   b. Complete ratio checks.
   c. Sample the mix on plastic sheeting to ensure set time is appropriate and complete.
   d. Label and retain all spray samples. Submit to Engineer when requested.

Q. Drying and recoating:
1. Provide fans, heating devices, or other means to prevent condensate or dew on substrate surface or between coats and during curing after applying the last coat.
2. Allow each coat to cure or dry thoroughly, in accordance with if required in CSM’s printed instructions, before recoating.

3. Use CSM's printed instructions and the requirements specified in this Section to determine minimum required drying time:
    a. Do not allow excessive drying time or exposure, which may impair bond between coats.
    b. Recoat all coatings within time limits recommended by CSM.
    c. If time limits are exceeded, abrasive blast clean and de-gloss clean before applying another coat.
4. If limitations on time between abrasive blasting and coating are not met before attaching components to surfaces that cannot be abrasive blasted, coat components before attachment.
5. Ensure primer and intermediate coats of coating are unscarred and completely integral when applying each succeeding coat.
6. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
7. Leave no holidays. Repair all holidays in accordance with the requirements on pertinent Coating Detail Sheets or as recommended by the CSM.
8. Sand and feather in to a smooth transition and recoat scratched, contaminated, or otherwise damaged coating surfaces so repairs are invisible to the naked eye.

R. Workmanship:
1. Ensure that coated surfaces are free from runs, drips, ridges, waves, laps, and brush marks. Coats shall be applied to produce a smooth, even film of uniform thickness completely coating corners and crevices.
2. Coat surfaces without drops, overspray, dry spray, excessive runs, ridges, waves, holidays, laps, or brush marks.
3. Remove splatter and droppings after coating work is completed.
4. Evenly apply each coat of material and sharply cut to a line created with masking tape or other suitable materials.
5. Avoid over spraying or spattering paint on surfaces not to be coated. Protect glass, hardware, floors, roofs, vehicles, and other adjacent areas and installations by taping, drop cloths, or other suitable measures.
6. When coating complex steel shapes, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces with the primer before overall coating system application:
    a. Brush apply stripe coat to ensure proper coverage.
    b. Do not stripe coat with spray or roller.
7. Ensure that finish coat, including repairs, has a uniform color and gloss.

S. Coating properties, mixing, and thinning:
1. Thin prime coat and apply as recommended by the CSM. .Thinned coating must comply with prevailing air pollution control regulations.
2. If maximum recoat time is exceeded, prepare surface with solvent washing, light abrasive blasting, or other procedures per CSM’s instructions.
3. Allow adequate drying time between coats as instructed by the CSM, adjusted as necessary for the site conditions.
4. Ensure that coatings, when applied, provide a satisfactory film and a smooth even surface. Lightly sand glossy undercoats to provide a surface suitable for proper application and adhesion of subsequent coats. Thoroughly stir and strain coating materials during application and maintain uniform consistency.
5. Mix coatings with 2 or more components in accordance with CSM’s instructions.

6. Where necessary to suit conditions of the surface, temperature, weather and method of application, thin the coating per CSM's recommendations:
    a. Ensure that volatile organic content (VOC) of the thinned coating complies with prevailing air pollution control regulations.
    b. Thin coatings to only what is necessary to obtain proper application characteristics.
    c. Use a thinner recommended by the CSM.

T. Film thickness and continuity:
1. Apply coating to the specified thicknesses:
    a. Apply additional coats when necessary to achieve specified thicknesses, especially at edges and corners.
2. Verify WFT of the coating system first coat and after applying each subsequent coat.
3. Do not allow the minimum thickness at any point to deviate more than 25 percent from the required average.
4. Do not allow the surface area covered per gallon of coating for various types of surfaces to exceed those recommended by the CSM:
    a. Provide coating coverage worksheets listing the maximum and minimum coverage for each unit volume of coating for concrete surfaces.
5. Apply additional coats to achieve the specified dry film thickness if brush or roller application methods cannot achieve the specified film thicknesses per coat.

U. Protecting coated surfaces:
1. Do not handle, work on, or otherwise disturb coated items until the coating is completely dry and hard.
2. After installation, recoat shop-coated surfaces with specified coating system as necessary to match surrounding surfaces, and to coordinate with the specified color identification requirements.

V. Special requirements:
1. Before erection, apply all but the final finish coat to interior surfaces of roof plates, roof rafters and supports, pipe hangers, piping in contact with hangers, and contact surfaces inaccessible after assembly. Apply final coat after erection.
2. Coat structural slip-critical connections and high strength bolts and nuts after erection.
3. Areas damaged during erection:
    a. Prepare surface for spot repairs as specified for the coating system.
    b. Recoat with prime coat before applying subsequent coats.
    c. Touch up surfaces after installation.
    d. Clean and dry surfaces to be coated at time of application.
4. Coat underside of equipment bases and supports not galvanized with at least 2 coats of primer specified before setting the equipment in place.
5. Coat aluminum in contact with concrete.

3.10 APPLICATION REQUIREMENTS FOR CONCRETE COATING SYSTEMS

A. Apply filler/surfacer as recommended by CSM to fill bug holes and air voids in concrete or block texture in CMU, leaving a uniformly filled surface that does not produce blowholes or outgassing causing the coating system to pinhole:
   1. Allow filler/surfacers to cure sufficiently before applying prime coat as required by the CSM. Use the CSM-recommended drying time between coats.

B. Apply surfacer or filler and let dry before coating application:
   1. Use the drying time between filler/surfacer and coating system specified by the CSM for the site conditions:
      a. Let concrete substrate dry before applying filler/surfacers or coating system materials.
   2. If the maximum recoat time is exceeded, prepare surfaces by solvent washing, light abrasive blasting, and other procedures per CSM's instructions.
   3. Apply a complete parge coat of the specified filler/surfacer material over the entire substrate before applying the coating system:
      a. Scrub filler/surfacer into the substrate to completely fill open air voids and bug holes.
      b. Completely cover the substrate, unless otherwise specified, above such filled voids by 1/8 inch of thickness.
      c. Provide relatively flat, uniformly even surface before coating application.
   4. Secondary containment: Place surfacer or filler 1/16 inch thick above concrete plane to create a monolithic surface free of pinholes:
      a. Floor surfaces: Broadcast with aggregate to create a non-slip surface texture.
      b. Remove excess aggregates and apply base coat to encapsulate embedded non-slip aggregate.

C. Concrete substrate temperatures:
   1. Apply filler/surfacers and the coating system when temperatures are falling, typically late afternoon or evening:
      a. Do not coat concrete with rising concrete substrate surface temperatures or substrates in direct sunlight, to minimize outgassing from the substrate and formation of pinholes, and/or blistering.
   2. Should bubbles, pinholes, or other discontinuities form in the applied coating system material, they shall be repaired:
      a. Should discontinuities develop in the filler/surfacer material or in the first coat of the coating material, repair them before the next coat.
      b. When discontinuities occur, open the air void behind or beneath the discontinuities and completely fill with specified coating material. Then, abrade the coated area around the discontinuities repair reapply coating over that area.

D. Perform application detail work in accordance with these Specifications, the CSM’s current written recommendations, and drawings, whichever is stricter.

E. Concrete coating systems application requirements:
   1. Concrete coating minimum dry film thickness excludes parge coat, block filler, and sealer.

3.11 COATING SYSTEM SCHEDULE

A. Appendix A specifies surfaces to be coated in the field with the coating systems required.

3.12 SURFACES NOT REQUIRING COATING

A. Stainless steel piping, valves, pipe supports, instrument sunshades.

B. Sliding surfaces on expansion joints, motor and pump shafts, machined surfaces at bearings and seals, grease fittings, etc.

C. Galvanized structural steel framing, galvanized roof decking, galvanized pipe supports.

D. Copper and brass pipe, fittings, valves, etc.

E. Bronze valves, bearings, bushings, and fasteners.

F. Corrosion resistant special alloys: Inconel, Alloy 20, Hastelloy, etc.

G. Exterior Concrete.

H. Plastic surfaces except coat PVC, CPVC, and other plastic piping system exposed to sunlight.

I. Buried piping that is encased in concrete or cement mortar.

3.13 QUALITY CONTROL

A. Owner-provided inspection or inspection by others does not limit the Contractor's or CSA's responsibilities for quality workmanship or quality control as specified or as required by the CSM's instructions. Owner inspection is in addition to any inspection required of the Contractor.

B. Owner may perform, or contract with an inspection agency to perform, quality control inspection and testing of the coating work covered by this Section. These inspections may include the following:
   1. Inspect materials upon receipt to ensure that the CSM supplied them.
   2. Verify that specified storage conditions for the coating system materials, solvents, and abrasives are provided.
   3. Inspect and record findings for substrate cleanliness.
   4. Inspect and record pH of concrete and metal substrates.
   5. Inspect and record substrate profile (anchor pattern).
   6. Measure and record ambient air and substrate temperature.
   7. Measure and record relative humidity.
   8. Check for substrate moisture in concrete.
   9. Verify that mixing of coating system materials is in accordance with CSM's instructions.
   10. Inspect, confirm, and record that coating system materials' "pot life" is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.
   11. Perform adhesion testing.

12. Measure and record the coating system's thickness.
13. Verify proper curing of the coating system in accordance with the CSM's instructions.
14. Holiday or continuity testing in accordance with NACE SP0188 for coatings that will be immersed or exposed to aggressively corrosive conditions.

C. Contractor shall perform holiday testing in accordance with NACE SP0188 to identify holidays or pinholes needing repair for coating over 100 percent of surfaces:
   1. Coated steel that will be immersed or exposed to aggressively corrosive conditions.
   2. Coated concrete.
   3. Perform holiday tests after proper application and coating system cure.

3.14 CORRECTIVE MEASURES

A. Repair pinholes or holidays identified by Holiday Testing as follows:
   1. Remove the coating system with a grinder or other suitable power tool.
   2. Remove coating system at all pinholes and holidays at least 2 inches diameter around the defect back to expose substrate.
   3. Concrete voids: chip back to expose entire cavity in all directions:
      a. Completely fill void with approved filler/surfacer material using a putty knife or other suitable tool, and strike off. Cure per CSM’s recommendations.
   4. Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system.
   5. Vacuum the prepared area to remove all dust, dirt, etc., leaving clean, sound surfaces.
   6. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.
   7. Apply the coating system with enough coats to achieve the specified finish coat thickness over the defect and coating removal area. Feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline.
   8. Follow curing time between coats as specified by CSM for the site conditions. Solvent wash and abrasive blast per CSM's instructions if the maximum recoat time is exceeded.
   9. Apply coating at specified dry film thickness.

3.15 CLEANUP

A. Remove surplus materials, protective coverings, and accumulated rubbish after completing coating. Thoroughly clean surfaces and repair overspray or other coating-related damage.

3.16 FINAL INSPECTION

A. Conduct final inspection of coating system work to determine whether it meets specifications requirements.

B. Conduct subsequent final inspection with Engineer to ensure work conforms to contract documents requirements.

C. Mark any rework required:
   1. Re-clean and repair, as specified, at no additional cost to the Owner.

END OF SECTION

APPENDIX A
Schedule of Surfaces to be Coated

A. The following schedule is incomplete. Coat unlisted surfaces with same coating system as similar listed surfaces. Contact Engineer for clarification.

EPU-M-1	Metals, exterior, non-immersed
EPX-M-1	Structural steel
EPX-M-2	Metals, interior, non-immersed
EPX-M-5	Aluminum surfaces in contact with concrete or masonry. Locations where Alkali-resistant bitumastic is specified.

Notes:

1: Non-immersed ferrous metal surfaces include:
- a. Doors, doorframes, ventilators, louvers, grilles, exposed sheet metal, and flashing.
- b. Pipe, valves, pipe hangers, supports and saddles, conduit, cable tray hangers, and supports.
- c. Motors and motor accessory equipment.
- d. Drive gear, drive housing, coupling housings, and miscellaneous gear drive equipment.
- e. Valve and gate operators and stands.
- f. Structural steel.
- g. Crane and hoist rails.
- h. Exterior of tanks and other containment vessels.
- i. Mechanical equipment supports, drive units, and accessories.
- j. Bare electrical equipment: boxes, exposed conduit, and accessories.
- k. Pumps not submerged.
- l. Other miscellaneous metals.

2: Immersed ferrous metal surfaces include:
- a. Interior surfaces of ferrous metal tanks.
- b. Field priming of ferrous metal surfaces with defective shop-prime coat; including non-submerged service.
- c. Bell rings, underside of manhole covers and frames.
- d. Sump pumps, including underside of base plates and submerged suction and discharge piping.
- e. Exterior of submerged piping and valves other than stainless steel or PVC piping.
- f. Submerged pipe supports and hangers.
- g. Stem guides.
- h. Other submerged iron and steel metal unless specified otherwise.

Appendix B			
Coating Detail Sheet			
Coating System	EPU-M-1		
Coating Material	Two coats epoxy with polyurethane finish coat		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 890	Carboguard 890	Carbothane 134 VOC
International Paint	Devran 224V	Devran 224V	Devthane 379H
PPG	Amerlock 2VOC	Amerlock 2VOC	Amershield VOC
Sherwin Williams	Macropoxy 646 100	Macropoxy 646 100	Hi Solids Polyurethane 250
Tnemec	Series 66HS	Series 66HS	Series 1095
Service Condition	Interior or Exterior, subject to direct sunlight. Non-immersion.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP10, Near-White Blast Cleaning. Shop primed surfaces: SSPC-SP2, Hand Tool Cleaning or SSPC-SP3, Power Tool Cleaning. Damaged primer or rust: SSPC-SP10, Near White Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush Blast Cleaning. Test for surface contaminants.		
Surface profile			
Ferrous Metal	2.5 to 3.0 mils		
Nonferrous Metal	1.5 to 2.0 mils		
Galvanized Metal	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	10 to 13 mils		
Primer	4 to 5 mils		
Intermediate Coat	4 to 5 mils		
Finish Coat	2 to 3 mils		
Application			
Special CTR Training	Not required.		

Appendix B			
Coating Detail Sheet			
Coating System	EPX-M-1		
Coating Material	Epoxy		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 890	None Applied	Carboguard 890
International Paint	Bar-Rust 236	None Applied	Bar-Rust 236
PPG	Amerlock 2/400 Series	None Applied	Amerlock 2/400 Series
Sherwin Williams	Macropoxy 646	None Applied	Macropoxy 646
Tnemec	Series 66HS	None Applied	Series 66HS
Service Condition	Interior, non-corrosive.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP10, Near-White Blast Cleaning. Shop primed surfaces: SSPC-SP2, Hand Tool Cleaning or SSPC-SP3, Power Tool Cleaning. Damaged primer or rust: SSPC-SP10, Near White Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush Blast Cleaning. Test for surface contaminants.		
Surface profile			
Ferrous Metal	2.5 to 3.0 mils		
Nonferrous Metal	1.5 to 2.0 mils		
Galvanized Metal	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	10 to 12 mils		
Primer	4 to 6 mils		
Finish Coat	4 to 6 mils		
Application			
Special CTR Training	Not required.		

Appendix B			
Coating Detail Sheet			
Coating System	EPX-M-2		
Coating Material	Epoxy		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 890	Carboguard 890	Carboguard 890
International Paint	Bar-Rust 236	Bar-Rust 236	Bar-Rust 236
PPG	Amerlock 2/400 Series	Amerlock 2/400 Series	Amerlock 2/400 Series
Sherwin Williams	TankClad HS	TankClad HS	TankClad HS
Tnemec	Series 66HS	Series 66HS	Series 66HS
Service Condition	Immersed, non-immersed, moderately corrosive environment.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP5, White Metal Blast Cleaning. Shop primed surfaces: SSPC-SP7, Brush-Off Blast Cleaning. Damaged primer or rust: SSPC-SP5, White Metal Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Surface profile			
Ferrous Metal	2 to 4 mils		
Nonferrous Metal	1.0 to 1.5 mils		
Galvanized Metal	1.0 to 1.5 mils		
System Thickness (Dry Film)			
Total	12 to 16 mils		
Primer	4 to 6 mils		
Intermediate Coat	4 to 6 mils		
Finish Coat	4 to 6 mils		
Application			
Special CTR Training	Not required.		

Appendix B			
Coating Detail Sheet			
Coating System	EPX-M-5		
Coating Material	Epoxy mastic		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	CSM recommended	None applied	Carbomastic 15
International Paint	CSM recommended	Bar-Rust 231LV	Bar-Rust 231LV
PPG	No product specified	No product specified	No product specified
Sherwin Williams	CSM recommended	No product specified	No product specified
Tnemec	CSM recommended	Series 135	Series 135
Service Condition	Interior, corrosive environment, confined enclosures, where minimal surface preparation is possible.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP11, Power to Cleaning to Bare Metal. Shop primed surfaces: SSPC-SP3, Power Tool Cleaning. Damaged primer or rust: SSPC-SP11, Power to Cleaning to Bare Metal.		
Nonferrous Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Surface profile			
Ferrous Metal	2.0 to 2.5 mils		
Nonferrous Metal	1.0 to 1.5 mils		
System Thickness (Dry Film)			
Total	15 to 19 mils		
Primer	2 to 4 mils		
Finish Coat	15 mils		
Application			
Special CTR Training	Not Required.		

SECTION 10400

SIGNAGE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Plastic and metal signs for building and site use.

1.02 REFERENCES

A. National Fire Protection Association (NFPA):
   1. 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response.

B. Occupational Safety and Health Administration (OSHA).

1.03 SUBMITTALS

A. Product data.

B. Shop drawings: Include lists of sign types, sizes, text, and colors; mounting details; locations; and cast metal plaque rubbings and templates.

C. Samples: Include actual materials.

D. Manufacturer's installation instructions.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed products for minimum 5 years with satisfactory performance record of minimum 5 years.

B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 10 projects of similar scope as Project with satisfactory performance record.

C. Regulatory requirements: Provide signage in accordance with Americans with Disabilities Act as published in the Federal Register, Volume 56, No. 144, Friday, July 26, 1991.

PART 2 PRODUCTS

2.01 PLASTIC SIGNAGE SYSTEM

A. Manufacturers:
   1. One of the following or equal:
      a. Best Manufacturing Sign Systems, System 900013.
      b. Andco Industries Corp., equivalent product.

c. Vomar Products, Inc., equivalent product.

B. Attachment:
1. Vinyl tape, self-adhering.

C. Lettering:
1. Helvetica medium, 3/4 inches high.

D. Material for interior use:
1. Plastic 1/8-inch thick raised letters.

E. Material for exterior use:
1. Fiberglass 1/4 inch thick with high gloss finish, raised letters, blasted from single piece of fiberglass for integral letter and background.
2. No adhesive as mechanical fastening of letters shall be allowed.

F. Colors:
1. As selected by Engineer from manufacturer's standard colors.

G. See Schedule A for specific sign size, location, text, pictogram, and quantity.

2.02 METAL SAFETY SIGNS

A. Manufacturer: Meeting OSHA Requirements; 40-mil thick aluminum with baked enamel finish. One of the following or equal:
1. Seton Name Plate Co., Special Wording.
2. Emedco.

B. Danger sign colors:
1. Background: White.
2. Heading: White lettering on red oval with white border in black rectangular panel.
3. Message: Black lettering on white.
4. Size: As scheduled.

C. Caution sign colors:
1. Background: Yellow.
2. Heading: Yellow lettering on black rectangular panel.
3. Message: Black lettering on yellow.
4. Size: As scheduled.

D. Safety instruction signs:
1. Background: White.
2. Heading: White lettering on green rectangular panel.
3. Message: Black lettering.
4. Size: As scheduled.

E. Warning sign colors:
1. Background: Orange.
2. Heading: Black lettering on orange diamond in black rectangular panel.
3. Message: Flack lettering on orange.
4. Size: As scheduled.

F. Notice information signs:
   1. Background: White.
   2. Heading: White lettering on blue rectangular panel.
   3. Message: Black lettering.
   4. Size: As scheduled.

G. Fasteners: Round head stainless steel bolts or screws.

H. See Schedule B for specific sign size, location, text, and quantity.

PART 3 EXECUTION

3.01 PREPARATION

A. Protect adjacent surfaces which may be damaged by installation of signs.

B. Prepare substrates in accordance with sign manufacturer's instructions.

C. Remove scale, dirt, grease, and other contaminates from substrates.

3.02 INSTALLATION

A. Install signs in accordance with sign manufacturer's instructions.

B. Fasten signs securely in level, plumb, and true to plane positions.

C. Install signs where or as indicated in the following schedules.

3.03 SCHEDULES

A. Plastic Signage System Schedule.

B. Metal Safety Sign Schedule.

END OF SECTION

SCHEDULE A

PLASTIC SIGNAGE SYSTEM SCHEDULE

A. Room Numbers:
   1. Location: On wall outside room adjacent to latch side of doors or when not enough space on latch side, on nearest adjacent wall.
   2. Height: 60 inches above floor to center of sign.
   3. Size: 6 inches square.
   4. Colors: As selected by the Engineer.
   5. Text: Room number as indicated on the Drawings.

B. Room Names:
   1. Location: On wall outside room adjacent to latch side of doors or when not enough space on latch side, on nearest adjacent wall.
   2. Height: 60 inches above floor to center or sign.
   3. Size: 6 inches square.
   4. Colors: As selected by Engineer.
   5. Text: Sign per door describing room function as indicated on the Drawings.

C. Fire Extinguishers:
   1. Location: Adjacent to fire extinguishers.
   2. Height: 60 inches above floor to center of sign.
   3. Size: 6 inches square.
   4. Colors: White letters on OSHA Red background.
   5. Text: FIRE EXTINGUISHER.

END OF SCHEDULE A

SCHEDULE B

METAL SAFETY SIGN SCHEDULE

D. REMOTELY CONTROLLED AUTOMATIC EQUIPMENT:
   1. Location: On front and back of equipment that starts automatically by remote control.
   2. Height: 60 inches above floor to center or sign.
   3. Size: 10 inches X 14 inches.
   4. Heading: DANGER
   5. Wording: THIS EQUIPMENT STARTS AUTOMATICALLY
BY REMOTE CONTROL

E. HIGH VOLTAGE WARNING:
   1. Location: On front and back of equipment, adjacent to doors to rooms containing devices, and devices that operate at 600 volts or greater.
   2. Height: 60 inches above floor to center or sign.
   3. Size: 10 inches X 14 inches.
   4. Heading: DANGER
   5. Wording: HIGH VOLTAGE
KEEP OUT

F. NO SMOKING WITHIN 25 FEET OF BUILDING ENTRY:
   1. Location: As indicated on the Drawings.
   2. Height: Pole mounted with top of sign at 5 feet above grade.
   3. Size: 14 inches wide by 10 inches high.
   4. Heading: NOTICE
   5. Wording: NO SMOKING WITHIN 25 FEET OF BUILDING.
   6. Pictogram: International “No Smoking” symbol.

END OF SCHEDULE B

SECTION 10520

FIRE PROTECTION SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Fire extinguishers and cabinets.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. E814-11a - Standard Test Method for Fire Tests of Penetration Firestop Systems.

B. National Fire Protection Association (NFPA):
   1. 10 - Standard for Portable Fire Extinguishers.

C. Underwriters Laboratories, Inc. (UL):
   1. 711 - Rating and Fire Testing of Fire Extinguishers.

1.03 SUBMITTALS

A. Product data:
   1. Extinguishers: Materials description for fire extinguishers; include ratings and classifications.
   2. Installation instructions for each product specified.

B. Shop drawings:
   1. Small-scale plans showing locations of fire extinguisher cabinets and individual fire extinguishers.
   2. Schedule showing each type of cabinet and extinguisher to ensure proper fit and function.
   3. Indicate installation procedures and accessories required for a complete installation.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Minimum 5 years with satisfactory performance record.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following or equal:
   1. Activar Construction Products Group – JL Industries.

2.02 FIRE EXTINGUISHERS

A. Multi-purpose chemical type:
   1. Extinguisher unit containing a fluidized and siliconized mono ammonium phosphate powder; nonconductive and nontoxic.
   2. Construction: Heavy duty steel cylinder with metal valve and siphon tube, o-ring seal, replaceable valve stem seal, visual pressure gage, pull pin and upright squeeze grip.
   3. Finish: Factory powder-coated: Red.
   4. UL Effectiveness Rating in accordance with UL 711: Class A, B, and C fires.
   5. UL Rating in accordance with UL 711: 4A-80BC.
   6. Drawing will use the symbol FE for “Fire Extinguisher”.

B. Regular dry chemical type:
   1. Extinguisher unit containing a siliconized dry sodium bicarbonate base; nontoxic.
   2. Construction: Heavy duty steel cylinder with metal valve and siphon tube, o-ring seal, replaceable valve stem seal, visual pressure gage, pull pin, and upright squeeze grip.
   3. Finish: Factory powder-coated; Red.
   4. UL Effectiveness Rating in accordance with UL 711: Class B and C fires.
   5. UL Rating in accordance with UL 711: 80.
   6. Drawing will use the symbol EFE for “Electrical Fire Extinguisher”.

2.03 WALL BRACKETS

A. Type: Standard as manufactured by fire extinguisher manufacturer.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance NFPA 10, Standard for Portable Fire Extinguishers.

3.02 LOCATIONS

A. Install fire extinguisher type, FE and EFE, as indicated on the Drawings.

B. Install fire extinguisher wall brackets as indicated on the Drawings.

END OF SECTION

SECTION 15050

COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic design and performance requirements for building mechanical equipment and process mechanical equipment.

1.02 REFERENCES

A. American Gear Manufacturer's Association (AGMA) Standards:
   1. 6001-E08 - Design and Selection of Components for Enclosed Gear Drives.

B. American Bearing Manufactures Association (ABMA) Standards:
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. American Petroleum Institute (API):
   1. 682 - Shaft Sealing Systems for Centrifugal and Rotary Pumps.

D. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A48 - Standard Specification for Gray Iron Castings.
   3. A125 - Standard Specification for Steel Springs, Helical, Heat-Treated.
   4. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   6. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
   7. A536 - Standard Specification for Ductile Iron Castings.
   8. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   9. B61 - Standard Specification for Steam or Valve Bronze Castings.
   10. B62 - Standard specification for Composition Bronze or Ounce Metal Castings.
   11. B505 - Standard Specification for Copper Alloy Continuous Castings.
   12. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
   13. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   14. F594 - Standard Specification for Stainless Steel Nuts.

E. Hydraulic Institute (HI).

F. Occupational Safety and Health Administration (OSHA).

G. Unified Numbering System (UNS).

1.03 DEFINITIONS

A. Resonant frequency: That frequency at which a small driving force produces an ever-larger vibration if no dampening exists.

B. Rotational frequency: The revolutions per unit of time usually expressed as revolutions per minute.

C. Critical frequency: Same as resonant frequency for the rotating elements or the installed machine and base.

D. Peak vibration velocity: The root mean square average of the peak velocity of the vibrational movement times the square root of 2 in inches per second.

E. Rotational speed: Same as rotational frequency.

F. Maximum excitation frequency: The excitation frequency with the highest vibration velocity of several excitation frequencies that are a function of the design of a particular machine.

G. Critical speed: Same as critical frequency.

H. Free field noise level: Noise measured without any reflective surfaces (an idealized situation); sound pressure levels at 3 feet from the source unless specified otherwise.

I. Operating weight: The weight of unit plus weight of fluids or solids normally contained in unit during operation.

1.04 DESIGN REQUIREMENTS

A. General:
   1. Product requirements as specified in Section 01600 - Product Requirements.
   2. Project conditions as specified in Section 01610 - Project Design Criteria.
   3. Provisions specified under each technical equipment specification prevail over and supersede conflicting provisions specified in this Section.
   4. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries required for proper operation.
   5. Vibration considerations:
      a. Resonant frequency:
         1) For single-speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the operating rotational frequencies or multiples of the operating rotational frequencies that may be excited by the equipment design.
         2) For variable-speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the range of operating frequencies.
      b. Design, balance, and align equipment to meet the vibration criteria specified in Section 15958 - Mechanical Equipment Testing.
   6. Equipment units weighing 50 pounds or more: Provide with lifting lugs or eyes to allow removal with hoist or other lifting device.

B. Power transmission systems:
   1. V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, variable frequency drives, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints are to be rated for 24 hour-a-day continuous service or frequent stops-and-starts intermittent service, whichever is most severe, and sized with a service factor of 1.5 or greater in accordance with manufacturer recommendations:
      a. Apply service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
      b. Apply service factors in accordance with AGMA 6001-E08, other applicable AGMA standards, or other applicable referenced standards.

C. Equipment mounting and anchoring:
   1. Mount equipment on cast-iron or welded-steel bases with structural steel support frames.
      a. Utilize continuous welds to seal seams and contact edges between steel members.
      b. Grind welds smooth.
   2. Provide bases and supports with machined support pads, dowels for alignment of mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits.
   3. Provide jacking screws in bases and supports for equipment weighing over 1,000 pounds.
   4. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load specified in Section 01612 - Seismic Design Criteria, and other loads as required for proper operation of equipment.
      a. For equipment with an operating weight of 400 pounds or greater and all equipment that is supported higher than 4 feet above the floor, provide calculations for:
         1) The operating weight and location of the centroid of mass for the equipment.
         2) Forces and overturning moments.
         3) Shear and tension forces in equipment anchorages, supports, and connections.
         4) The design of equipment anchorage, supports, and connections based on calculated shear and tension forces.
   5. Anchorage of equipment to concrete or masonry:
      a. Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
      b. Unless otherwise indicated on the Drawings, select and provide anchors from the types specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
      c. Provide bolt sleeves around cast-in anchor bolts for 400 pounds or greater equipment.
         1) Adjust bolts to final location and secure the sleeve.
   6. Anchorage of equipment to metal supports:
      a. Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.
   7. Unless otherwise indicated on the Drawings, install equipment supported on concrete over non-shrink grout pads as specified in this Section.

1.05 SUBMITTALS

A. As specified in Section 01600 - Product Requirements.

B. Product data:
   1. For each item of equipment:
      a. Design features.
      b. Load capacities.
      c. Efficiency ratings.
      d. Material designations by UNS alloy number or ASTM Specification and Grade.
      e. Data needed to verify compliance with the Specifications.
      f. Catalog data.
      g. Nameplate data.
      h. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
   2. Gear reduction units:
      a. Engineering information in accordance with applicable AGMA standards.
      b. Gear mesh frequencies.

C. Shop drawings:
   1. Drawings for equipment:
      a. Drawings that include cut-away drawings, parts lists, material specification lists, and other information required to substantiate that proposed equipment complies with specified requirements.
   2. Outline drawings showing equipment, driver, driven equipment, pumps, seal, motor(s) or other specified drivers, variable frequency drive, shafting, U-joints, couplings, drive arrangement, gears, base plate or support dimensions, anchor bolt sizes and locations, bearings, and other furnished components.
   3. Installation instructions including leveling and alignment tolerances, grouting, lubrication requirements, and initial Installation Testing procedures.
   4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
   5. Recommended or normal operating parameters such as temperatures and pressures.
   6. Alarm and shutdown setpoints for all controls furnished.

D. Calculations:
   1. Structural:
      a. Substantiate equipment base plates, supports, bolts, anchor bolts, and other connections meet minimum design requirements specified and seismic design criteria as specified in Section 01612 - Seismic Design Criteria.
   2. Mechanical:
      a. ABMA 9 or ABMA 11 L10 life for bearings calculation methods for drivers, pumps, gears, shafts, motors, and other driveline components with bearings.
      b. Substantiate that operating rotational frequencies meet the requirements of this Section.

c. Torsional analysis of power transmission systems: When torsional analysis specified in the equipment sections, provide:
1) Sketch of system components identifying physical characteristics including mass, diameter, thickness, and stiffness.
2) Results of analysis including first and second critical frequencies of system components and complete system.
d. Calculations shall be signed and stamped by a licensed engineer.

3. Drinking water:
a. If applicable, conform to the requirements of Section 01600 - Product Requirements for materials in contact with drinking water.

E. Operation and maintenance manuals:
1. As specified in Section 01782 - Operating and Maintenance Manuals.
2. Equipment with bearings:
a. Include manufacturer and model number of every bearing.
b. Include calculated ball pass frequencies of the installed equipment for both the inner and outer raceways.

F. Commissioning submittals: As specified in Section 01756 - Commissioning.

G. Project closeout documents: As specified in Section 01770 - Closeout Procedures.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials as specified in Section 01600 - Product Requirements including special requirements for materials in contact with drinking water.

B. Ferrous materials:
1. Steel for members used in fabrication of assemblies: ASTM A36.
2. Iron castings: ASTM A48, tough, close-grained gray iron, free from blowholes, flaws, and other imperfections.
3. Ductile iron castings: ASTM A536, Grade 65-45-12, free from flaws and imperfections.
4. Galvanized steel sheet: ASTM A653, minimum 0.0635-inch (16-gauge).
5. Expanded metal: ASTM A36, 13-gauge, 1/2-inch flat pattern expanded metal.
6. Stainless steel:
a. As specified in Section 05120 - Structural Steel.
b. In contact or within 36 inches of water: Type 316 or 316L.
c. In sea air environment: Type 316 or 316L.
d. Other locations: Type 304 or 304L.
e. Source cleaning and passivation as specified in Section 05120 - Structural Steel.

C. Non-ferrous materials:
1. Bronze in contact with drinking water: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C89833, C89520, or C92200 in accordance with ASTM B61, B62, B505, or B584, when not specified otherwise.
2. Bronze in contact with wastewater: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C83600, C89833, C89520,

C92200, or C93700 in accordance with ASTM B61, B62, B505, or B584, when not specified otherwise.
3. Aluminum.

D. Dielectric materials for separation of dissimilar metals:
1. Neoprene, bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other materials as specified.

E. Non-shrink grout and epoxy non-shrink grout: As specified in Section 03600 - Grouting.

2.02 ANCHORS AND FASTENERS

A. Mechanical anchoring to concrete and masonry:
1. As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry:
a. Type 316 stainless steel.
2. Design as specified in Section 01612 - Seismic Design Criteria.

B. High-strength fasteners:
1. As specified in Section 05120 - Structural Steel.

C. Mechanical assembly fasteners:
1. Stainless steel:
a. High-temperature service or high-pressure service:
1) Bolts: ASTM A193, Grade B8 (Type 304) or Grade B8M (Type 316), Class 1, heavy hex.
2) Nuts: ASTM A194, Grade 8, heavy hex.
3) Washers: Alloy group matching bolts and nuts.
b. Low-temperature service:
1) Bolts: ASTM A320, Grade B8 (Type 304) or Grade B8M (Type 316), Class 1, heavy hex.
2) Nuts: ASTM A194, Grade 8 (Type 304) or Grade B8M (Type 316), heavy hex.
3) Washers: Alloy group matching bolts and nuts.
c. General service:
1) Bolts: ASTM F593, Alloy Group 1 (Type 304) or Alloy Group 2 (Type 316).
2) Nuts: ASTM F594, Alloy Group 1 (Type 304) or Alloy Group 2 (Type 316).
3) Washers: Alloy group matching bolts and nuts.

2.03 SHAFT COUPLINGS

A. General:
1. Type and ratings: Provide non-lubricated type, designed for not less than 50,000 hours of operating life.
2. Sizes: Provide as recommended by manufacturer for specific application, considering horsepower, speed of rotation, and type of service.

B. Shaft couplings for close-coupled electric-motor-driven equipment:
1. Use for:
a. Equipment 1/2 horsepower or larger.

b. Reversing equipment.
c. Equipment subject to sudden torque reversals or shock loading:
d. Examples:
1) Reciprocating pumps, blowers, and compressors.
2) Conveyor belts.

2. Manufacturers: One of the following or equal:
a. Lovejoy.
b. T.B. Woods.
3. Provide flexible couplings designed to accommodate angular misalignment, parallel misalignment, and end float.
4. Manufacture flexible component of coupling from synthetic rubber or urethane.
5. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
6. Do not allow metal-to-metal contact between driver and driven equipment.

C. Shaft couplings for direct-connected electric-motor-driven equipment:
1. Use for 1/2 horsepower or larger and subject to normal torque, non-reversing applications.
2. Manufacturers: One of the following or equal:
a. Rexnord.
b. T.B. Woods.
3. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.
4. Provide flexible connecting element of rubber and reinforcement fibers.
5. Provide service factor of 2.0.
6. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.

D. Spacer couplings: Where cartridge-type mechanical seals or non-split seals are specified, provide a spacer-type coupling of sufficient length to remove the seal without disturbing the driver or driven equipment unless noted otherwise in the individual equipment specifications.

E. Specialized couplings: Where requirements of equipment dictate specialized features, supply coupling recommended for service by manufacturer:
1. Includes any engine-driven equipment.

2.04 STUFFING BOX, SEAL CHAMBER, AND SHAFT SEALS

A. General:
1. Unless otherwise noted in the equipment section, provide cartridge-type, double mechanical shaft seals for pumps.
2. Provide a stuffing box large enough for a double mechanical seal.
3. Where packing is specified, provide stuffing box large enough to receive a double mechanical seal.
4. Provide seal or packing flush connections, (3/4-inch size unless another size is indicated on the Drawings).
5. Provide and route leakage drain line to nearest equipment floor drain indicated on the Drawings.
6. For pumps with packing, design packing gland to allow adjustment and repacking without dismantling pump except to open up packing box.
7. Seal or packing flush requirements shall be in accordance with API Standard 682 requirements. Unless otherwise indicated, specified or required

by the equipment and seal manufacturers, the following API flushing Plan arrangements shall be utilized as appropriate for the application:
   a. Single seal, clean water applications: Plan 11 (Discharge bypass to seal).
   b. Single seal, vertical pump applications: Plan 13 (Seal bypass to suction).
   c. Single seal, clean hot water (greater than 180 degrees Fahrenheit) applications: Plan 23 (Seal cooler and pumping ring).
   d. Single seal, solids, or contaminants containing water applications: Plan 32 (External seal water).
   e. Double seal applications: Plan 54 (External seal water).

B. Packing: When specified in the equipment section of the specifications, provide the following type of packing:
   1. Wastewater, water, and sludge applications:
      a. Asbestos free.
      b. PTFE (Teflon™) free.
      c. Braided graphite.
      d. Manufacturers: One of the following or equal:
         1) Chesterton, 1400.
         2) John Crane, equivalent product.
   2. Drinking water service:
      a. Asbestos free.
      b. Material: Braided PTFE (Teflon™).
      c. Manufacturers: One of the following or equal:
         1) Chesterton, 1725.
         2) John Crane, equivalent product.

C. Mechanical seals: Provide seal types specified in the equipment sections and as specified:
   1. Provide seal types meeting the following requirements:
      a. Balanced hydraulically.
      b. Spring: Stationary, out of pumping fluid, Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
      c. O-ring: Viton™ 747.
      d. Gland: Type 316L stainless steel.
      e. Set screws: Type 316L stainless steel.
      f. Faces: Reaction bonded, silicon carbide.
      g. Seal designed to withstand 300 pounds per square inch gauge minimum differential pressures in either direction; no requirement for seal buffer pressure to be maintained when pump is not operational even though process suction head may be present in pump.
   2. Cartridge-type single mechanical:
      a. Manufacturers: One of the following or equal:
         1) Chesterton, S10.
         2) John Crane, 5610 Series.
   3. Cartridge-type double mechanical: Manufacturers:
      a. One of the following or equal:
         1) Chesterton, S20.
         2) John Crane, 5620 Series.
   4. Split-face single mechanical: Manufacturers:
      a. One of the following or equal:
         1) Chesterton, 442.
         2) John Crane, 3740.

2.05 GEAR REDUCTION UNITS

A. Type: Helical or herringbone, unless otherwise specified.

B. Design:
   1. Made of alloys treated for hardness and for severe service.
   2. AGMA Class II service:
      a. Use more severe service condition when such is recommended by unit's manufacturer.
   3. Cast-iron housing with gears running in oil.
   4. Anti-friction bearings.
   5. Thermal horsepower rating based on maximum horsepower rating of prime mover, not actual load.
   6. Manufactured in accordance with applicable AGMA standards.

C. Planetary gear units are not to be used.

2.06 BELT DRIVES

A. Sheaves:
   1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap tightening screws.
   2. When 2 sheave sizes are specified, provide separate belts sized for each set of sheaves.
   3. Statically balanced for all; dynamically balanced for sheaves that operate at a peripheral speed of more than 5,500 feet per minute.
   4. Key bushings to drive shaft.

B. Belts: Anti-static type when explosion-proof equipment or environment is specified.
   1. When spare belts are specified, furnish 1 spare belt for every different type and size of belt-driven unit:
      a. Where 2 or more belts are involved, furnish matched sets.
      b. Identify as to equipment, design, horsepower, speed, length, sheave size, and use.
      c. Package in boxes labeled with identification of contents.

C. Manufacturers: One of the following or equal:
   1. Dodge, Dyna-V belts with matching Dyna-V sheaves and Taper-Lock bushings.
   2. T.B. Woods, Ultra-V belts with matching Sure-Grip sheaves and Sure-Grip bushings.

2.07 BEARINGS

A. Type: Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.

B. Oil-lubricated bearings: Provide either pressure lubricating system or separate oil reservoir splash-type system:
   1. Size oil-lubrication systems to safely absorb heat energy generated in bearings when equipment is operating under normal conditions and with the temperature 15 degrees Fahrenheit above the maximum design temperature as specified in Section 01610 - Project Design Criteria.

2. Provide an external oil cooler when required to satisfy the specified operating conditions:
    a. Provide air-cooled system if a water-cooling source is not indicated on the Drawings.
    b. Equip oil cooler with a filler pipe and external level gauge.

C. Grease lubricated bearings, except those specified to be factory sealed: Fit with easily accessible grease supply, flush, drain, and relief fittings.
1. Lubrication lines and fittings:
    a. Lines: Minimum 1/4-inch diameter stainless steel tubing.
    b. Multiple fitting assemblies: Mount fittings together in easily accessible location.
    c. Use standard hydraulic-type grease supply fittings:
        1) Manufacturers: One of the following or equal:
            a) Alemite.
            b) Zerk.

D. Ratings: Rated in accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours.

2.08 MOTORS (NOT USED)

2.09 GEAR MOTORS (NOT USED)

2.10 VENDOR CONTROL PANELS (NOT USED)

2.11 EQUIPMENT SUPPORT FRAMES

A. Bolt holes shall not exceed bolt diameter by more than 25 percent, up to a limiting maximum diameter oversize of 1/4-inch.

2.12 SAFETY EQUIPMENT

A. Safety guards:
1. Provide guards that protect personnel from rotating shafts or components within 7.5 feet of floors or operating platforms.
2. Requirements:
    a. Allow visual inspection of moving parts without removal.
    b. Allow access to lubrication fittings.
    c. Prevent entrance of rain or dripping water for outdoor locations.
    d. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.
3. Materials:
    a. Sheet metal: Carbon steel, 12-gauge minimum thickness, hot-dip galvanized after fabrication.
    b. Fasteners: Type 304 stainless steel.

B. Insulation:
1. Insulate all surfaces with normal operating temperatures above 120 degrees Fahrenheit when surface is within 7.5 feet height from any operating floor or level.
2. Insulation thickness such that temperature is below 120 degrees Fahrenheit.
3. Insulation Type 3 and cover Type 5.

C. Warning signs:
   1. Provide warning signs in accordance with OSHA requirements for equipment that starts automatically or remotely.
   2. Material, sign size, and text: As specified in Section 10400 - Signage.
   3. Mount warning signs with stainless steel fasteners at equipment.

2.13 SPRING VIBRATION ISOLATORS

A. Design requirements:
   1. Telescopic top and bottom housing with vertical stabilizers to resist lateral and vertical forces.
   2. Use steel coil springs.
   3. Design vibration isolators in accordance with seismic design criteria as specified in Section 01612 - Seismic Design Criteria.

B. Performance requirements: Minimum spring deflection of 1inch under static load and capable of limiting transmissibility to 10 percent maximum at design operating load.

C. Manufacturers: One of the following or equal:
   1. California Dynamics Corporation, Type RJSD.
   2. Mason Industries, equivalent product.

D. Materials:
   1. Fabricate isolators using welded-steel or shatterproof ductile iron in accordance with ASTM A536 Grade CS-45-12.
   2. Spring steel: ASTM A125.

2.14 NAMEPLATES

A. Fastened to equipment at factory in an accessible and visible location.

B. Stainless steel sheet engraved or stamped with text, holes drilled or punched for fasteners.

C. Fasteners: Number 4 or larger oval head stainless steel screws or drive pins.

D. Text:
   1. Manufacturer’s name, equipment model number and serial number, motor horsepower when appropriate, and identification tag number.
   2. Indicate the following additional information as applicable:
      a. Maximum and normal rotating speed.
      b. Service class per applicable standards.
   3. Include for pumps:
      a. Rated total dynamic head in feet of fluid.
      b. Rated flow in gallons per minute.
      c. Impeller, gear, screw, diaphragm, or piston size.
   4. Include for gear reduction units:
      a. AGMA class of service.
      b. Service factor.
      c. Input and output speeds.

2.15 SHOP FINISHES

A. Provide appropriate factory coatings as specified in Section 09960 - High-Performance Coatings:
   1. Motors and gear reducers: Shop finish paint with manufacturer's standard coating, unless otherwise specified in the individual equipment specification.

2.16 SPECIAL TOOLS

A. Supply 1 set of special tools as specified in Section 01600 - Product Requirements.

2.17 SOURCE TESTING

A. Testing requirements unless specified otherwise in the individual equipment specifications:
   1. Mechanical equipment: Level 1 General Equipment Performance Test as specified in Section 15958 - Mechanical Equipment Testing.
   2. Vendor control panels: As specified in Section 17950 - Commissioning for Instrumentation and Controls.

2.18 SHIPPING

A. As specified in Section 01600 - Product Requirements.

B. Prior to shipment of equipment:
   1. Bearings (and similar items):
      a. Pack separately or provide other protection during transport.
      b. Greased and lubricated.
   2. Gear boxes:
      a. Oil filled or sprayed with rust preventive protective coating.
   3. Fasteners:
      a. Inspect for proper torques and tightness.

PART 3 EXECUTION

3.01 DELIVERY, HANDLING, STORAGE, AND PROTECTION

A. As specified in Section 01600 - Product Requirements.

B. Inspect fasteners for proper torques and tightness.

C. Storage:
   1. Bearings:
      a. Rotate units at least once per month or more often as recommended by the manufacturer to protect rotating elements and bearings.
   2. Gear boxes:
      a. Inspect to verify integrity of protection from rust.

D. Protection:
   1. Equipment Log shall include description of rotation performed as part of maintenance activities.

3.02 INSTALLATION

A. Field measurements:
   1. Prior to shop drawings preparation, take measurements and verify dimensions indicated on the Drawings.
   2. Ensure equipment and ancillary appurtenances fit within available space.

B. Sequencing and scheduling:
   1. Equipment anchoring: Obtain anchoring material and templates or setting drawings from equipment manufacturers in adequate time for anchors to be cast-in-place.
   2. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.

C. Metal work embedded in concrete:
   1. Accurately place and hold in correct position while concrete is being placed.
   2. Clean surface of metal in contact with concrete immediately before concrete is placed.

D. Concrete surfaces designated to receive non-shrink grout:
   1. Heavy sandblast concrete surface in contact with non-shrink grout.
   2. Clean concrete surfaces of sandblasting sand, grease, oil, dirt, and other foreign material that may reduce bond to non-shrink grout.
   3. Saturate concrete with water. Concrete shall be saturated surface damp at time non-shrink grout is placed.

E. Install equipment in accordance with manufacturer's installation instructions and recommendations.

F. Lubrication lines and fittings:
   1. Support and protect lines from source to point of use.
   2. Fittings:
      a. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
      b. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
      c. Fittings for underwater bearings: Bring fittings above water surface and mount on edge of structure above.

G. Alignment of drivers and equipment:
   1. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after complete unit has been leveled on its foundation.

2. Comply with procedures of appropriate HI, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
    a. Maximum total coupling offset (not the per-plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).
    b. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.
3. Use reverse-indicator arrangement dial-type or laser-type alignment indicators: Mount indicators on the driver/coupling flange and equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.
4. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.
5. When alignment satisfies most stringent tolerance of system components, grout between base and foundation:
    a. Allow minimum 48 hours for grout to harden.
    b. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
    c. Correct alignment as required.
6. After functional testing is complete, dowel motor or drivers and driven equipment:
    a. Comply with manufacturer's instructions.

H. Grouting under equipment bases, baseplates, soleplates, and skids:
1. Unless otherwise indicated on the Drawings, grout with non-shrink grout as specified in Section 03600 – Grouting:
    a. Non-shrink epoxy grout required only when indicated on the Drawings.
2. Comply with equipment manufacturer's installation instructions for grouting spaces, and tolerances for level and vertical and horizontal alignment.
3. Install grout only after:
    a. Equipment is leveled and in proper alignment.
    b. Piping connections are complete and in alignment with no strain transmitted to equipment.
4. Do not use leveling nuts on equipment anchors for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting.
5. Use jack screws for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting following the procedure defined below:
    a. Drill and tap equipment base plates, sole plates, and skids for jack screws.
    b. Use suitable number and size of jack screws.
    c. End of jack screws shall bear on circular steel plates epoxy bonded to equipment foundation.
    d. Jack screw threads that will be in contact with grout: Wrap with multiple layers of tape or other material, acceptable to Engineer, to prevent grout from bonding to threads.
    e. Place and cure grout as specified in Section 03600 - Grouting.
    f. After grout is cured, remove jack screws and material used to prevent bonding to grout:
        1) Provide jack screws to Owner for future use.

g. Tighten equipment anchors in accordance with equipment manufacturer requirements.
h. Fill holes where jack screws have been removed with grout.
i. Cure as specified in Section 03600 - Grouting.

6. For equipment bases, baseplates, soleplates, and skids where it is not practical to use jack screws, use steel wedges and shims.
   a. Wrap wedges and shims that contact grout with multiple layers of tape or other material, acceptable to Engineer, to prevent grout from bonding.
   b. Place and cure grout as specified in Section 03600 - Grouting.
   c. Remove wedges or shims.
   d. Tighten equipment anchors to in accordance with equipment manufacturer requirements.
   e. Fill voids where wedges and shims have been removed with grout.
   f. Cure as specified in Section 03600 - Grouting.
7. Preparation of equipment bases, baseplates, soleplates, and skids for grouting:
   g. Metal in contact with grout: Grit blast to white metal finish.
   h. Clean surfaces of equipment bases, baseplates, soleplates, and skids in contact with grout of dirt, dust, oil, grease, paint, and other material that will reduce bond.
7. Preparation of concrete equipment foundation for grouting:
   a. Rough concrete surfaces in contact with grout.
   b. Concrete contact surface shall be free of dirt, dust, laitance, particles, loose concrete, or other material or coatings that will reduce bond.
   c. Saturate concrete contact surface area with water for minimum of 24 hours prior to grouting.
   d. Remove standing water just prior to grout placement, using clean rags or oil-free compressed air.

8. Forms and header boxes:
   a. Build forms for grouting of material with adequate strength to withstand placement of grouts.
   b. Use forms that are rigid and liquid tight. Caulk cracks and joints with an elastomeric sealant.
   c. Line forms with polyethylene film for easy grout release. Forms carefully waxed with 2 coats of heavy-duty paste wax will also be acceptable.
9. Grout placement requirements:
   a. Minimum ambient and substrate temperature: 45 degrees Fahrenheit and rising:
      1) Conform to grout manufacturer’s temperature requirements.
   b. Pour grout using header box.
   c. Keep level of grout in header box above bottom of equipment bases, baseplates, soleplates, and skids at all times to prevent air entrapment.
   d. Grout shall flow continuously from header box to other side of forms without trapping air or forming voids.
   e. Vibrate, rod, or chain grout to facilitate grout flow, consolidate grout, and remove entrapped air.
   f. After grout sets, remove forms and trim grout at 45-degree angle from bottom edge of equipment bases, baseplates, soleplates, and skids.
   g. Cure as specified in Section 03600 - Grouting.

I. Field welding:
   1. Use welding procedures, welders, and welding operators qualified and certified in accordance with AWS D1.1.
   2. Shielded arc welding.

J. Field finishes:
   1. Protect motors.
   2. Clean equipment.
   3. Apply primer and coating systems as specified in Section 09960 - High-Performance Coatings requirements.

K. Special techniques:
   1. Use applicable special tools and equipment, including precision machinist levels, dial indicators, and gauges as required in equipment installations.

L. Tolerances:
   1. Completed equipment installations: Comply with requirements for intended use and specified vibration and noise tolerances.

M. Warning signs:
   1. Mount securely with stainless fasteners at equipment that can be started automatically or from remote locations.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Functional testing requirements unless specified otherwise in the individual equipment specifications:
   1. Mechanical equipment: Level 1 tests as specified in Section 15958 - Mechanical Equipment Testing.
   2. Vendor control panels: As specified in Section 17950 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 15075

EQUIPMENT IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Equipment nameplates.
   2. Special items.

1.02 SUBMITTAL

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Shop drawings:
   1. Product data.
   2. Installation instructions.

C. Samples.

PART 2 PRODUCTS

2.01 EQUIPMENT NAMEPLATES

A. Material and fabrication:
   1. Stainless steel sheet engraved or stamped with text, holes drilled, or punch for fasteners.

B. Fasteners:
   1. Number 4 or larger oval head stainless steel screws or drive pins.

C. Text:
   1. Manufacturer’s name, equipment model number and serial number, identification tag number; and when appropriate, drive speed, motor horsepower with rated capacity, pump rated total dynamic head, and impeller size.

2.02 SPECIAL ITEMS

A. In addition, special coating of following items will be required:

Item	Color
Steel guard posts	In accordance with standard details

B. Paint minimum 2 inches high numbers on or adjacent to accessible valves, pumps, flowmeters, and other items of equipment which are indicated on the Drawings or in Specifications by number.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01600 - Product Requirements.

3.02 PREPARATION

A. Prepare and coat surfaces of special items as specified in Section 09960 – High -Performance Coatings.

B. Prepare surface in accordance with product manufacturer's instructions.

END OF SECTION

SECTION 15084

DUCTWORK INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Internal acoustical insulation and external thermal insulation for metal air ductwork systems.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
   2. G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

B. Sheet Metal and Air Conditioning Contractor's National Association (SMACNA).

C. California Code of Regulations (CCR):
   1. Title 24 - Building Standard Code.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Certification of compliance with CCR Title 24 energy and approval by the California Energy Commission.

1.04 QUALITY ASSURANCE

A. Comply with SMACNA ducting construction standards and the specified requirement, whichever is more stringent.

B. Compliance with CCR Title 24.

PART 2 PRODUCTS

2.01 INTERNAL DUCTWORK INSULATION

A. Manufacturers: One of the following or equal:
   1. Owens Corning, QuietR flexible duct liner or Fiberglass rigid duct liner.
   2. Johns Manville, Linacoustic RC flexible duct liner or Permacoat Linacoustic R-300 rigid duct liner.

B. Type: Flexible or board type duct liner with 1 coated surface meeting the following:
   1. Thickness: As required to achieve the following R-values:
      a. For ducting exterior to weather protected spaces provide 2 inches minimum thickness to meet an installed value of R8; comply with minimum R-value requirements in accordance with CCR Title 24; provide additional weatherproof exterior barrier covering.
      b. For interior ducting in ceiling plenums, attics or other unconditioned spaces provide 1-1/2 inches minimum thickness to meet an installed value of R6; comply with minimum R-value requirements in accordance with CCR Title 24.
   2. Temperature range: 40 to 250 degrees Fahrenheit.
   3. Density: 1.5 pounds per cubic foot.
   4. Thermal conductivity: 0.25 Btu-inch per hour per square foot per degree Fahrenheit at 75 degrees Fahrenheit.
   5. Fire hazard classification in accordance with ASTM E84:
      a. Flame spread: 25.
      b. Smoke developed: 50.
   6. Service conditions: Velocities to 2,500 feet per minute.
   7. Acoustical performance: NRC of 0.55 minimum.
   8. Bacterial growth: None in accordance with ASTM G21.

C. Edge treatment: Provide leading edges with galvanized metal nosing; seal other edges with manufacturer's recommended edge treatment.

PART 3 EXECUTION

3.01 INTERNAL DUCTWORK INSULATION

A. Provide rigid insulation on rectangular ducts carrying conditioned air that pass through outdoor or unconditioned spaces, or as indicated on the Drawings.

B. Install with coated surface facing inside of duct; attach with adhesive to duct and provide fasteners spaced at not to exceed 12 inches transverse (perpendicular) to flow and 18 inches parallel (longitudinal) to flow; provide fasteners within 3 inches of transverse edges and 4 inches of longitudinal edges.

C. Follow manufacturer's published installation instructions.

D. Install metal nosing on leading edges and seal other exposed edges with manufacturer's edge treatment.

END OF SECTION

SECTION 15740

HEAT PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Heat pump units.

1.02 REFERENCES

A. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
   1. 210-240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
   2. 270 - Sound Rating of Outdoor Unitary Equipment.
   3. 340/360 - Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.

B. Air Movement and Control Association International, Inc. (AMCA):
   1. 210 - Laboratory Methods for Testing Fans for Certified Aerodynamic Performance Rating.

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   1. Standard 15 - Safety Standard for Refrigeration Systems.
   2. Standard 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
   3. Standard 62.1 - Ventilation for Acceptable Indoor Air Quality.

D. American National Standards Institute (ANSI):
   1. Z21.47 - Gas Fired Central Furnaces (except Direct Vent Central Furnaces) with Addenda.

E. California Code of Regulations (CCR):
   1. Title 24 - Building Standards Code.

F. Federal Specification (FS):
   1. Standard 141 - Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing.

G. National Electrical Code (NEC).

H. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

I. National Fire Protection Association (NFPA):
   1. 54 - National Fuel Gas Code.
   2. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

J. National Roofing Contractors Association (NRCA).

K. Underwriters' Laboratories, Inc. (UL):
   1. 900 – Standard for Air Filter Units.

1.03 DEFINITIONS

A. NEMA: Type 3R enclosure in accordance with NEMA 250.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Shop drawings:
   1. System layout, mechanical, electrical power, and control diagrams.
   2. Nameplate information.
   3. Materials.
   4. Supports, vibration isolators, and seismic bracing calculations and details.
   5. Primary and ancillary equipment.
   6. Proposed cutting and patching, when required.
   7. Maximum recommended equipment vibration levels and field-testing method.
   8. Sound power level in each of 8 octave bands and overall Sones.
   9. Bearing life.
   10. Fan performance curves showing specified operating condition.
   11. Copy of factory test results.
   12. For projects in California, certification of compliance with CCR Title 24 efficiency standards and approval by the California Energy Commission.

C. Operation and maintenance data as specified in Section 01782 - Operation and Maintenance Manuals.

D. Warranties.

E. Provide required commissioning submittals as specified in Section 01756 - Commissioning.

1.05 QUALITY ASSURANCE

A. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels.

B. Regulatory requirements:
   1. For projects located in California, comply with requirements of CCR Title 24 energy efficiency regulations.

C. Qualification of manufacturer: Manufacturer with experienced personnel, physical facilities, and management capacity sufficient to produce products of quality specified with a minimum 5 years satisfactory performance record.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver units in 1 piece (or modular, if required), factory assembled, piped, internally wired, and factory tested.

B. Protect equipment from dust and atmospheric exposure as recommended by the unit manufacturer:
   1. Provide temporary closures for equipment openings designed for airflow.

1.07 WARRANTY

A. Special warranties:
   1. Refrigerant compressors and closed or sealed refrigerant systems warranty duration: Provide 5-year warranty.
   2. Electric heaters (if supplied) warranty duration: Provide 5-year warranty.
   3. Evaporator and condensing coils warranty duration: Provide 5-year warranty.

1.08 MAINTENANCE

A. Extra materials: Provide 2 extra (3 total) sets of filters per unit installed.

B. Provide 1 set of sheaves and belts for change-out, if required, for final balance per unit installed.

C. After final balance, provide 1 extra set of belts for each unit installed.

D. Special tools: Deliver 1 set of special tools needed to assemble and disassemble the components of the unit requiring regular maintenance.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements and 15050 - Common Work Results for Mechanical Equipment.

B. Inclusion of a specific manufacturer's name in the Specifications does not mean that the specific manufacturer's standard product will be acceptable. Specified manufacturer's or other manufacturer's standard product shall be modified as required to meet the Specifications.

C. All supplied components of the unit shall be furnished and fully integrated by the unit system supplier, having unit responsibility:
   1. Furnish and install all piping, valves, dampers, sensors and wiring within the unit package.
   2. Provide a unit mounted control panel prewired on the unit to all dampers and sensors within the unit.

D. Motors:
   1. Totally enclosed.
   2. Voltage and number of phases as scheduled.
   3. Compressor motors:
      a. Cooled by refrigerant gas passing through windings.
      b. Provided with line break thermal and current overload protection.
   4. Fan and blower motors:
      a. Permanently lubricated ball bearings.
      b. Integral automatic reset thermal overload protection.

5. Other requirements as specified.

E. Electrical:
   1. Provide a single conduit connection in the unit for both power and control wiring.

2.02 SYSTEM DESCRIPTION

A. Design requirements:
   1. Provide fans that have sharply rising pressure characteristics which extend throughout the operating range and continue to rise beyond the efficiency peak.
   2. Provide fans that peak as close as possible to the maximum efficiency and whose operating range is within the normal fan selection range.
   3. When scheduled, provide guided vibration isolator for fans, so that not more than 10 percent of the vibration amplitude of the fan and motor is transmitted to the supporting structure.
   4. Design fan inner scroll and air stream surfaces to maintain smoothness for entire fan service life.
   5. Seismic supports: Design supports to comply with the criteria specified in Section 01612 - Seismic Design Criteria.
   6. Wind supports: Design supports to comply with the criteria specified in Section 01614 - Wind Design Criteria.
   7. Electrical components: UL listed and meeting the design and installation requirements of the NEC.
   8. Roof curbs: Designed in accordance with NRCA Standards.
   9. Gas, water piping, drains, and venting: In accordance with building code, mechanical code, and plumbing code as specified in Section 01410 - Regulatory Requirements and in accordance with applicable codes.
   10. Fans supplied with heat pump units: Rated in accordance with AMCA 210.
   11. Unit heat pumps: Rated in accordance with AHRI Standards 210-240 or 340/360 and AHRI 270. Conform to the latest version of ASHRAE 15.
   12. Unit heat pumps with auxiliary heating options: Certified in accordance with ANSI Z21.47.
   13. Insulation and adhesives: In accordance with NFPA 90A requirements for flame spread and smoke generation.
   14. Refrigerant: HCFC R-410A.
   15. Finishes: When not specified with fan type, coat ferrous metals as specified in Section 09960 - High-Performance Coatings.
   16. For projects located in California, comply with energy efficiency requirements of CCR Title 24.

B. Performance requirements:
   1. Performance requirements as specified and as scheduled on the Heat Pump Schedule indicated on the Drawings.
   2. Outdoor noise levels: Outdoor noise levels in the 8 octave band ranges, as measured in accordance with AHRI Standard 270 for unit heat pumps and split system heat pumps shall not exceed the following:

OCTAVE BANDS								
Unit Nominal Capacity (Tons)	**63**	**125**	**250**	**500**	**1,000**	**2,000**	**4,000**	**8,000**
0 to 5	64	70	71	74	74	71	67	67
6	79	85	78	74	71	73	66	59
7-1/2 to 10	64	70	73	79	82	78	74	67
12 and larger	84	88	84	83	84	78	72	68

3. Units shall be capable of starting and running from 45 to 125 degrees Fahrenheit ambient outdoor air temperature and exceeding the maximum load criteria of AHRI Standard 210-240 or 340/360.
4. Capable of starting and providing heating at or above 0 degrees Fahrenheit outdoor ambient air temperature.
5. Minimum cooling and heating capacities, energy efficiency ratios (EER), and coefficient of performance (COP), as rated in accordance with AHRI 210-240 or 340/360 and 270, unless scheduled otherwise:

				Heating High Temperature(1)		**Heating Low Temperature(2)**	
Nominal Capacity (Tons)	**Standard cfm**	**Cooling Capacity (Btuh)**	**EER(3)**	**Capacity (Btuh)**	**COP**	**Capacity (Btuh)**	**COP**
3	1,200	36,400	11.0	35,200	3.0	18,400	2.0
4	1,750	47,000	11.0	47,000	3.0	26,400	2.0
5	2,000	59,000	11.0	59,000	3.0	26,400	2.1
6	2,400	72,800	11.0	70,400	3.0	36.800	2.0
7-1/2	3,000	87,000	11.0	89,000	3.0	49,000	2.0
10	4,000	113,000	11.0	116,000	3.0	65,000	2.0

Notes:

(1)High temperature heating standard:
   a. 70 degrees Fahrenheit dB indoor entering air temperature.
   b. 47 degrees Fahrenheit dB, 43 degrees Fahrenheit wet bulb outdoor entering air temperature.

(2) Low temperature heating standard:
   a. 70 degrees Fahrenheit dB indoor entering air temperature.
   b. 17 degrees Fahrenheit dB, 15 degrees Fahrenheit wet bulb outdoor entering air temperature.

(3) EER value:
   a. Deduct 0.2 from the required EER's for units with a heating section other than electric resistance heat.
   b. EER value based on CCR Title 24 requirements.

1. Units with heating capabilities: Meet or exceed the following efficiencies:
   a. Annual fuel utilization efficiency: 80 percent.

b. Steady state efficiency: 80 percent.
c. For projects located in California, California seasonal efficiency: 76.9 percent.

6. Unit air flows for cooling: A minimum of 300 cubic feet per minute per ton but not exceeding 500 cubic feet per minute per ton of cooling unless scheduled otherwise.
7. Filter:
   a. Media: UL 900 listed, Class I or Class II, approved by local authorities.
   b. Efficiency: 45 to 50 percent dust spot efficiency when rated per ASHRAE Test Standard 52.2.
   c. Face velocity: Per manufacturer recommendation.

C. Provide electrical equipment, conduit and wire as specified in Section 15936 - Instrumentation and Control Devices for HVAC.

2.03 PACKAGED HEAT PUMPS

A. Manufacturers: One of the following or equal:
1. Trane, Series WSC120.
2. Carrier, similar series.
3. Johnson controls, similar series.

B. Compressors:
1. Fully hermetically sealed, high efficiency, reciprocating, or scroll type, with internal and external vibration isolation.
2. Equipped with high-pressure relief.

C. Fans:
1. Indoor air fan:
   a. Direct or belt driven, forward curved, double inlet, centrifugal type, steel with corrosion resistant finish, statically and dynamically balanced.
   b. Permanently sealed ball bearings and permanently lubricated.
   c. Adjustable pitch motor pulley.
   d. Where the condenser fan exceeds 7.49 horsepower, provide variable speed or 2-speed fan with low speed at 2/3 of the high speed.
2. Outdoor air fan:
   a. Propeller type, direct drive, aluminum blades, dynamically balanced, and vertical discharge.
   b. Permanently sealed ball bearings and permanently lubricated.
3. Induced draft blower:
   a. Direct or belt drive, single inlet, forward curved centrifugal type, statically and dynamically balanced.
   b. Made from steel with corrosion resistant finish.

D. Coils:
1. Evaporator and heat pump coils: Seamless copper tubes with mechanically bonded aluminum plate fins.
2. Evaporator and heat pump coils, internal piping, and appurtenances: Factory applied phenol-formaldehyde thermosetting resinous coating.

E. Refrigerant components: Refrigerant circuit including:
1. Accumulator.
2. Filter drier.

3. Expansion device.
4. Gauge ports.
5. Flow control valves.
6. Circuit feed system.
7. Strainer.
8. Reversing valve.
9. Service and gauge connections on compressor suction and discharge, and liquid lines to charge, evacuate, and contain refrigerant.

F. Electric heating section: When electric heat is scheduled:
   1. Provide balanced 3-phase heating coils of capacity as scheduled.

G. Gas heating section: When gas heat is scheduled, provide:
   1. Induced draft ignition type.
   2. Spark ignition non-continuous pilot.
   3. Redundant main gas valve and 2-stage heating.
   4. Heat exchange tubular type constructed of minimum 20 gauge aluminized steel.
   5. Burners in shot type constructed of aluminum-coated steel.

H. Electric heating section: When electric heat is scheduled:
   1. Provide balanced 3-phase heating coils of capacity as scheduled.

I. Controls and equipment safety features:
   1. Provide system controls for a complete functioning system that operates as described. Provide, as a minimum, the following:
      a. Condenser fan controls.
      b. Evaporator fan controls.
      c. All motor contactors.
      d. 24-volt control circuit and transformer, if 24-volt control is specified in the Air Conditioning Unit Schedule.
      e. Manual reset circuit breakers.
      f. Power disconnect switch.
      g. Electronic thermostat.
      h. 5-minute compressor cycle delay.
      i. Differential enthalpy economizer control.
      j. Check filter switch suitable for field connection remote alarm.
      k. 2-stage heating and cooling.
      l. Flame proving controls.
      m. Outdoor coil defrost system controls.
      n. Heater controls: When auxiliary heat is scheduled, provide heat package controls to actuate auxiliary heat when mechanical heating is locked out.
      o. Provide with a low ambient cooling option.
   2. Equipment safety features:
      a. High-pressure switches.
      b. Compressor over-temperature and overcurrent.
      c. Loss of charge/low pressure switch.
      d. Freeze stat on evaporator.
      e. Lock out protection.

f. When auxiliary electric heater is specified on Heat Pump Schedule additional safety features:
1) Heat limiters for primary and secondary overcurrent and thermal protection:
a) Automatic reset switches.
b) Branch circuit protection.
g. Heating high temperature limit switch.
h. Heating induced draft motor pressure switch.
i. Heating flame roll out switch.
3. Provide dry-contacts for the following status and alarms:
a. Failed.
b. Running.
c. Dirty Filter.
4. Provide an input connection for a smoke alarm shutdown.
5. Interface to building HVAC controls:
a. Provide contacts and signals to operate unit with the HVAC control system as specified in Section 15936 - Instrumentation and Control Devices for HVAC.

J. Electrical:
1. Provide 15-amp 120-volt, single phase, ground fault interrupter convenience outlet at condenser unit; provide factory installed transformer, and independent fuse or breaker protection for outlet.
2. Provide power disconnect switch at each piece of unit; mount disconnect in NEMA Type 3R enclosure if exterior to unit.

K. Unit casing:
1. Manufactured of minimum 22-gauge galvanized steel, bonderized, corrosion protected, and exterior coated with a baked enamel finish interior primer coated. Comply with FS Test Method Standard 141 (Method 6061) 500-hour salt spray test.
2. Weatherproof design, reinforced and braced for maximum rigidity.
3. Indoor air section compartment: Insulated with minimum 1/2 inch thick, permanent, fireproof, odorless glass fiber material, and coated on the air side. Aluminum foil face fiberglass insulation shall be used in the furnace compartment.
4. Provide gasketed, removable panels or access doors to service equipment components and connections.
5. Provided with:
a. Filter rack for 2-inch filters accessible through hinged access door with gaskets.
b. Non-corrosive drain pan in accordance with ASHRAE Standard 62.1.
c. Minimum 3/4-inch horizontal drain connection.
d. Knockouts for utility and control connections.
e. Minimum 16-gauge steel roll formed base rail with lifting holes.

L. Filter section:
1. Manufacturers: The following or equal:
a. American Air Filter.
2. Provide filter with at least a MERV 13 rating.
3. Low velocity 2-inch thick pleated filters of commercially available sizes.
4. Filter face velocity: Per manufacturer’s recommendations.

5. Filters for any 1 unit shall be the same size.

2.04 ACCESSORIES

A. Curb assemblies:
   1. Provide where called for on the Heat Pump and/or as indicated on the Drawings.
   2. Factory fabricated of aluminum with wood nailer strip and gaskets.
   3. Capable of supporting entire unit weight.
   4. Suitable for installing and connecting ductwork to curb.
   5. In accordance with NRCA Standards.
   6. Height:
      a. Shall extend a minimum of 12 inches above top of built up roofing, but shall be no more than 15 inches high for Packaged Heat Pump Units.
      b. Shall extend a minimum of 8 inches above top of built up roofing, but shall be no less than 14 inches high for Split System Heat Pump Units outdoor condensing unit.
   7. Flashing in accordance with NRCA Standards.

B. Economizer, when scheduled provide:
   1. Integrated type capable of compressor operation while modulating to utilize up to 100 percent outdoor air for cooling when outdoor air and humidity are at set acceptable levels.
   2. Including:
      a. Differential bulb enthalpy control.
      b. Damper drive motor.
      c. Gravity relief damper.
      d. Low leakage dampers, not to exceed 3 percent leakage at 1-inch static pressure.
   3. Differential enthalpy sensor for economizer control.

C. Sensors: As specified in Section 15936 – Instrumentation and Control Devices for HVAC.

D. Provide flue hood protector assembly to protect from the hot sides of the gas flue hood.

E. Provide hail guard to protect against damage from hail and other flying debris.

F. Provide NO_x reduction kit to reduce NO_x emission levels to no more than 40 nanograms per joule.

G. Provide dirty filter switch with contacts for field installed remote light or alarm.

H. Provide coil guard grill to protect condenser coil from penetration by large objects.

I. Provide condensate drain per mechanical code as specified in Section 01410 - Regulatory Requirements.

J. Flexible duct connectors: As specified in Section 15820 - Ductwork Accessories.

PART 3 EXECUTION

3.01 GENERAL

A. Inspect all components for shipping damage, conformance to specifications, and proper torques and tightness of fasteners, as specified in Section 15050 - Common Work Results for Mechanical Equipment.

B. Prior to installation, protect equipment from dust and atmospheric exposure as recommended by the unit manufacturer:
   1. Provide temporary closures for equipment openings designed for airflow.

C. During installation and until equipment is operated, protect equipment and ducts from dust and debris by covering openings with tape or plastic.

D. Examine and verify details and sections indicated on the Drawings, ascertain adequacy, and determine conflicts in dimensions and clearances:
   1. Take measurements and verify dimensions to ascertain fit of installation.
   2. Ascertain structural sufficiency to support installation.
   3. Ascertain that supports and openings are correctly located; otherwise cut new openings where required:
      a. Submit details of proposed cutting and patching.
   4. Confirm specified thermostat or other controls are compatible with specified equipment.

3.02 INSTALLATION

A. As specified in Section 15050 - Common Work Results for Mechanical Equipment:
   1. Before installation, remove dust and debris from equipment and ducts.

B. Anchoring and support:
   1. Provide anchoring and support designed in accordance with current engineering practice for equipment and appurtenances by attaching or connecting to supporting members or by providing other supports.

C. Adjust alignment of ducts where necessary to resolve conflicts with architectural features or to resolve conflicts with the work of other trades.

D. Install and wire unit air conditioners, controls, and thermostats in accordance with manufacturer's recommendations:
   1. Provide local disconnect switches.

E. Provide flexible duct and flexible piping connections at connections to unit air conditioners.

F. Install roof curb and unit as recommended by unit manufacturer.

G. Install NRCA approved flashing and counterflashing.

H. Provide venting in accordance with building code, mechanical code, and plumbing code as specified in Section 01410 - Regulatory Requirements and in accordance with NFPA 54.

I. Upon completion of installation, clean duct, and debris from ductwork, and equipment.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer’s Certificate of Source Testing.
      b. Manufacturer’s Certificate of Installation and Functionality Compliance.
   2. Manufacturer’s Representative onsite requirements:
      a. Installation: 1 trip, 1 day minimum.
      b. Functional Testing: 1 trips, 1 day minimum each.
   3. Training:
      a. Maintenance: 2 hours per session, 2 sessions.
      b. Operation: 1 hours per session, 2 sessions.
   4. Process operational period:
      a. As required by Owner or Contractor.

C. Source testing:
   1. Test as specified in Section 15958 - Mechanical Equipment Testing.
   2. Equipment:
      a. Test witnessing: Not witnessed.
      b. Conduct Level 1 General Equipment Performance Test.
      c. Conduct Level 1 Vibration Test.
      d. Conduct Level 1 Noise Test.
      e. Factory test in cooling and heating modes including economizer operation. Evacuate coils and refrigerant system for 30 minutes prior to final charging of unit before shipment.
   3. Electrical Instrumentation and Controls:
      a. Test witnessing: Not witnessed.
      b. Conduct testing as specified in Section 17950 - Commissioning for Instrumentation and Controls.

D. Functional testing:
   1. Equipment:
      a. Test witnessing: Witnessed.
      b. Conduct Level 2 General Equipment Performance Test.
      c. Conduct Level 2 Vibration Test.
      d. Conduct Level 2 Noise Test.
      e. Test equipment and installation to verify tightness, operation, and unit heat pump vibration is within manufacturer's submitted maximum.
      f. Test equipment performance and balance equipment as specified in Section 15954 - Testing, Adjusting, and Balancing for HVAC.
      g. Test for outdoor sound power at levels.
   2. Electrical Instrumentation and Controls:
      a. Test witnessing: Witnessed.
      b. Conduct testing as specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.04 SCHEDULES

A. As indicated on the Drawings.

END OF SECTION

SECTION 15812

METAL DUCTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Aluminum ductwork.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

B. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   1. HVAC Systems-Duct Design.
   2. Seismic Restraint Manual Guidelines for Mechanical Systems.

C. Underwriters Laboratories, Inc. (UL):
   1. 181A - Closure Systems for Use with Rigid Air Ducts.

1.03 SYSTEM DESCRIPTION

A. Design requirements:
   1. Custom design and fabricate metal ductwork for the applications indicated on the Drawings and for the conditions specified.
   2. In accordance with SMACNA Manual for gauge of sheet metal, joint types, reinforcement, bracing, hangers and supports, fabrication, and installation:
      a. Sheet metal thicknesses: The greater of that thickness required to in accordance with SMACNA for the design pressure specified and the following minimum thicknesses:

Diameter or Largest Dimension of Rectangular Duct (Inches)	Minimum Sheet Thickness, Inches (B&S Gauge)
Up to 12	0.025 (22)
13 to 30	0.032 (20)
Larger than 31	0.040 (18)

      b. Spacing of hangers and supports:
         1) Provide supports as indicated on the Drawings.
         2) When supports are not shown, provide supports as required in accordance with SMACNA but no greater than the spacing indicated on the Drawings or the following requirements; whichever is less:
            a) Ducts 18 inches and smaller in largest dimension: 8 feet on center.
            b) Ducts over 18 inches in largest dimension: 4 feet on center.

c. Support connections:
1) Provide as indicated on the Drawings.
2) When not indicated on the Drawings, provide in accordance with SMACNA.
3) As a minimum, all support connections to metal or wood roofs shall be located at roof framing members only.
4) No penetrations through roof deck, roof membrane, or connections to roof membrane are acceptable.

3. Design pressure: 2 inches water column unless otherwise indicated on the Drawings or specified.
4. Seismic design criteria: As specified in Section 01612 - Seismic Design Criteria and in accordance with SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems.
5. Hanger reinforcement:
a. Ducts 18 inches and smaller in largest dimension: None.
b. Ducts over 18 inches and under 30 inches in largest dimension: 1-1/2 inches by 1-1/2 inches by 1/8-inch angles, 8 feet on center.
c. Ducts 30 inches and larger in largest dimension: 1-1/2 inches by 1-1/2 inches by 1/8-inch angles, 4 feet on center.
6. When ducts are specified with insulation on interior walls, size duct to provide clear inside dimensions indicated on the Drawings.

B. Miscellaneous design details:
1. Changes in duct size:
a. Use uniformly tapering sections.
b. Taper not more than 1 inch in 5 inches of run unless otherwise indicated on the Drawings.
2. Bends: With the exception of miter bends, design bends with inside radii equal to duct width or diameter:
a. Install turning vanes at all 90 degree beds.
3. Duct sleeves: Install duct sleeve when ducts pass through concrete or masonry walls, slabs, or ceilings.
4. Access openings: Install in locations that allow access to dampers, fusible links, controllers, and similar devices.
5. Flexible connections: Install at connections to air handling equipment and at locations indicated on the Drawings.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data:
1. Duct and component material and details of construction.
2. System layout including floor and wall penetrations.
3. Supports and anchoring details.
4. Components used in the duct system including turning vanes, dampers, flexible connections, and access doors.

C. Design data: Seismic design calculations:
1. Design calculations for duct construction as specified in Section 01612 -Seismic Design Criteria and in accordance with SMACNA.

D. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.

PART 2 PRODUCTS

2.01 MATERIALS

A. Ducts: Aluminum alloy 3003 H14 in accordance with ASTM B209.

B. Flexible connectors: As specified in Section 15084 - Ductwork Insulation.

C. Reinforcing: Formed or extruded aluminum angles.

D. Ductwork insulation: As specified in Section 15084 - Ductwork Insulation.

2.02 COMPONENTS

A. Duct sleeves:
   1. Sleeve flanges: 4 inches wide.
   2. Size: 2 inches larger than the duct or duct with external insulation.

B. Access openings:
   1. Size: 2 inches less than duct size.
   2. Doors:
      a. Gauge not less than duct sheet.
      b. Provide continuous hinge and latch on outside.
   3. Gasket: Along door periphery.
   4. Visual panel: 1/8-inch thick, clear plexiglass.

C. Splitter dampers: Provide at branch take-offs where necessary for balancing system.

D. Extractors:
   1. Components:
      a. Synchronized steel curved blades.
      b. Heavy side rails.
      c. Screw operator.
   2. Provide extractors at take-off from main supply duct adjacent to diffusers, registers, or grilles where splitter is not used.

2.03 FABRICATION

A. Fabricate ductwork to the configuration and dimensions indicated on the Drawings.

B. Dimensions indicate net free area. Increase duct dimensions by thickness of insulation when internal insulation is specified.

C. Do not utilize S clips, duct tape, or externally applied mastic on medium pressure duct systems.

D. Do not use snap lock seams.

E. Provide flexible duct connectors at all connections to fans and other air movement equipment.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive metallic ductwork as specified in this Section:
   1. Take measurements and verify dimensions on shop drawings to verify fit of installation.
   2. Verify that supports and openings are correctly located.

B. Examine and verify structural details and determine conflicts in dimensions and clearances.

3.02 INSTALLATION

A. Cover ductwork openings with tape, plastic, or sheet metal to reduce the amount of dust or debris which may collect in the system at each of the following times:
   1. At the time of rough installation.
   2. During storage on the construction site.
   3. Until final start-up of the heating and cooling equipment.

B. Before installation remove dust and debris from ducts.

C. Adjust duct alignment where necessary to resolve conflicts with architectural features or to resolve conflicts with the work of other trades.

D. Install ductwork to provide a system free of buckling, warping, or vibration.

E. Hangers:
   1. Install hangers as indicated on the Drawings.
   2. When hangers are not detailed, conform to SMACNA HVAC System Duct Design and Seismic Restraint Manual standards and the following requirements:
      a. Rectangular ducts concealed in ceiling spaces:
         1) Use metal strap hangers.
         2) Fasten to sides of duct with 2 screws.
         3) Fasten to bottom of duct with 1 screw.
      b. Rectangular ducts in exposed areas:
         1) Install shelf angle trapeze hangers or Unistrut type hangers.
         2) Install sway bracing as required by seismic calculations, minimum 1 brace at right angle to each duct run.
      c. Round ducts in exposed areas:
         1) Install 2 half-round bands with rods bolted to panels.
         2) Install sway bracing as required by seismic calculations, minimum 1 brace at right angle to each duct run.
   3. Flexible connections: As specified in Section 15084 - Ductwork Insulation.

F. Provide closed-cell neoprene gaskets at flanged joints.

G. Tapes and mastics used to seal ductwork shall be listed and labeled in accordance with UL 181A and shall be marked.

3.03 FIELD QUALITY CONTROL

A. Inspect ductwork under operating conditions:
   1. Correct audible leaks and leaks that can be felt with the hand.

B. Test and balance ducting systems as specified in Section 15954 - Testing, Adjusting, and Balancing for HVAC.

END OF SECTION

SECTION 15820

DUCTWORK ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Dampers and damper operators.
   2. Diffusers, grilles, and registers.
   3. Screens.
   4. Flexible duct connectors.
   5. Other ductwork accessories.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

B. National Fire Protection Association (NFPA):
   1. 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
   2. 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.

C. Uniform Building Code (UBC).

D. Underwriters Laboratories, Inc. (UL):
   1. 555 - Fire Dampers.
   2. 555S - Smoke Dampers.

1.03 DEFINITIONS

A. Dampers, diffusers, grilles, and registers specified are indicated on the Drawings by the abbreviations listed below. Each abbreviation is followed by a hyphen and a number to designate the required style of unit:
   1. BD: Balancing Damper.
   2. BDD: Backdraft Damper.
   3. DG: Door Grille.
   4. FD: Fire Damper.
   5. FL: Flexible Duct Connector.
   6. RR: Return Register or Grille.
   7. SD: Smoke Damper.
   8. SFD: Smoke and Fire Damper combination.
   9. SR: Supply Register, Grille, or Diffuser.

B. NEMA Type 1 enclosure in accordance with NEMA 250.

C. Return registers:
   1. RR designation includes wall, ceiling, and duct mounted air exhaust or return devices including diffusers and grilles with or without control dampers.
   2. When no return register style is indicated on the Drawings, provide Style RR-4; provide 4 inch flanged drop frame when duct mounting indicated.

D. Supply registers:
   1. SR designation includes wall, ceiling, and duct mounted air supply devices including diffusers and grilles with or without control dampers.
   2. When no supply register style is indicated on the Drawings, provide Style SR-4; provide 4 inch flanged drop frame when duct mounting indicated.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

PART 2 PRODUCTS

2.01 DAMPERS

A. Manufacturers:
   1. Provide dampers manufactured by the same manufacturer.
   2. Dampers:
      a. Manufacturers: One of the following or equal:
         1) One manufacturer's model is listed with each style, similar models from other listed vendors are acceptable:
            a) Ruskin Manufacturing.
            b) American Warming and Ventilating.
            c) Swartwout.

B. Materials:
   1. Metallic ductwork: Aluminum for aluminum duct work; aluminum or galvanized steel for galvanized steel ductwork unless specified otherwise with styles.
   2. Fiberglass reinforced plastic ductwork: Fiberglass reinforced plastic where not otherwise specified.

C. Components: Include specified damper type with frame actuators, clips, connectors, and other accessories necessary for mounting; provide locking quadrant manual actuator or electric actuator as indicated on the Drawings.

D. Volume control and balancing dampers (BD):
   1. BD-3, Style 3 Balancing Damper, Commercial Rectangular Control Damper:
      a. Service: Office or laboratory air distribution systems; suitable for up to 6,000 feet per minute velocity and 13 inches water column pressure.
      b. Size and installation: Size as indicated on the Drawings suitable for mounting in rectangular ducting.
      c. Frame: 0.125-inch thick 6063T5 aluminum with mounting flanges on both sides.
      d. Blades: Opposed airfoil shape 6063T5 aluminum.

e. Blade axles: Hexagonal plated steel with molded synthetic bearings.
f. Seals: Extruded vinyl blade edge; flexible metal compressible type for jamb as required.
g. Finish: Mill Aluminum.
h. Manufacturers: One of the following or equal:
1) Ruskin, Model CD50.
2) Greenheck, similar model.

E. Smoke dampers (SD):
1. SD-1, Style 1 Smoke Damper, Ultra Low Leakage Smoke Damper:
a. Service: Duct mounting to provide UL 555S Class I smoke control.
b. Size and installation: Size to match ducting as indicated on the Drawings suitable for mounting as indicated.
c. Frame: 6.5 inches deep 0.125 thickness 6063T5 aluminum.
d. Blades: 6-inch wide airfoil type, opposed action 6063T5 aluminum with 0.5 inches hexagonal axles and stainless steel sleeve bearings pressed into the frame.
e. Finish: Mill.
f. Manufacturers: The following or equal:
1) Ruskin, Model SD50.

F. Damper operators:
1. General: Provide manual or electric damper operator for each damper furnished; type as indicated on the Drawings.
2. Manual operators:
a. Gears or mechanical, to operate damper manually with a force not exceeding 20 pounds.
b. Provide manual operators with locking quadrant.
c. Provide 3/8 inch, or larger, square double-ended drive shaft adequate for required damper torque.
d. Provide sufficient number of operators for torque required to operate damper.
3. Electric damper operators:
a. Manufacturers: One of the following or equal:
1) Honeywell, Model M445A.
2) Johnson Controls, Model M100.
b. 2-position spring return.
c. 1 internal single pole double throw auxiliary switch rated 5 ampere, 120 volt, single phase, and 60 hertz.
d. Housed in die-cast aluminum case with mounting flange.
e. Motor and gear train components immersed in oil.
f. When required, provide auxiliary transformers factory wired to damper operator and installed in NEMA Type 1 enclosure fastened to motor housing.

2.02 DIFFUSERS, GRILLES, AND REGISTERS

A. Manufacturers:
1. Provide diffusers, grilles, and registers manufactured by the same manufacturer.

2. Diffusers, grilles, and registers: One of the following or equal. One manufacturer's model is listed with each style, similar models from other listed vendors are acceptable:
    a. Titus Manufacturing Corp.
    b. Tuttle and Bailey.
    c. Kees, Inc.
    d. Metal Industries, Inc., (MetalAire).
    e. Krueger.

B. Materials:
1. For metallic ductwork: Aluminum for aluminum duct work; aluminum or galvanized steel for galvanized steel ductwork unless specified otherwise with styles.
2. For fiberglass reinforced plastic ductwork: Fiberglass reinforced plastic where not otherwise specified.

C. Components: Include specified style with frame, clips, connectors, and other accessories necessary for mounting.

D. Appearance: Similar for units in same room or space.

E. Finishes:
1. In chlorine, hypochlorite, or sodium bisulfite storage or pumping rooms and building exhaust systems for these areas: Coat with two 1-1/2 mils thick coats of synthetic vinyl plastic coating suitable for use in gas contaminated exhaust system including chlorine, sulfur dioxide, ozone, or a combination thereof of such gases:
    a. Manufacturers: One of the following or equal:
        1) Bisonite M, Amercoat® Number 23 and 55.
        2) Plasite, 2441.
2. In laboratory room exhaust systems: Coat with 2 finish coats of synthetic resin over prime applied on clean surface suitable for use in a laboratory exhaust system:
    a. Manufacturers: The following or equal:
        1) Carboline Eisen-Heiss.
3. In other locations, specified factory standard with the style requirements of a color selected by Engineer from standard manufacturer's colors.

F. Supply diffuser, grille, and register styles:
1. SR-3, Supply Register Style 3:
    a. Size and installation: Rectangular grille size as indicated on the Drawings framed for surface mounting on gypsum or directly mounted on exposed ducting; provide 4 inch flanged drop frame when duct mounted.
    b. Faceplate: Removable grille with double deflection blades spaced at 3/4 inch; front blades parallel to long dimension; provide gasket at frame for sealing.
    c. Core: Adjustable vanes with rectangular or round neck to match ducting.
    d. Damper: Provide opposed blade volume control damper suitable for use with ducting type; damper to be adjustable through the face of the unit.
    e. Materials: Aluminum frame, core, damper, and faceplate.

f. Manufacturers: One of the following or equal:
1) Titus, Model 272FL.
2) Krueger, Model 5880H.

G. Return diffuser, grille, and register styles:
1. RR-3, Return Register Style 3:
a. Size and installation: Rectangular grille with size as indicated on the Drawings framed for surface mounting on gypsum or directly mounted on exposed ducting; provide 4 inch flanged drop frame when duct mounted.
b. Faceplate: Removable grille with fixed blades spaced at 3/4 inch; front blades parallel to long dimension with 35 degree deflection; provide gasket at frame for sealing.
c. Core: When connected to ducting, provide suitable rectangular or round neck to match ducting; when filter indicated on the Drawings, provide 1-inch deep filter frame and hinged face with 1/4-turn fasteners.
d. Damper: When connected to ducting, provide opposed blade volume control damper suitable for use with ducting type; damper to be adjustable through the face of the unit.
e. Materials: Aluminum frame, core, damper, and faceplate.
f. Manufacturers: The following or equal:
1) Titus, Model 350FL or Model 350FF1.

2.03 SCREENS

A. Characteristics and features:
1. Bird screen: 1/2-inch mesh by 14 gauges.
2. Insect screens: 18 by 14 mesh.
3. Screens and frames, same material as ductwork, hood, louver, fan, or equipment connected to screen.
4. Screens secured in frames.

PART 3 EXECUTION

3.01 PREPARATION

A. Before installation, remove dust and debris from ducts and accessories.

3.02 INSTALLATION

A. Install items in accordance with manufacturer’s instructions.

B. FL-3, Flexible Connections: Install at connections between duct and air handling equipment and at locations indicated on the Drawings.

C. FL-1 and FL-2, Flexible Connections:
1. Install at building expansion joints and as indicated on the Drawings.
2. Install with collar and metal band to form airtight joints.
3. Install with minimum 4 inches of slack in fabric.
4. Exterior locations: Install sheet metal weather cover over fabric.
5. Duct alignment shall be a maximum of 1/2-inch offset.
6. The minimum/maximum gap shall be 2-inches and 6-inches.
7. Lap longitudinal joints and glue per manufacturer’s recommendations.

3.03 FIELD QUALITY CONTROL

A. Set grilles, dampers, and diffusers to achieve flows and flow patterns indicated on the Drawings and test finished system as specified in Section 15954 - Testing, Adjusting, and Balancing for HVAC.

B. Mark final balance positions on all manual damper actuators with paint pen in a distinctive color.

END OF SECTION

SECTION 15936

INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Controls for Heating, Ventilating, and Air Conditioning (HVAC) Systems.

1.02 REFERENCES

A. CSA International (CSA).

B. National Electrical Code (NEC).

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).

D. National Fire Protection Association (NFPA):
   1. 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

E. Underwriters' Laboratories, Inc. (UL):
   1. 268A - Standard for Smoke Detectors for Duct Application.
   2. 508 - Standard for Industrial Control Equipment.
   3. 1479 - Fire Tests of Through-Penetration Firestops.

F. California Code of Regulations (CCR):
   1. Title 24 - Building Standard Code.

1.03 DEFINITIONS

A. NEMA:
   1. Type 1 enclosure in accordance with NEMA 250.
   2. Type 3 enclosure in accordance with NEMA 250.
   3. Type 3R enclosure in accordance with NEMA 250.
   4. Type 4 enclosure in accordance with NEMA 250.
   5. Type4X enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. General requirements:
   1. All electrical components shall be UL-listed and meet the design and installation requirements of the NEC.
   2. Complete, functional system: Provide all necessary electrical power and control systems, components, and wiring to make a complete functioning system.
   3. Comply with electrical Sections for electrical power and control systems.
   4. System control functions to perform as described in Products.
   5. Materials: New, free from defects, and of the quality specified.

6. Common manufacturer: Provide components, component accessories, and devices, as much as possible, by the same manufacturer throughout the work.
7. Mounting: Mount control components and devices in accessible locations for maintenance and as recommended by the manufacturer; provide necessary manufacturer-approved mounting and configuration hardware for mounting and operation of control components and devices.
8. Components and systems must in accordance with CCR Title 24 energy conservation regulations and be listed with the California Energy Commission as approved for sale in California.

B. Fire detection system design requirements:
   1. Provide all supply and exhaust fans greater than 2,000 cubic feet per minute with a smoke control system including the following minimum components:
      a. Fan and air handling unit interlocks interlock to shut down upon smoke detection signal from fire alarm control panel.
      b. Field wiring terminal blocks for connection of shut down signals from local fire alarm control panel.

1.05 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

C. Shop drawings:
   1. Manufacturer's information including:
      a. Catalog information clearly marked to show specific products, models, and sizes being furnished.
      b. Component cut sheets.
   2. Provide certification that components and systems meet CCR Title 24 and are approved by the California Energy Commission.

1.06 QUALITY ASSURANCE

A. The control system shall be designed in accordance with UL and CSA standards.

B. Regulatory requirements: In accordance with CCR Title 24.

1.07 DELIVERY, STORAGE, AND HANDLING

A. The system control products shall be stored and handled per manufacturer's recommendations.

1.08 SITE CONDITIONS

A. Elevation and ambient conditions as specified in Section 01610 - Project Design Criteria.

1.09 WARRANTY

A. Special warranties: Warranty period begins at date of Project Acceptance or first date of Beneficial Use by the Owner:
   1. 1 year: Parts and on-site labor for components, systems, and programming.

PART 2 PRODUCTS

2.01 THERMOSTATS

A. General:
   1. Thermostat types: Thermostat types are called out on the drawings by the letter T followed by a number; this designation refers to the specified thermostat types specified in this Section; where no type is called out, provide 1 of the specified types that will match the controlled equipment requirements and provide a functioning system.
   2. Manufacturers: One of the following or equal:
      a. Johnson Controls, model as specified with each type.
      b. Honeywell, Tradeline, equivalent models.

B. T-1, Type 1 Thermostat, Heating Only, Line Voltage:
   1. Manufacturers: The following or equal: Johnson Controls Model:
      a. Dry locations (no hose bibs or open water processes in room): Model A19BAC-1 in NEMA 1 enclosure.
      b. Wet Locations (hose bibs or open water processes in room): Model A19PRC-1 in NEMA 4X enclosure.
   2. Switch action: Single-pole double-throw, open on rising temperature.
   3. Sensing element: Coiled bulb and capillary.
   4. Setpoint: 30 to 110 degrees Fahrenheit with knob adjuster and visible scale.
   5. Electrical ratings: 16 amps alternating current at 120 volts, 9.2 amps alternating current at 208 volts.

C. T-2, Type 2 Thermostat, Cooling Only, Line Voltage:
   1. Manufacturers: The following or equal: Johnson Controls Model:
      a. Dry locations (no hose bibs or open water processes in room): Model A19BBC-2 in NEMA 1 enclosure.
      b. Wet locations (hose bibs or open water processes in room): Model A19KNC-1 in rain and dusttight enclosure.
   2. Switch action: Single-pole double-throw, close on rising temperature.
   3. Sensing element: Coiled bulb and capillary.
   4. Setpoint: 30 to 110 degrees Fahrenheit with knob adjuster and visible scale.
   5. Electrical ratings: 16 amps alternating current at 120 volts, 9.2 amps alternating current at 208 volts.
   6. Differential range: For dry locations, 3 to 12 degrees Fahrenheit adjustable; for wet locations, 5 degrees Fahrenheit fixed.

2.02 HVAC CONTROL DESCRIPTIONS

A. General: Provide control systems that will maintain room or area comfort under changing ambient conditions and varying use; descriptions in this Section are general in nature and do not cover every mode of operation.

B. Electrical Building Control Sequence:
   1. Air Handling Unit AHU-101 will be controlled by a thermostat with adjustable set points. The cooling set point for AHU-101 will be 90°F. When the temperature rises 5 degrees above the cooling set point, the unit will energize. When the temperature drops 5 degrees below the set point, the unit will de-energize. The heating set point for AHU-101 will be 55°F. When the temperature drops 5 degrees below the heating set point, the unit will energize. When the temperature rises 5 degrees above the heating set point, the unit will de-energize:

PART 3 EXECUTION

3.01 PREPARATION

A. Before installation remove dust and debris from equipment and accessories.

B. During installation and until equipment is operated, protect equipment and accessories from dust and debris.

3.02 INSTALLATION

A. Install as indicated on the Drawings, in accordance with NFPA 90A, and per the manufacturer's written instructions.

B. Coordinate installation of HVAC control systems with other trades:
   1. Prior to installation, coordinate wiring and conduit requirements with electrical subcontractor.

C. Mount remote annunciator and test station on wall near smoke detector:
   1. Devices shall be easily accessible from floor level.
   2. Label annunciator and test station.

D. Provide all electrical work to support smoke detector:
   1. Coordinate with electrical subcontractor.

E. Sensor and control station mounting:
   1. Where not otherwise indicated, mount 5 feet above floor or walking level.
   2. Provide insulating back plates when mounting is on an exterior wall or a wall adjoining an unconditioned space.
   3. Shield outside thermostats or sensors from the sun; provide thermostats with remote bulb and compensated capillary.
   4. Install locking covers where indicated on the Drawings.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Functional testing:
   1. HVAC Instrumentation and Controls:
      a. Test witnessing: Witnessed.

b. Test each control component and system as part of HVAC system testing, adjusting, and balancing as specified in Section 15954 - Testing, Adjusting, and Balancing for HVAC.

END OF SECTION

SECTION 15954

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Heating, ventilation, and air conditioning systems testing, adjusting, and balancing.

1.02 REFERENCES

A. Associated Air Balance Council (AABC):
   1. National Standards for Field Measurements and Instrumentation, Total System Balance, Air Distribution Systems.

B. National Environmental Balancing Bureau (NEBB):
   1. Procedural Standards for Testing, Adjusting, and Balancing Environmental Systems.

C. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   1. Heating, Ventilating, and Air Conditioning Systems - Testing, Adjusting, and Balancing.

D. Testing, Adjusting, and Balancing Bureau (TABB):
   1. International Standards for Environmental Systems Balance.

1.03 TESTING, ADJUSTING, AND BALANCING WORK REQUIREMENTS

A. Procure the services of an independent air balance and testing agency belonging to and in good standing with the AABC, NEBB, or the TABB to perform air balancing, testing, and adjustment of building and process air conditioning, heating, and ventilating air systems.

B. The Work includes: Balancing new air systems installed as part of this contract and existing air systems affected by the installation of new equipment.

C. Perform testing of heating, ventilating, and air conditioning equipment, balancing of distribution systems, and adjusting of air terminal units and ductwork accessories to ensure compliance with Specifications and Drawings. Perform tests for following:
   1. Air conditioning units.
   2. Heat pump units.
   3. Central station air handlers.
   4. Evaporative coolers.
   5. Heating units.
   6. Fans.
   7. Odor scrubber fans.
   8. Condensers.
   9. Air terminal units.

10. Ductwork accessories.
11. Ducting.
12. HVAC controls.
13. Other specified HVAC equipment.

D. Test each mode of operation of thermostats, electronic controllers, and pneumatic, electric or electronic heating, ventilating, and air conditioning instruments to ensure operation as specified.

E. Test and adjust room distribution patterns at air outlets.

F. Provide instruments required for testing, adjusting, and balancing operations; retain possession of instruments; remove instruments from site at completion of services.

G. Make instruments available to the Engineer to facilitate spot checks during testing.

H. Provide test holes for pressure and pitot flow measurements; provide plugs for all test holes after testing.

1.04 QUALITY ASSURANCE

A. Test, balance, and adjust environmental systems in accordance with either:
1. AABC: National Standards for Field Measurements and Instrumentation, Total Systems Balance, Air Distribution-Hydronic System.
2. NEBB: Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
3. TABB: International Standards for Environmental Systems Balance.

B. Perform services under direction of AABC, NEBB, or TABB certified supervisor.

C. Calibrate and maintain instruments in accordance with requirements of standards. Make calibration histories of instruments available for examination.

D. Make measurements in accordance with accuracy requirements of standards.

E. Testing, adjusting, and balancing performance requirements:
1. Comply with procedural standards of certifying association.
2. Execute each step of prescribed testing, balancing, and adjusting procedures without omission.
3. Accurately record required data.
4. Make measurements in accordance with recognized procedures and practices of certifying association.
5. Measure air volume discharged at each outlet and adjust air outlets to design air volumes within 5 percent over.

1.05 SUBMITTALS

A. Resumes of proposed supervisor and personnel showing training and qualifications.

B. Interim reports: At least 30 days prior to starting field work, submit the following:
1. Set of report forms filled out as to design flow values and installed equipment pressure drops, and required cubic feet per minute for air terminals.

2. Develop heating, ventilating, and air conditioning system schematic similar to Figure 6-1 in SMACNA Testing, Adjusting, and Balancing.
3. Complete list of instruments proposed to be used, organized in appropriate categories, with data sheets for each showing:
    a. Manufacturer and model number.
    b. Description and use when needed to further identify instrument.
    c. Size or capacity range.
    d. Latest calibration date.

C. Final report: At least 15 days prior to Contractor's request for final inspection, submit 3 copies of final reports, on applicable reporting forms. Include:
1. Identify instruments which were used and last date of calibration of each.
2. Procedures followed to perform testing, adjusting, and balancing.
3. Identification and succinct description of systems included in report.
4. Initial balance test results made with all dampers and air control devices in full open positions.
5. Description of final locations and sizes, including opening area and dimensioned configuration of orifices and other restrictions used to achieve final balanced flows.
6. Description of final location and opening positions of dampers, registers, louvers, and valves.
7. Schematics of systems included in report; use schematics as part of testing, adjusting, and balancing report to summarize design and final balanced flows.
8. Testing, adjusting, and balancing report forms.
9. Final field results established for system balancing including airflow, fan speeds, and fan static pressures at the fan inlet and outlet.
10. Appendices.
11. Include appendices for:
    a. Raw field data taken during testing.
    b. Sample calculation sheet for each type of calculation made to convert raw field data to final results.
    c. Initial air balance results with dampers and registers in full open position; include airflow at all inlets and outlet, initial fan speed and fan suction and discharge pressures.

D. Proposed schedule for testing and balancing.

E. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.06 SITE CONDITIONS

A. Prior to start of testing, adjusting, and balancing, verify that:
1. Systems installation is complete and in full operation.
2. Outside conditions are within reasonable range relative to design conditions.
3. Lighting fixtures are energized.
4. Special equipment such as computers, laboratory equipment, and electronic equipment are in full operation.
5. Requirements for preparation for testing and balancing have been met for elements of each system which require testing.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Perform Functional Tests as specified in Section 01756 - Commissioning.

B. Testing, adjusting, and balancing acceptance criteria: Consider testing, adjusting, and balancing procedures successful and complete when heating, ventilating, and air conditioning systems and components are functioning properly and system air flows are within specified tolerances of design flows.

3.02 TESTING, ADJUSTING, AND BALANCING

A. Test, adjust, and balance separate complete heating, ventilating, and air conditioning systems.

B. Include in testing, adjusting, and balancing related existing heating, ventilating, and air conditioning components.

C. Perform testing, adjusting, and balancing cycles until airflows meet acceptance criteria:
   1. Ascertain airflow balance between overall requirements and flow in individual supply and exhaust grilles.

D. Initial testing, adjusting, and balancing: Perform first test on each system with dampers, grilles, orifices, and other variable airflow devices in their full open position; measure and report initial airflows, fan speed, and fan static pressures at fan inlet and outlet:
   1. Adjust total system flow downward or upward by adjusting fan speed until 1 inlet or outlet is at indicated flow and all other flows exceed indicated flows.
   2. Adjust fan speed by changing fan drives or sheaves as necessary.

E. Subsequent testing, adjusting, and balancing: Perform adjustments in subsequent testing, adjusting, and balancing by adjusting dampers, louvers, or size of orifices or plates:
   1. Measure and record air volume discharged at each inlet and outlet and adjust air inlets and outlets to design air volumes within 0 to 5 percent over design rates.
   2. Adjust fan speeds and motor drives within drive limitations, for required air volume.
   3. Measure cubic feet per minute and static pressures and adjust air supply and exhaust fan units to deliver at least 100 to 105 percent of the design air volume.
   4. Measure and record static air pressure conditions on fans, including filter and coil pressure drops, and total pressure across the fan.
   5. Evaluate building and room pressure conditions to determine adequate supply and return air conditions.

6. Evaluate space and zone temperature of conditions to determine adequate performance of the systems to maintain temperatures without draft.
7. Permanently mark final balance positions of balancing dampers.

F. Develop heating, ventilating, and air conditioning system schematics similar to Figure 6-1 in SMACNA Testing, Adjusting, and Balancing.

G. Accurately record the required data on AABC, NEBB, or TABB test and balance report forms.

H. Measure amperage draw of fan and pump motors for final balance.

I. Test primary source equipment in accordance with AABC, NEBB, or TABB procedures:
1. Primary source equipment includes items listed in this Section not previously tested as part of this testing, adjusting, and balancing work.
2. Complete appropriate AABC, NEBB, or TABB equipment test forms for each piece of equipment.
3. Calculate cooling and heating capacities to show conformance with specified capacities.
4. Adjust equipment as needed to deliver specified cooling and heating loads.
5. Record final equipment performing characteristics and adjustment settings in the final design report.

END OF SECTION

SECTION 15958

MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Testing of mechanical equipment and systems.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. S1.4 Specification for Sound Level Meters.

B. Hydraulic Institute (HI).

C. National Institute of Standards and Technology (NIST).

1.03 SUBMITTALS

A. Provide Source Test Plans as specified in Section 01756 - Commissioning.

B. Provide Installation and Functional Testing Plans as specified in Section 01756 - Commissioning.

C. Provide vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Manuals:
   1. Include motor rotor bar pass frequencies for motors larger than 500 horsepower.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 GENERAL

A. Commissioning of equipment as specified in:
   1. This section.
   2. Section 01756 - Commissioning.
   3. Equipment sections:
      a. If testing requirements are not specified, provide Level 1 Tests.

B. Test and prepare piping as specified in Section 15956 - Piping Systems Testing.

C. Operation of related existing equipment:
   1. Owner will operate related existing equipment or facilities necessary to accomplish the testing.

2. Schedule and coordinate testing as required by Section 01756 - Commissioning.

D. Provide necessary test instrumentation that has been calibrated within 1 year from date of test to recognized test standards traceable to the NIST or approved source:
   1. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for tests.
   2. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.

E. Test measurement and result accuracy:
   1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments:
      a. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
   2. Do not adjust results of tests for instrumentation accuracy:
      a. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

3.02 VARIABLE SPEED EQUIPMENT TESTS

A. Establish performance over the entire speed range and at the average operating condition.

B. Establish performance curves for the following speeds:
   1. The speed corresponding to the rated maximum capacity.
   2. The speed corresponding to the minimum capacity.
   3. The speed corresponding to the average operating conditions.

3.03 PUMP TESTS, ALL LEVELS OF TESTING

A. Test in accordance with the following:
   1. Applicable HI Standards.
   2. This Section.
   3. Equipment sections.

B. Test tolerances: In accordance with appropriate HI Standards, except the following modified tolerances apply:
   1. From 0 to plus 5 percent of head at the rated design point flow.
   2. From 0 to plus 5 percent of flow at the rated design point head.
   3. No negative tolerance for the efficiency at the rated design point.
   4. No positive tolerance for vibration limits. Vibration limits and test methods in HI Standards do not apply, use limits and methods specified in this or other Sections of the Specifications.

3.04 DRIVERS TESTS

A. Test other drivers as specified in the equipment section.

3.05 NOISE REQUIREMENTS AND CONTROL

A. Perform noise tests in conjunction with vibration test analysis.

B. Make measurements in relation to reference pressure of 0.0002 microbar.

C. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.

D. Set sound level meter to slow response.

E. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.

3.06 PRESSURE TESTING

A. Hydrostatically pressure test pressure containing parts at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher.

3.07 INSPECTION AND BALANCING

A. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits.

B. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.

C. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.

D. Critical speed of rotating equipment:
   1. Satisfy the following:
      a. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, all non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment's maximum operating speed.
      b. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall at least 25 percent below the equipment's lowest operating speed.
      c. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.

E. Vibration tests:
   1. Definitions:
      a. Root mean square: for pumps operating at speeds greater than 600 rpm, the vibration measurement shall be measured as the overall velocity in inches per second root mean square (RMS).
      b. Peak-to-peak displacement: The root means squared average of the peak-to-peak displacement multiplied by the square root of 2.

c. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.
d. Peak acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.
e. High frequency enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectrum of acceleration versus frequency:
    1) Manufacturers: One of the following or equal:
        a) Rockwell Automation, Entek Group, "Spike Energy" analysis.
        b) CSI, "PeakVue."
f. Rotor bar pass frequency (RBF), for detecting loose rotor bars.
g. Low speed equipment: Equipment or components of equipment rotating at less than 600 revolutions per minute.
h. High speed equipment: Equipment and equipment components operating at or above 600 revolutions per minute.
i. Preferred operating range: Manufacturer’s defined preferred operating range (POR) for the equipment.
j. Allowable operating range: Manufacturer’s defined allowable operating range (AOR) for the equipment.

2. Vibration instrumentation requirements:
    a. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12-bit A/D converter, fast fourier transform circuitry, phase measurement capability, time wave form data storage, high-frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles per minute, adjustable fast fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra, data output port, circuitry for integration of acceleration data to velocity or double integration to displacement:
        1) Manufacturers: One of the following or equal:
            a) Computational Systems Inc., (CSI) Division of Emerson Process Management, Model 2120A, Data Collector/analyzer with applicable analysis software.
            b) Pruftechnik, VIBXPERT II.
    b. Analyzer settings:
        1) Units: English, inches/second, mils, and gravitational forces.
        2) Fast fourier transform lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 revolutions per minute; 3,200 lines minimum for High Frequency Enveloping; 1,600 lines minimum for low speed equipment.
        3) Sample averages: 4 minimum.
        4) Maximum frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
        5) Amplitude range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
        6) Fast fourier transform windowing: Hanning Window.
        7) High pass filter: Minus 3 dB at 120 cycles per minute for high speed equipment. Minus 3 dB at 21 cycles per minute for low speed equipment.

c. Accelerometers:
1) For low speed equipment: Low frequency, shear mode accelerometer, 500 millivolts per gravitational force sensitivity, 10 gravitational force range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount.
a) Manufacturers: One of the following or equal:
(1) Wilcoxon Research, Model 797L.
(2) PCB, Model 393C.
2) For high speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder.
a) Manufacturers: One of the following or equal:
(1) Wilcoxon Research, Model 793.
(2) Entek-IRD Model 943.

3. Accelerometer mounting:
a. Use magnetic mounting or stud mounting.
b. Mount on bearing housing in location with best available direct path to bearing and shaft vibration.
c. Remove paint and mount transducer on flat metal surface or epoxy mount for High Frequency Enveloping measurements.

4. Vibration acceptance criteria:
a. Testing of rotating mechanical equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.
b. Vibration displacement limits: Unless otherwise specified, equipment operating at speeds 600 revolutions per minute or less is not to exhibit unfiltered readings in excess of following:

Operating Conditions and Application Data	Overall Peak-to-Peak Displacement	
	Field, mils	Factory, mils
Operation within the POR	3.0	4.0
Operation within the AOR	4.0	5.0
Additive value when measurement location is greater than 5 feet above foundation.	2.0	2.0
Additive value for solids-handling pumps	2.0	N/A
Additive value for slurry pumps	2.0	N/A

c. Vibration velocity limits: Unless otherwise specified, equipment operating at speeds greater than 600 revolutions per minute is not to exceed the following peak velocity limits:

HI Pump Type	Horsepower	Field Test	Factory Test
		Overall RMS	Overall RMS
Horizontal Solids Handling Centrifugal Pumps	Below 33 hp	0.25	0.28
Horizontal and Vertical In-Line Centrifugal Pumps (other than Non-Clog type)	Between 33 and 100 hp	0.28	0.31
	100 hp and above	0.31	0.34
Vertical Solids Handling Centrifugal Pumps	Below 33 hp	0.30	0.33
Vertical Turbine, Mixed Flow, and Propeller Pumps (solids-handling type pumps)	Between 33 and 100 hp	0.32	0.35
	100 hp and above	0.34	0.35
Non-Solids Handling Centrifugal Pumps HI Types BB1, BB2, BB3, BB4, BB5, OH1, OH2, OH3, OH4, OH5, and OH7	Below 268 hp	0.15	0.19
	268 hp and above	0.19	0.22
Vertical Turbine, Mixed Flow, and Propeller Pumps HI Types VS1, VS2, VS3, VS4, VS5, VS6, VS7, and VS8	Below 268 hp	0.13	
	268 hp and above	0.17	
Slurry Pumps		0.25	0.30
Motors		See Applicable Motor Specification	See Applicable Motor Specification
Gear Reducers, Radial		Not to exceed AGMA 6000-B96 limits	Not to exceed AGMA 6000-B96 limits
Other Reducers, Axial		0.1	N/A

d. Equipment operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.

e. Additional criteria:

1) No narrow band spectral vibration amplitude components, whether sub-rotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without manufacturer's detailed verification of origin and ultimate effect of such excitation.

2) The presence of discernable vibration amplitude peaks in Test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.

3) For motors, the following shall be cause for rejection:
   a) Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that is more than 40 percent of the peak at rotational frequency.
   b) Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.
   c) Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around 2 times the rotor bar pass frequency.
   d) Phasing problems evidenced by 1/3 line frequency side band spectral peaks around the 2 times electrical line frequency peak.
4) The presence of peaks in a High Frequency Enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high frequency envelope analysis repeated.

5. Vibration testing results presentation:
   a. Provide equipment drawing with location and orientation of measurement points indicated.
   b. For each vibration measurement take and include appropriate data on equipment operating conditions at the time vibration data is taken; for pumps, compressors, and blowers record suction pressure, discharge pressure, and flow.
   c. When Vibration Spectra Data required:
      1) Plot peak vibration velocity versus frequency in cycles per minute.
      2) Label plots showing actual shaft or part rotation frequency, bearing inner and outer race ball pass frequencies, gear mesh frequencies and relevant equipment excitation frequencies on the plot; label probable cause of vibration peaks whether in excess of specification limits or not.
      3) Label plots with equipment identification and operating conditions such as tag number, capacity, pressure, driver horsepower, and point of vibration measurement.
      4) Plot motor spectra on a log amplitude scale versus frequency.
   d. For low speed equipment, plot peak vibration displacement versus frequency as well as velocity versus frequency.
   e. Provide name of manufacturer and model number of the vibration instrumentation used, including analyzer and accelerometer used together with mounting type.

3.08 TESTING LEVELS

A. Level 1 Tests:
   1. Level 1 General Equipment Performance Test:
      a. For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.
      b. Operate at rated design load conditions.

c. Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

2. Level 1 Pump Performance Test:
   a. Measure flow and head while operating at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
   b. Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.
3. Level 1 Vibration Test:
   a. Test requirement:
      1) Measure filtered vibration spectra versus frequency in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component.
      2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
   b. Equipment operating condition: Test at specified maximum speed.
4. Level 1 Noise Test:
   a. Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.

B. Level 2 Tests:
1. Level 2 General Performance Test:
   a. For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
   b. Operate at rated design load conditions.
   c. Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
2. Level 2 Pump Performance Test:
   a. Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
   b. Test for flow and head at 2 additional conditions; 1 at 25 percent below the rated flow and 1 at 10 percent above the rated flow.
   c. Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.
3. Level 2 Vibration Test:
   a. Test requirement:
      1) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each

vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.

b. Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.

c. Natural frequency test of field installed equipment:
1) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears, and supports.
2) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.
3) Perform with equipment and attached piping full of intended service or process fluid.

4. Level 2 Noise Test:
a. Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at 3 feet horizontally from the surface of the equipment at mid-point height of the noise source.

C. Level 3 Tests:
1. Level 3 General Equipment Performance Tests:
a. For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
b. Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.
d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
e. Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.

2. Level 3 Pump Performance Test:
a. Test 4 hours minimum for flow and head at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
b. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes; for factory testing, test at other speeds may be omitted if test driver at reduced speeds is used for rated condition testing.
c. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing

housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.

3. Level 3 Vibration Test:
    a. Requirements: Same as Level 2 vibration test except data taken at each operating condition tested and with additional requirements below.
    b. Perform High Frequency Enveloping Analysis for gears and bearings.
        1) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a smooth surface and direct path to the bearing to detect bearing defects.
        2) Report results in units of acceleration versus frequency in cycles per minute.
    c. Perform Time Wave Form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).
    d. Plot vibration spectra on 3 different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.
4. Level 3 Noise Test: Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at 4 locations approximately 90 degrees apart in plain view; report results for each of 8 octave band mid-points beginning at 63 hertz.

D. Level 4 Tests:
1. Level 4 General Equipment Performance Test:
    a. For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.
    b. Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
    c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.
    d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings, using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
    e. Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
2. Level 4 Pump Performance Test:
    a. Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test with furnished motor at full speed.
    b. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.

c. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.
d. Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
e. Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
    1) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
    2) Perform efficiency testing with test fluids at maximum rated speed.
    3) Perform priming time testing with test fluids at maximum rated speed.

3. Level 4 Vibration Test: Same as Level 3 vibration test.
4. Level 4 Noise Test: Same as Level 3 Noise Test except with data taken at each operating condition tested.

END OF SECTION

SECTION 16050

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. General requirements applicable to all Electrical Work.
   2. General requirements for electrical submittals.

B. Interfaces to equipment, instruments, and other components:
   1. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
   2. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the Work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:
      a. Make all changes necessary to meet the manufacturer's wiring requirements.
   3. Submit all such changes and additions to the Engineer for acceptance as specified in Document 01005 - General Conditions.
   4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:
      a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
   5. Loop drawings:
      a. Provide all electrical information required in the preparation of loop drawings including, but not limited to:
         1) Conduit numbers and associated signal(s) contained within each conduit.
         2) Wire numbers.
         3) Equipment terminal numbers.
         4) Junction boxes and signal(s) contained within each junction box.
         5) Equipment power sources, and associated circuit numbers.
         6) As-built drawings detailing wiring.

C. All electrical equipment and systems for the entire Project must comply with the requirements of the Electrical Specifications, whether referenced in the individual Equipment Specifications or not:
   1. The requirements of the Electrical Specifications apply to all Electrical Work specified in other sections.
   2. Inform all vendors supplying electrical equipment or systems of the requirements of the Electrical Specifications.

3. Owner is not responsible for any additional costs due to the failure of Contractor to notify all subcontractors and suppliers of the Electrical Specifications requirements.

D. Contract Documents:
   1. General:
      a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.
   2. Specifications:
      a. The General and Supplementary Conditions of the Contract Documents govern the Work.
      b. These requirements are in addition to all General Requirements.
   3. Contract Drawings:
      a. The Electrical Drawings show desired locations, arrangements, and components of the Electrical Work in a diagrammatic manner.
      b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work to ensure the best possible installation:
         1) The equipment locations and dimensions indicated on the Drawings are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
         2) The Contractor has the freedom to select any of the named manufacturers identified in the individual specification sections; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
      c. Installation details:
         1) The Contract Drawings include typical installation details the Contractor is to use to complete the Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
         2) Not all typical installation details are referenced within the Drawing set. Apply and use typical details where appropriate.
      d. Schematic diagrams:
         1) All controls are shown de-energized.
         2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
         3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
         4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.

5) Schematic diagrams are to be used in conjunction with the descriptive operating sequences in the Contract Documents. Combine all information and furnish a coordinated and fully functional control system.

E. Alternates/Alternatives:
1. Coordinate with Document 01005 - General Conditions for substitute item provisions.

F. Changes and change orders:
1. As specified in Document 01005 - General Conditions.

1.02 REFERENCES

A. Code compliance:
1. As specified in Section 01410 - Regulatory Requirements.
2. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.
3. The standards listed are hereby incorporated into this Section.
a. American National Standards Institute (ANSI).
b. American Society of Civil Engineers (ASCE):
1) ASCE 7 - Minimum Design Loads for Buildings and Other Structures.
c. ASTM International (ASTM).
d. Illuminating Engineering Society (IES).
e. Institute of Electrical and Electronics Engineers (IEEE).
f. Insulated Cable Engineers Association (ICEA).
g. International Code Council (ICC):
1) International Code Council Evaluation Service (ICC-ES):
a) AC 156 - Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).
h. International Society of Automation (ISA).
i. National Electrical Manufacturers Association (NEMA):
1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
j. National Fire Protection Association (NFPA):
1) 70 - National Electrical Code (NEC).
k. National Institute of Standards and Technology (NIST).
l. Underwriters' Laboratories, Inc. (UL).

B. Compliance with laws and regulations:
1. As specified in Document 01005 - General Conditions.

1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth by:
1. IEEE.
2. NETA.
3. IES.
4. ISA.
5. NEC.
6. NEMA.
7. NFPA.

8. NIST.

B. Specific definitions:
   1. FAT: Factory acceptance test.
   2. ICSC: Instrumentation and controls subcontractor.
   3. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
   4. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
   5. PCIS: Process control and instrumentation system.
   6. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
   7. Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
   8. Spare: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that physically contains a device with no load connections to be made.
   9. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
   10. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.04 SYSTEM DESCRIPTION

A. General requirements:
   1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from:
      a. The Electrical Drawings are schematic in nature; use the Structural, Architectural, Mechanical, and Civil Drawings for all dimensions and scaling purposes.
   2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
   3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work.
   4. Coordinate all aspects of the Work with the electrical subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the electrical subcontractor, the other subcontractors or suppliers.

5. Demolition:
    a. Where demolition is specified or indicated on the Drawings, disconnect all associated electrical equipment and render the equipment safe.
    b. Remove and dispose of all conduit, wire, electrical equipment, controls, etc. associated with the items and/or areas to be demolished as indicated on the Drawings unless otherwise indicated.
    c. Salvage electrical equipment as specified in Section 01738 - Selective Alterations and Demolition.
    d. For each piece of equipment to be removed, remove all ancillary components (e.g. instruments, solenoid valves, disconnect switches, etc.).
    e. Conduit:
        1) Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:
            a) Remove exposed conduit to the point of encasement or burial.
            b) Cut conduit flush and plug or cap encased or buried conduit.
        2) Where conduits are to remain in place and removal is not indicated on the Drawings:
            a) Cap conduit open ends.
            b) Re-label empty conduits as spare.
    f. Remove all wire back to the source for all conduits to be removed or abandoned in place.
    g. Provide new nameplates for modified electrical distribution equipment, motor control centers etc. to identify equipment and circuits that are no longer used as spares.
    h. Provide new typewritten schedules for all modified panelboards.
6. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
    a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
    b. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.
7. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation:
    a. As specified in the Contract Documents.
8. Defective work:
    a. As specified in Document 01005 - General Conditions.

B. Existing system:
    1. South Headworks Building:
        a. Demolish old MCC-A:
            1) Any existing loads that remain on old MCC-A shall be reconnected to newer MCC-A.
        b. Demolish four Raw Sewage Pumps VFDs.
        c. Demolish the existing generator and ATS.
    2. Maintenance Building:
        a. Demolish 45 kVA dry type transformer.

3. Effluent Pump Station:
    a. Demolish 750 kVA pad mounted transformer XRFM-1 which steps medium voltage down to 480 volts to serve the Effluent Pump Station.
    b. Demolish MCC-EPS which serves all loads at the Effluent Pump Station including five Effluent Pumps, three Impure Water Pumps, two Drain Pumps, an integral lighting panelboard, and other loads.
    c. Demolish PLC panel PLC-5.

C. New system:
1. South Headworks Building:
    a. Reconnect any existing loads that remain on old MCC-A shall be reconnected to newer MCC-A.
    b. Provide four Raw Sewage Pumps VFDs.
2. Maintenance Building:
    a. Provide 75 kVA dry type transformer.
3. Effluent Pump Station:
    a. Provide 750 kVA pad mounted transformer XRFM-1 to step medium voltage down to 480 volts to serve the Effluent Pump Station.
    b. Provide new CMU electrical building with HVAC, lights, and receptacles:
        1) Provide MCC-EPS to serve all loads at the Effluent Pump Station including five Effluent Pumps, three Impure Water Pumps, two Drain Pumps, an integral lighting panelboard, and other loads.
        2) Provide a standalone VFD for each Effluent Pump.
        3) Provide PLC panel PCM-5.
        4) Provide all conduit and wire to connect new electrical distribution and controls equipment to existing loads.

D. Operating facility:
1. As specified in Section 01140 - Work Restrictions.
2. The WCW Water Pollution Control Plant is an operating facility. Portions of this facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
    a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction schedule to meet the requirements of the Owner. All changes in schedule and any needs to reschedule are included in the Work.
    b. As weather and water demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
    c. Coordinate the construction and power renovation, bear all costs, so that all existing facilities can continue operation throughout construction.
3. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
4. The standards of documentation, instrument tagging, cable and conductor ferruling, terminal identification and labeling that apply to the new installation apply equally to the existing installation which forms part of the modified system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330 - Submittal Procedures and this Section.

B. General:
   1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
   2. Furnish the submittals required by each section in the Electrical Specifications.
   3. Adhere to the wiring numbering scheme specified in Section 16075 - Identification for Electrical Systems throughout the Project:
      a. Uniquely number each wire.
      b. Wire numbers must appear on all Equipment Drawings.
   4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

C. Seismic requirements:
   1. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads based on the seismic design criteria in Section 01612 - Seismic Design Criteria.
   2. For equipment installed in structures designated as seismic design category C, D, E or F, prepare and submit the following:
      a. Statement of seismic qualification, and special seismic certification:
         1) “Statement of seismic qualification:” Provide manufacturer’s statement that the equipment satisfies the seismic design requirements of the building code indicated in Section 01410 - Regulatory Requirements, including the requirements of ASCE 7, Chapter 13.
         2) “Special seismic certification:” Provide manufacturer’s certification that the equipment, when subjected to shake table testing in accordance with ICC-ES AC 156, meets the “Post-Test Functional Compliance Verification” requirements of ICC-ES AC 156 for “Components with Ip = 1.5.” Compliance shall include both operability and containment of hazardous materials as appropriate to the unit being tested.
      b. Substantiating test data: With seismic qualification and special seismic certification statements, submit results of testing in accordance with ICC-ES AC 156.
      c. Anchoring design calculations and details:
         1) Submit project-specific drawings and supporting calculations, prepared and sealed by a professional engineer licensed in the state where the Project is being constructed, and showing details for anchoring electrical equipment to its supports and for anchoring supports provided with the equipment to the structure. Prepare calculations in accordance with the requirements of Section 01612 - Seismic Design Criteria.
   3. Exemptions: A “statement of seismic qualification” and a “special seismic certification” are not required for the following equipment:
      a. Temporary or moveable equipment.
      b. Equipment anchored to the structure and having a total weight of 20 pounds or less.
      c. Distribution equipment anchored to the structure and having a total unit weight of 3 pounds per linear foot, or less.

D. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.

2. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before Functional Acceptance Testing.

E. Material and equipment schedules:
   1. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
      a. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

F. Schedule of values:
   1. In addition to completing all items referred to in the schedule of values, Section 01292 - Schedule of Values, submit per unit material and labor costs used in developing the final bid for the electrical system, for the express purpose of pricing and cost justification for any proposed change orders. In addition to the items shown on the schedule of values, provide per unit material and labor costs for conduit and wire installation for specific types, sizes, and locations as indicated on the Drawings and Conduit Schedule. It is the responsibility of the electrical subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.

G. Roof penetrations:
   1. Submit details of all portions of the electrical installation that penetrate the roof. Include details showing support of the penetrating component, and the sealing means to be utilized.

H. Record Documents:
   1. Furnish as specified in Section 01770 - Closeout Procedures.

I. Test reports:
   1. As specified in Section 01330 - Submittal Procedures.
   2. Additional requirements for field acceptance test reports are specified in Sections 01756 - Commissioning and 16950 - Field Electrical Acceptance Tests.

J. Calculations:
   1. Where required by specific Electrical Specifications:
      a. Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

1.06 QUALITY ASSURANCE

A. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements.

1.08 PROJECT OR SITE CONDITIONS

A. Site conditions:
   1. Provide an electrical, instrumentation and control system, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
   2. Seismic load resistance:
      a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612 - Seismic Design Criteria.
   3. Wind load resistance:
      a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site wind loads as specified in Section 01614 - Wind Design Criteria.
   4. Altitude, temperature and humidity:
      a. As specified in Section 01610 - Project Design Criteria.
      b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating factors applied.
      c. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer's guidelines:
         1) Provide all power conduits wiring for these devices (e.g. heaters, fans, etc.) whether indicated on the Drawings or not.
   5. Site security:
      a. Abide by all security and safety rules concerning the Work on the Site, as specified in Sections 01500 - Temporary Facilities and Controls.

B. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA Standard 250 for the following types of enclosures:
   1. NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
   2. NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.
   3. NEMA Type 4X: Made from corrosion resistant materials and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion. Provide specific materials as specified or indicated on the Drawings.
   4. NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.

C. Plant area Electrical Work requirements:
   1. Provide all Electrical Work in accordance with the following table, unless otherwise specifically indicated on the Drawings:

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
South Headworks Building - Inside	12	GRC	D	GALV STL
South Headworks Building - Outside	4X SST 316	PCS	W, X	SST 316
Chlorine Contact Basin	4X SST 316	PCS	W, X	SST 316
Effluent Pump Station - Inside	4	GRC	W	GALV STL
Effluent Pump Station - Outside	4X SST 316	PCS	W, X	SST 316
Maintenance Building	12	GRC	D	GALV STL

2. Modify exposed conduit runs as specified in Section 16130 - Conduits.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. General:
   1. As specified in Sections 01312 - Project Meetings and 01756 - Commissioning.
   2. Testing requirements are specified in Section 01756 - Commissioning, 16950 - Field Electrical Acceptance Tests and other sections.
   3. General scheduling requirements are specified in Section 01321 - Schedules and Reports.
   4. Work restrictions and other scheduling requirements are specified in Section 01140 - Work Restrictions.
   5. Commissioning requirements as specified in Section 01756 - Commissioning.

B. Pre-submittal conference:
   1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire Project, equipment, control philosophy, schedules, and submittal requirements.
   2. Contractor, electrical subcontractor, all suppliers, and individual equipment manufacturers furnishing major pieces of equipment must attend.

1.11 WARRANTY

A. Warrant the Electrical Work as specified in Document 01005 - General Conditions:
   1. Provide additional warranty as specified in the individual Electrical Specifications.

1.12 SYSTEM START-UP

A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
   1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Before Substantial Completion, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

B. Furnish all spare parts as required by other sections of the Specifications.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide similar items of same manufacturer throughout the electrical and instrumentation portion of the Project.

B. Allowable manufacturers are specified in individual Electrical Specifications.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the Specifications.

B. Provide materials complying with the applicable industrial standard as specified in Document 01005 - General Conditions.

C. Stainless steel:
   1. Where stainless steel is indicated or used for any portion of the Electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
   2. Provide exposed screws of the same alloys.

3. Provide finished material free of any burrs or sharp edges.
4. Use only stainless steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.
5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
6. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products.

PART 3 EXECUTION

3.01 EXAMINATION

A. The electrical subcontractor is encouraged to visit the site to examine the premises completely before bidding.

B. It is the electrical subcontractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

C. Comply with pre-bid conference requirements as specified in Document 01002 - Instructions to Bidders

D. Review the site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Equipment locations shown on Electrical Drawings may change due to variations in equipment size or minor changes made by others during construction:
   1. Verify all dimensions indicated on the Drawings:
      a. Actual field conditions govern all final installed locations, distances, and levels.
   2. Review all Contract Documents and approved equipment shop drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
   3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
   4. Provide a complete electrical system:
      a. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical system.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. Cutting and patching:
   1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:
      a. Secure the permission of the Engineer before performing any operation likely to affect the strength of a structural member such as drilling, cutting or piercing:
         1) Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:
            a) Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.
            b) Use tone-locate system or X-ray to ensure that area is clear of obstructions.
      b. Review the complete Drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
   2. Perform all patching to the same quality and appearance as the original work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
      a. 3M: CP 25WB+: Caulk.
      b. 3M: Fire Barrier: Putty.
   3. Use the installation details indicated on the Drawings as a guide for acceptable sealing methods.

D. Install all conduits and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:
   1. Install all conduits and equipment in accordance with working space requirements in accordance with the NEC.
      a. This includes any panel, disconnect switch or other equipment that can be energized while open exposing live parts regardless of whether it is likely to require examination or has serviceable parts.
   2. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.
      a. Adjust equipment locations as necessary to avoid any obstruction or interferences.
   3. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.
   4. Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.

E. Earthwork and concrete:
   1. Install all trenching, shoring, concrete, backfilling, grading and resurfacing associated with the Electrical Work:
      a. Requirements as specified in the Contract Documents.

F. Roof penetrations:
   1. Seal conduit penetrations in accordance with roofing manufacturer's instructions.

G. Terminations:
   1. Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.

H. Miscellaneous installation requirements:
   1. In case of interference between electrical equipment indicated on the Drawings and the other equipment, notify the Engineer as specified in Document 01005 - General Conditions.
   2. Location of manholes and pullboxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pullboxes with Mechanical and Civil Work.
   3. Provide additional manholes or pullboxes to those shown where they are required to make a workable installation.
   4. Circuits of different service voltage:
      a. Voltage and service levels:
         1) Medium voltage: greater than 1.0 kV.
         2) Low voltage: 120 V to 480 V.
         3) Instrumentation: Less than 50 VDC.
      b. Install different service voltage circuits in separate raceways, and junction boxes, and pullboxes.
      c. In manholes, install all cables operating at less than 50 VDC in PVC coated flexible metallic conduit, with corrosion resistant fittings.

I. Labeling:
   1. Provide all nameplates and labels as specified in Sections 16075 - Identification for Electrical Systems and 16305 - Electrical System Studies.

J. Equipment tie-downs:
   1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing criteria, which apply to the Site.
      a. All control panels must be permanently mounted and tied down to structures in accordance with the Project seismic criteria.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Loop tests shall be conducted as specified in Section 01756 - Commissioning and Section 17950 - Commissioning for Instrumentation and Controls.
   1. Electrical Contractor shall be on site and assist with troubleshooting and correcting issues found during loop testing.

C. For Owner and Engineer witnessed FAT:
   1. Contractor is responsible for the Owner's and Engineer's costs associated with FAT as specified in Section 01756 - Commissioning.

D. Owner training:
   1. As specified in Section 01756 - Commissioning and in this Section.
   2. Provide source testing and owner training on electrical equipment as defined in the table below:

Table1: Source Testing and Owner Training Requirements:

Section Number	**Section Title**	**Source Testing**	**Owner Training Requirements**	
		(Witnessed or Non-witnessed)	**Maintenance (hrs per session)**	**Operation (hrs per session)**
16264	Variable Frequency Drives 60 - 500 Horsepower	Non-Witnessed	16	16
16444	Low Voltage Motor Control Centers	Non-Witnessed	4	4

3.08 FIELD QUALITY CONTROL

A. Inspection:
   1. Allow for inspection of electrical system installation as specified in Section 01450 - Quality Control.
   2. Provide any assistance necessary to support inspection activities.
   3. Engineer inspections may include, but are not limited to, the following:
      a. Inspect equipment and materials for physical damage.
      b. Inspect installation for compliance with the Drawings and Specifications.

c. Inspect installation for obstructions and adequate clearances around equipment.
d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
e. Inspect equipment nameplate data to verify compliance with design requirements.
f. Inspect raceway installation for quality workmanship and adequate support.
g. Inspect cable terminations.

4. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in Section 16950 - Field Electrical Acceptance Tests.

B. Field acceptance testing (Functional Testing):
1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
2. Perform the field acceptance tests as specified in Section 16950 - Field Electrical Acceptance Tests.
3. Record results of the required tests along with the date of test:
a. Use conduit identification numbers to indicate portion of circuit tested.

C. Workmanship:
1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
a. Neatly coil and label spare wiring lengths.
b. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the Engineer.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 01770 - Closeout Procedures.

B. Remove all foreign material and restore all damaged finishes to the satisfaction of the Engineer and Owner.

C. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust or other matter before energization of the equipment or system start-up:
1. Use of compressors or air blowers for cleaning is not acceptable.

D. Clean and re-lamp all new and existing luminaries that were used in the areas affected by the construction..

E. As specified in other sections of the Contract Documents.

3.11 PROTECTION

A. Protect all Work from damage or degradation until Substantial Completion.

B. Maintain all surfaces to be painted in a clean and smooth condition.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16060

GROUNDING AND BONDING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Grounding materials and requirements.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. ASTM International (ASTM):
   1. B3 - Standard Specification for Soft or Annealed Copper Wire.
   2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.

D. Underwriters Laboratories, Inc. (UL):
   1. 467 - Ground and Bonding Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Catalog cutsheets.

1.05 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. All grounding components and materials shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 PROJECT/SITE CONDITIONS (NOT USED)

1.08 SEQUENCING (NOT USED)

1.09 SCHEDULING (NOT USED)

1.10 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.11 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Compression connectors: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Burndy.
   4. Thomas & Betts.

B. Ground rods: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Nehring
   4. Thomas & Betts.

C. Ground cable: One of the following or equal:
   1. Erico.
   2. Harger
   3. Nehring.
   4. Southwire.

D. Precast ground well boxes: One of the following or equal:
   1. Brooks Products, 3-RT Valve Box.
   2. Christy Concrete Products, G12 Valve Box.

2.02 SYSTEM DESCRIPTION

A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.

B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:
   1. Grounding electrodes.
   2. Bonding jumpers.
   3. Ground connections.

C. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.

D. The ground system resistance (electrode to ground) of the completed installation, as determined by tests specified in Section 16950 - Field Electrical Acceptance Tests, shall be:
   1. 1 ohm or less for electrical buildings.

2.03 EXISTING PRODUCTS (NOT USED)

2.04 MATERIALS

A. Ground rod:
   1. Minimum: 3/4-inch diameter, 10 feet long.
   2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core:
      a. The copper-to-steel bond shall be corrosion resistant.
   3. In accordance with UL 467.
   4. Sectional type joined by threaded copper alloy couplings.
   5. Fit the top of the rod with a threaded coupling and steel-driving stud.

B. Ground cable:
   1. Requirements:
      a. Soft drawn (annealed).
      b. Concentric lay, coarse stranded in accordance with ASTM B8.
      c. Bare copper in accordance with ASTM B3.
   2. Size is as indicated on the Drawings, but not less than required by the NEC. Use the following type of wire unless otherwise indicated on the Drawings:
      a. Size #6 AWG and smaller; solid conductor.
      b. Size #4 AWG and larger; stranded conductor.

C. Compression connectors:
   1. Manufactured of high copper alloy specifically for the particular grounding application.
   2. Suitable for direct burial in earth and concrete.
   3. Identifying compression die number inscription to be impressed on compression fitting.

D. Equipment grounding conductors:
   1. Conductors shall be the same type and insulation as the load circuit conductors:
      a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
   2. Minimum size in accordance with the NEC.

E. Grounding electrode conductors:
   1. Minimum size in accordance with the NEC.

F. Main bonding jumpers and bonding jumpers:
   1. Minimum size in accordance with the NEC.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Precast ground well boxes:
   1. Minimum 10 inch interior diameter.
   2. Traffic-rated cast iron cover.
   3. Permanent “GROUND” marking on cover.

2.09 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
   1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
   2. Provide a separate grounding conductor in each individual raceway for parallel feeders.

C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
   1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.

D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
   1. Individually bond these raceways to the ground bus in the equipment.

E. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.

F. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

G. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.

H. Duct bank ground system:
   1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.
   2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.

I. Grounding at service (600 V or Less):
   1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.

J. Ground connections:
   1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using compression type grounding connectors as indicated on the Drawings, UL listed, and labeled for the application.
   2. Make ground connections in accordance with the manufacturer's instructions.
   3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.

K. Grounding electrode system:
   1. Ground ring:
      a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
      b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size as indicated on the Drawings.
      c. Minimum burial depth 36 inches or as indicated on the Drawings.
      d. Re-compact disturbed soils to original density in 6-inch lifts.
   2. Ground rods:
      a. Locations as indicated on the Drawings.
      b. Length of rods forming an individual ground array shall be equal in length.
      c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
      d. Pre-crimp all ground rods, as recommended by the manufacturer, before crimping connector to ground rod.
   3. Metal underground water pipe:
      a. Bond metal underground domestic water pipe to grounding electrode system.
   4. Metal frame of building or structure:
      a. Bond metal frame of building or structure to grounding electrode system.
   5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.

6. Where grounding conductors are not concrete-encased or direct buried, install in Schedule 40 PVC conduit for protection.
7. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.

L. Shield grounding:
1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable run.
3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
4. Terminate the signal cable shield on a dedicated grounding terminal block.

M. Where indicated on the Drawings, install ground rods in precast ground wells.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.09 ADJUSTING

A. Under the direction of the Engineer, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:
1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16070

HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Mounting and supporting electrical equipment and components.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. ASTM International (ASTM):
   1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   3. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Conform to the requirements of the Building Code as specified in Section 01410 - Regulatory Requirements.
   2. Demonstrate the following using generally accepted engineering methods:
      a. That the anchors to the structure are adequate to resist the loads generated in accordance with the Building Code and equipment requirements.
      b. That the required load capacity of the anchors can be fully developed in the structural materials to which they are attached.
   3. Design loading and anchoring requirements:
      a. As indicated in the Building Code unless otherwise specified.
      b. Seismic loading requirements:
         1) Freestanding, suspended or wall-hung equipment shall be anchored in place by methods that will satisfy the requirements for the seismic design specified in Section 16050 - Common Work Results for Electrical.
      c. Wind loading requirements:
         1) All exterior equipment shall be anchored in place by methods that will satisfy the requirements for wind design specified in Section 16050 - Common Work Results for Electrical.

d. Minimum safety factor against overturning: 1.5.
e. The foundation and structures to which hangers and supports are attached shall be capable of withstanding all anchor loads.

B. Performance requirements:
1. Hangers and supports individually and as a system shall resist all weights and code-required forces without deflections and deformations that would damage the supporting elements, the equipment supported, or the surrounding construction.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
1. Supports:
a. Materials.
b. Geometry.
c. Manufacturer.
2. Hardware:
a. Materials.
b. Manufacturer.

C. Shop drawings:
1. Complete dimensioned and scalable shop drawings of all supporting structures, trapezes, wall supports, etc.
2. Complete anchoring details for equipment, lighting and raceway, supporting structures, trapezes, and wall supports for all equipment:
a. For free standing supports and wall supports supporting equipment weight in excess of 200 pounds:
1) Stamped by a professional engineer licensed in the state where the Project is being constructed.
b. Said submittals, by virtue of the fact that they bear the stamp of a registered engineer, will be reviewed for general consistency with the requirements specified in the Contract Documents, but not for context, accuracy, or method of calculation.
3. Include data on attachment hardware and construction methods that will satisfy the design loading and anchoring criteria.

D. Installation instructions:
1. Furnish anchorage instructions and requirements based on the seismic and wind conditions of the Site:
a. Stamped by a professional engineer licensed in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM STARTUP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Preformed channel:
      a. Thomas & Betts.
      b. Power-Strut.
      c. Unistrut.
      d. Cooper B-Line.
      e. Robroy.
      f. Tyco.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Use materials appropriate for the area as specified in Section 16050 - Common Work Results for Electrical.

B. Preformed channel:
   1. Hot dip galvanized steel:
      a. Supports:
         1) In accordance with ASTM A123 or A153.
         2) Minimum zinc coating thickness of 2.5 mils.
      b. Hardware:
         1) Electro-galvanized.
         2) In accordance with ASTM A153.
   2. Stainless steel:
      a. Supports:
         1) In accordance with ASTM A240.
         2) ANSI Type 316 material.

b. Hardware:
    1) ANSI Type 316 material.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Anchor bolts:
    1. As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Paint and finish all supporting structures as specified in Section 09960 – High-Performance Coatings.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Preformed Channel:
    1. Mount all raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated racks unless otherwise indicated on the Drawings:
        a. Provide the necessary sway bracing to keep trapeze type structures from swaying under seismic events or wind loading.
    2. Brace and anchor freestanding equipment supports using methods that provide structural support based on the seismic loads and wind loads:
        a. Lateral deflection at top of supports not to exceed support height divided by 240 unless otherwise approved by the Engineer.
    3. Provide fabricated steel support pedestals for wall mounted panels that weigh more than 200 pounds:
        a. Fabricate pedestals out of welded angle, tube sections, or preformed channel.
        b. If the supported equipment is a panel or cabinet, match the supported equipment in physical appearance and dimensions.

c. Provide auxiliary floor supports for transformers hung from stud walls and weighing more than 200 pounds.

4. Mount all equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel:
    1) Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.
5. Corrosion protection:
    a. Isolate dissimilar metals, except where required for electrical continuity:
        1) Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.
6. Raceway:
    a. Furnish all racks and trapeze structures needed to support the raceway from the structure.
        1) Group raceway and position on racks to minimize crossovers.
        2) Provide the necessary bracing to keep trapeze type structures from swaying under loads from cable installation, seismic forces, or wind forces.
7. Anchoring methods:
    a. Solid concrete: Anchor bolts, anchor rods or post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
    b. Metal surfaces: Machine screws or bolts.
    c. Hollow masonry units: Post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
8. When supporting devices on metal or wood stud construction, bridge studs with preformed channel, and mount the devices to the channel.
9. Recoat or seal all drilled holes, cut or scratched surfaces or with products recommended by the manufacturer.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16075

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Identification of electrical equipment, devices and components.
   2. Material, manufacturing and installation requirements for identification devices.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

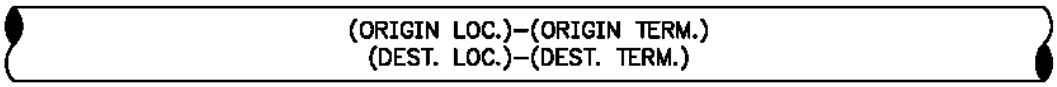
1.04 SYSTEM DESCRIPTION

A. Nameplates:
   1. Provide a nameplate for each piece of electrical equipment and devices, control panel and control panel components.
   2. Provide all nameplates of identical style, color, and material throughout the facility.
   3. Device nameplates information:
      a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.

B. Wire numbers:
   1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
      a. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
      b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
      c. Internal panel wires on a common terminal shall have the same wire number.
      d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:
         1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers in Section 16130 - Conduits.

2. Provide the following wiring numbering schemes throughout the project for field wires between process control module, (PCM), vendor control panels, (VCP), motor control centers, (MCC), field starters, field instruments, etc.

OR



Where:

ORIGIN LOC .= Designation for originating panel or device.
ORIGIN TERM. = Terminal designation at originating panel or device.
DEST. LOC. = Designation for destination panel or device.
DEST. TERM. = Terminal designation at destination panel or device or PLC.
I/O address at destination panel:

a. Identify equipment and field instruments as the origin.
b. PCMs are always identified as the destination.
c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g. T1, T2, T3, etc.).
f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen-Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):
    1) Discrete Point: W:X:Y/Z.
       Analog Point: W:X:Y.Z.
       Where:
       W= I for input, O for output.
       X= PLC number (1, 2, 3…).
       Y= Slot number (01, 02, 03…).
       Z= Terminal number (00, 01, 02…) for a discrete point or a word number for an analog point (1, 2, 3…)..
g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g. C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g. C0010A).

3. **Case 1**: Vendor control panel (VCP) to process control module (PCM):
   Field wire number/label: A-B/C-D.
   A = Vendor control panel number without hyphen (VCP#).
   B = Terminal number within VCP (manufacturer's or vendor's standard terminal number).
   C = Process control module number without hyphen (PCM#).
   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010).

   Examples: VCP#-10/PCM#-I: 1:01/01.
   VCP#-10/PCM#-O: 1:10/07.
   VCP#-10/PCM#-C0100.

4. **Case 2**: Field instrument to process control module (PCM):
   Field wire number/label: E-F/C-D.
   C = Process control module number without hyphen (PCM#).
   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010).
   E = Field mounted instrument tag and loop numbers without hyphen (EDV#).
   F = Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma.

   Examples: TIT#-2,3/PCM#-I: 1:01.1.
   TSH#-1/PCM#-I: 2:01/00.

5. **Case 3**: Motor control center (MCC) to process control module (PCM):
   Field wire number/label: G-B/C-D.
   B =Terminal number within Motor Control Center (manufacturer's or vendor's standard terminal number).
   C = Process control module without hyphen (PCM#).
   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010).
   G = Actual starter designation in the motor control center without hyphen (MMS#).

   Examples: MMS#-10/PCM#-I: 1:01/01.
   MMS#-10/PCM#-O: 1:10/07.
   MMS#-10/PCM#-C0100.

6. **Case 4**: Motor control center (MCC) to vendor control panel (VCP):
   Field wire number/label: G-B/A-B.
   A = Vendor control panel number without hyphen (VCP#).
   B = Terminal number within motor control center or vendor control panel (manufacturer's or vendors standard terminal number).
   G = Actual starter designation in the motor control center without hyphen (MMS#).

   Example: MMS#-X2/VCP#-10.

7. **Case 5**: Motor leads to a motor control center (MCC):
   Field wire number/label: H-I/G-B.
   B = Terminal number within motor control center (manufacturer's standard terminal number).
   G = Actual starter designation in the motor control center without hyphen (MMS#).
   H = Equipment tag and loop number without hyphen (PMP#).
   I = Motor manufacturer's standard motor lead identification (e.g. T1, T2, T3, etc.).

   Example: PMP-#-T3/MMS#-T3.

8. **Case 6**: Remote or separately mounted starter or variable frequency drive (VFD) to process control module (PCM):
   Field wire number/label: J-B/C-D.
   B = Terminal number within starter or variable frequency drive (manufacturer's standard terminal number).
   C = Process control module number without hyphen (VCP#).
   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010).
   J = Starter or variable frequency drive tag and loop number without hyphen (MMS#).

   Examples: MMS#-10/PCM#-I: 1:01/01.
   MMS#-10/PCM#-O: 2: 10/07.
   MMS#-10/PCM#-C0010.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Nameplates:
      a. Color.
      b. Size:
         1) Outside dimensions.
         2) Lettering.
      c. Material.
      d. Mounting means.
   2. Nameplate schedule:
      a. Show exact wording for each nameplate.
      b. Include nameplate and letter sizes.
   3. Wire numbers:
      a. Manufacturer's catalog data for wire labels and label printer.

C. Record documents:
   1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nameplates and signs:
   1. One of the following or equal:
      a. Brady.
      b. Seton.

B. Conductor and cable markers:
   1. Heat-shrinkable tubing:
      a. One of the following or equal:
         1) Raychem.
         2) Brady.
         3) Thomas & Betts.
         4) Kroy.

C. Conduit and raceway markers:
   1. Stainless steel, one of the following or equal:
      a. Panduit.

D. Medium voltage raceway voltage labels:
   1. One of the following or equal:
      a. Brady.
      b. Seton.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Nameplates:
   1. Colors:
      a. Warning nameplates: White-center, red face.
      b. Other nameplates: Black-center, white face.
   2. Laminated plastic engraving stock:
      a. 3/32-inch thick material.
      b. 2-ply.
      c. With chamfered edges.
   3. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
      a. No characters smaller than 1/8-inch in height.

B. Signs:
   1. Automatic equipment and high voltage signs:
      a. Suitable for exterior use.
      b. In accordance with OSHA regulations.

C. Conductor and cable markers:
   1. Machine printed black characters on white tubing.
   2. 10-point type or larger.

D. Conduit and raceway markers:
   1. Stainless steel:
      a. Type 304 or 316.
      b. Character height: 3/16-inch.

E. Medium voltage circuit raceway labels:
   1. Vinyl plastic.
   2. Minimum 1-inch high letters.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Nameplates:
   1. Provide all nameplates for control panel operator devices (e.g. pushbuttons, selector switches, pilot lights, etc.):
      a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Nameplates:
   1. Attach nameplates to equipment with rivets, bolts or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
   2. On NEMA Type 4, or NEMA Type 4Xenclosures, use epoxy-based cement to attach nameplates.
   3. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:
      a. Misaligned or crooked nameplates shall be remounted, or provide new enclosures at the discretion of the Engineer.

C. Conductor and cable markers:
   1. Apply all conductor and cable markers before termination.
   2. Heat-shrinkable tubing:
      a. Tubing shall be shrunk using a heat gun that produces low temperature heated air.
      b. Tubing shall be tight on the wire after it has been heated.
      c. Characters shall face the open panel and shall read from left to right or top to bottom.
      d. Marker shall start within 1/32 inch of the end of the stripped insulation point.

D. Conduit markers:
   1. Furnish and install conduit markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:
      a. Conduit markings shall match the conduit schedule.
   2. Mark conduits at the following locations:
      a. Each end of conduits that are greater than 10 feet in length.
      b. The middle of conduits that are 10 feet or less in length.
      c. Where the conduit penetrates a wall or structure.
      d. Where the conduit emerges from the ground, slab, etc.
   3. Mark conduits after the conduits have been fully painted.
   4. Position conduit markers so that they are easily read from the floor.

5. Attach non-metallic conduit markers with nylon cable ties:
    a. Provide ultraviolet resistant cable ties for conduit markers exposed to direct sunlight.
6. Attach stainless steel tags with stainless steel cable ties.
7. Mark conduits before construction review by Engineer for punch list purposes.
8. Label intrinsically safe conduits in accordance with the requirements of the NEC.

E. Medium voltage raceway labels:
    1. Apply at 50 foot intervals stating the voltage level contained within the raceway.

F. Signs and labeling:
    1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
        a. Fasten warning signs with round head stainless steel screws or bolts.
        b. Locate and mount in a manner to be clearly legible to operations personnel.
    2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc. where the voltage exceeds 600 volts.
    3. Furnish and install warning signs on equipment that has more than one source of power:
        a. Warning signs to identify every panel and circuit number of the disconnecting means of all external power sources.
    4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking:
        a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. Replace any nameplates, signs, conductor markers, cable markers or raceway labels that in the sole opinion of the Engineer do not meet the Engineer’s aesthetic requirements.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16123

600-VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. 600 volt class or less wire and cable.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. ASTM International (ASTM):
   1. B3 - Standard Specification for Soft or Annealed Copper Wire.
   2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

C. CSA International (CSA).

D. Insulated Cable Engineers Association (ICEA):
   1. NEMA WC 70/ICEA S-95-658-1999 - Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
   2. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.

E. National Fire Protection Association (NFPA):
   1. 72 - National Fire Alarm and Signaling Code.
   2. 101 - Life Safety Code.

F. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
   1. 568-C.2 - Balanced Twisted-Pair Telecommunication Cabling and Components Standard.
   2. 569-B – Commercial Building Standards for Telecommunications Pathways and Spaces.
   3. 1005 – Industrial Cabling Standard.

G. Underwriter's Laboratories Inc., (UL):
   1. 44 - Thermoset-Insulated Wires and Cables.
   2. 1277 - Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
   3. 1424 - Standard for Cables for Power-Limited Fire-Alarm Circuits.
   4. 1569 - Standard for Metal-Clad Cables.
   5. 2196 - Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control, and Data Cables.
   6. 2225 - Standard for Cables and Cable-Fittings for Use in Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions and abbreviations:
   1. AWG: American wire gauge.
   2. BCCS: Bare copper-covered steel.
   3. CPE: Chlorinated polyethylene.
   4. FEP: Fluorinated ethylene propylene.
   5. FHDPE: Foam high-density polyethylene.
   6. FPE: Foam polyethylene.
   7. OD: Outside diameter.
   8. PVC: Polyvinyl chloride.
   9. XHHW: Cross-linked high heat water resistant insulated wire.

C. Definitions of terms and other electrical considerations as set forth in the:
   1. ASTM.
   2. ICEA.

1.04 SYSTEM DESCRIPTION

A. Furnish and install the complete wire and cable system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Manufacturer of wire and cable.
   2. Insulation:
      a. Type.
      b. Voltage class.
   3. AWG size.
   4. Conductor material.
   5. Pulling compounds.

C. Shop drawings:
   1. Show splice locations:
      a. For each proposed splice location provide written justification describing why the splice is necessary.

D. Test reports:
   1. Submit test reports for meg-ohm tests.

E. Calculations:
   1. Submit cable pulling calculations to the Engineer for review and comment for all cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:

a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. All wires and cables shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER`S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. 600 volt class wire and cable:
      a. General Cable.
      b. Okonite Co.
      c. Southwire Co.
      d. Service Wire.
   2. Instrumentation class wire and cable:
      a. Alpha Wire Co.
      b. Belden CDT.
      c. General Cable.
      d. Okonite Co.
      e. Rockbestos Surprenant Cable Corp.

3. Network cables:
    a. General Cable.
    b. Belden.
    c. CommScope.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Conductors:
    1. Copper in accordance with ASTM B3.

2.04 MANUFACTURED UNITS

A. General:
    1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
    2. Permanently mark each wire and cable with the following at 24-inch intervals:
        a. AWG size.
        b. Voltage rating.
        c. Insulation type.
        d. UL symbol.
        e. Month and year of manufacture.
        f. Manufacturer's name.
    3. Identify and mark wire and cable as specified in Section 16075 - Identification for Electrical Systems:
        a. Use integral color insulation for #2 AWG and smaller wire.
        b. Wrap colored tape around cable larger than #2 AWG.

B. 600 volt class wire and cable:
    1. Provide AWG or kcmil sizes as indicated on the Drawings or in the Conduit Schedules:
        a. When not indicated on the Drawings, size wire as follows:
            1) In accordance with the NEC:
                a) Use 75 degree Celsius ampacity ratings.
                b) Ampacity rating after all derating factors, equal to or greater than rating of the overcurrent device.
            2) Provide #12 AWG minimum for power conductors.
            3) Provide #14 AWG minimum for control conductors.
    2. Provide Class B stranding in accordance with ASTM B8:
        a. Provide Class C stranding where extra flexibility is required.
    3. Insulation:
        a. XHHW-2.
        b. 90 degree Celsius rating.

C. Instrumentation class cable:
    1. Type TC.
    2. Suitable for use in wet locations.
    3. Voltage rating: 600 volts.
    4. Temperature rating:
        a. 90 degree Celsius rating in dry locations.
        b. 75 degree Celsius rating in wet locations.

5. Conductors:
    a. Insulation:
        1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
    b. #16 AWG stranded and tinned.
    c. Color code: ICEA Method 1:
        1) Pair: Black and white.
        2) Triad: Black, white and red.
        3) Multiple pairs or triads:
            a) Color-coded and numbered.
6. Drain wire:
    a. #18 AWG.
    b. Stranded, tinned.
7. Jacket:
    a. Flame retardant, moisture and sunlight resistant PVC.
    b. Ripcord laid longitudinally under jacket to facilitate removal.
8. Shielding:
    a. Individual pair/triad:
        1) Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
    b. Multiple pair or triad shielding:
        1) Group shield: Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
        2) Completely isolate group shields from each other.
        3) Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
    c. All shielding to be in contact with the drain wire.

D. Network cables:
1. Category 6:
    a. General:
        1) Provide Cat 6 cables meeting the standards set by TIA/EIA-568-C.2 and verified by third-party testing laboratory.
    b. Conductors:
        1) #23 AWG solid bare annealed copper.
        2) 4 Bonded pairs.
    c. Drain wire:
        1) #24 AWG stranded (7/32) tinned copper.
    d. Insulation:
        1) Non-Plenum: Polyolefin.
        2) Plenum: Fluoropolymer.
    e. Shielding:
        1) F/UTP - Overall Foil Shield.
    f. Color code:
        1) Pair 1: White/blue stripe and blue.
        2) Pair 2: White/orange stripe and orange.
        3) Pair 3: White/green stripe and green.
        4) Pair 4: White/brown stripe and brown.
    g. Outer jacket:
        1) Non-Plenum: Flame-Retardant PVC.
        2) Plenum: Low-Smoke, Flame-Retardant PVC.

h. Electrical characteristics
1) Voltage rating: 600VAC.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Wire ties:
1. One of the following or equal:
a. T&B, "Ty-Rap" cable ties.
b. Panduit, cable ties.

B. Wire markers:
1. As specified in Section 16075 - Identification for Electrical Systems.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Assembly and testing of cable shall comply with the applicable requirements of ICEA S-95-658-1999.

B. Test Type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Color-coding:
1. Color-coding shall be consistent throughout the facility.
2. The following color code shall be followed for all 240/120 volt and 208/120 volt systems:
a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.
d. Single phase system: Black for 1 hot leg, red for the other.
e. Neutral: White.
f. High phase or wild leg: Orange.
g. Equipment ground: Green.

3. The following color code shall be followed for all 480/277 volt systems:
    a. Phase A: Brown.
    b. Phase B: Orange.
    c. Phase C: Yellow.
    d. Neutral: Gray.
    e. Equipment ground: Green.
4. The following color code shall be followed for all 120 VAC control wiring:
    a. Power: Red.
    b. Neutral: White.
5. The following color code shall be followed for all general purpose DC control circuits:
    a. Grounded conductors: White with blue stripe.
    b. Ungrounded conductors: Blue.
6. Switch legs shall be violet. 3-way switch runners shall be pink.
7. Wires in intrinsically safe circuits shall be light blue.
8. Wire colors shall be implemented in the following methods:
    a. Wires manufactured of the desired color.
    b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
        1) Colored tape shall be wrapped to overlap 1/2 of the width of the tape.

C. Install conductors only after the conduit installation is complete, and all enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
    1. Install wires only in approved raceways.
    2. Do not install wire:
        a. In incomplete conduit runs.
        b. Until after the concrete work and plastering is completed.

D. Properly coat wires and cables with pulling compound before pulling into conduits:
    1. For all #4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
        a. Ideal Products.
        b. Polywater Products.
        c. 3M Products.
        d. Greenlee Products.
        e. Or equal as recommended by cable manufacturer.
        f. Do not use oil, grease, or similar substances.

E. Cable pulling:
    1. Prevent mechanical damage to conductors during installation.
    2. For cables #1 AWG and smaller, install cables by hand.
    3. For cables larger than #1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
    4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.
    5. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.

6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer's recommendation for the specified cable size:
    a. Make splices in manholes or pull boxes only.
    b. Leave sufficient slack to make proper connections.

F. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer's recommendations.

G. Install and terminate all wire in accordance with manufacturer's recommendations.

H. Neatly arrange and lace conductors in all switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
    1. Do not lace wires in gutter or panel channel.
    2. Install all wire ties with a flush cutting wire tie installation tool:
        a. Use a tool with an adjustable tension setting.
    3. Do not leave sharp edges on wire ties.

I. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug:
    1. Use ring type lugs if box lugs are not available on the equipment.

J. Lighting circuits:
    1. Each circuit shall have a dedicated neutral.

K. Splices:
    1. Provide continuous circuits from origin to termination whenever possible:
        a. Obtain Engineer's approval prior to making any splices.
    2. Lighting and receptacle circuit conductors may be spliced without prior approval from the Engineer.
    3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
        a. Splice box NEMA rating requirements as specified in Section 16050 - Common Work Results for Electrical.
        b. Make splices in labeled junction boxes for power conductors.
        c. Make splices for control and instrument conductors in terminal boxes:
            1) Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.
    4. Power and control conductors routed in common raceways may be spliced in common junction boxes.
    5. Clearly label junction and terminal boxes containing splices with the word "SPLICE LOCATED WITHIN".
    6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
    7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:
        a. In NEMA Type 4 or NEMA Type 4X areas, provide heat-shrink sleeves that are listed for submersible applications.
    8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
        a. A heat shrink insulating system listed for submersible applications.
        b. Or an epoxy resin splicing kit.

L. Apply wire markers to all wires at each end after being installed in the conduit and before meg-ohm testing and termination.

M. Instrumentation class cable:
   1. Install instrumentation class cables in separate raceway systems from power cables:
      a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
      b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
   2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
   3. Shield grounding requirements as specified in Section 16060 - Grounding and Bonding.

N. Copper Ethernet cables:
   1. Comply with TIA/EIA-568-C.2.
   2. Pathways:
      a. For initial installation, the maximum fill capacity for pathways (i.e. conduit, raceways, trays, baskets) is 40 percent. The maximum fill capacity of 60 percent is allowed to accommodate future additions after initial installation.
      b. Conduit should be run in the most direct route possible with no more than two 90 degree bends between pull boxes and serve no more than 3 outlet boxes.
   3. Cable bend radius:
      a. Proper cable bend radius control must be maintained throughout the pathways. The bend radius needs to be at a minimum 10 times the cable diameter.
   4. Cable pulling:
      a. Provide cable pulling swivel system to prevent winding and tangling of rope and cables during pull.
      b. The maximum pulling tension is not to exceed manufacturer recommendations. Cable installation should not in any way deform the cable jacket.
      c. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
   5. Cable management:
      a. Organize and manage cables for quick and easy moves, adds and changes.
   6. Testing:
      a. All cables and termination hardware shall be 100 percent tested for defects in installation and to verify cabling system performance under installed conditions according to the requirements of TIA/EIA-568-C.1 Section 11.
         1) All pairs of each installed cable shall be verified prior to system acceptance.
         2) Any defect in the cabling system installation including but not limited to cable, connectors, feed through couplers, patch panels, and connector blocks shall be repaired or replaced in order to ensure 100 percent useable conductors in all cables installed.

b. All twisted-pair copper cable links shall be tested for compliance to the requirements in TIA/EIA/568-C.2 for the appropriate Category of cabling installed.
c. All cables shall be tested in accordance with the contract documents, TIA/EIA standards, and best industry practice.
d. The field test equipment shall meet the requirements of TIA/EIA-568-C. The appropriate level III tester shall be used to verify Category 6 cabling.
e. Visually inspect UTP jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-C.1.
f. Visually inspect cable placement, cable termination, grounding and bonding, equipment and labeling of all components.
g. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors:
    1) Test operation of shorting bars in connection blocks.
    2) Test cables after termination but not cross-connection:
        a) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-C.2:
            (1) Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex.
            (2) Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

7. Separation from EMI sources:
    a. Comply with TIA/EIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
    b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
        1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
        2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
        3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches
    c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
        1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
        2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
        3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
    d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
        1) Electrical Equipment Rating Less Than 2 kVA: No requirement.

2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.

O. Signal cable:
1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.

P. Wiring allowances:
1. Equipment locations may vary slightly from the drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
2. Locations for pull boxes, manholes, and duct banks may vary slightly from the drawings. Include an allowance for necessary conductors and related materials to provide conductors to all pull boxes, manholes and duct banks within 20 linear feet of locations indicated on the Drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Grounding:
1. As specified in Section 16060 - Grounding and Bonding.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16124

MEDIUM VOLTAGE CABLES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Medium voltage cables rated 5,000 through 35,000 volts.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Association of Edison Illuminating Companies (AEIC):
   1. CS8 - Specification for Extruded Dielectric, Shielded Power Cables Rated 5 through 46 kV.

C. ASTM International (ASTM):
   1. B3 - Standard Specification for Soft or Annealed Copper Wire.
   2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   3. B496 - Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.

D. Insulated Cable Engineers Association (ICEA):
   1. S-93-639 - 5-46 kV Shielded Power Cable for Use in the Distribution of Electrical Energy.
   2. S-94-649 - Standard for Concentric Neutral Cables Rated 5 Through 46 kV.
   3. S-97-682 - Standard for Utility Shielded Power Cables Rated 5 Through 46 kV.

E. Underwriter's Laboratories (UL):
   1. 1072 - Standard for Safety for Medium-Voltage Power Cables.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Definitions of terms and other electrical considerations as set forth by:
   1. ICEA.
   2. ASTM.

1.04 SYSTEM DESCRIPTION

A. Furnish and install the complete medium voltage cable system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Manufacturer.
   2. Voltage class.
   3. Conductor:
      a. Size.
      b. Material.
      c. Stranding.
   4. Insulation:
      a. Type.
      b. Level.
   5. Shielding.
   6. Temperature rating.
   7. Jacket material.

C. Shop drawings:
   1. Show splice locations.
   2. Provide details on the pull plan:
      a. Show splice locations, if applicable.
      b. Cable layout locations, if applicable.
      c. Actions for protecting cables at each phase of the installation.

D. Calculations:
   1. Submit cable pulling calculations to the Engineer for review and comment showing that the maximum cable tension and sidewall pressure will not exceed Manufacturer recommended values:
      a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
   2. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

E. Qualifications:
   1. Submit qualifications for the individual(s) that will be performing medium voltage cable splices and terminations at least 30 calendar days before splicing or terminating.
   2. Documentation that the individual has received training by splice/termination Manufacturer or an independent testing laboratory.
   3. A statement of the number of years in which the individual has been splicing and terminating medium voltage cable.

F. Test reports:
   1. Submit AC withstand partial discharge (corona) test x-y plots after manufacture and prior to shipment.
   2. Submit field test reports as specified in Section 16950 - Field Electrical Acceptance Tests.

G. Record documents:
   1. Submit record documents with any field modification.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Manufacturer qualifications: Minimum of 10 years of experience in manufacturing medium voltage power cables.

C. Medium voltage cables shall be UL listed and labeled.

1.07 DELIVERY STORAGE AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT/SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Okonite Co.
   2. General Cable.
   3. Southwire Co.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Conductors:
   1. Annealed uncoated copper in accordance with ASTM B3.
   2. Compact stranded in accordance with ASTM B496.

B. Insulation:
   1. Ethylene propylene rubber, (EPR).

C. Jacket:
   1. Polyvinyl chloride (PVC).

2.04 MANUFACTURED UNITS

A. General:
   1. Permanently mark each cable with the following at 24-inch intervals:
      a. American Wire Gauge (AWG) size or circular mill area.
      b. Voltage rating.
      c. Grade of insulation.
      d. UL symbol.
      e. Manufacturer's name.

B. Medium voltage cable:
   1. Provide cables manufactured in the last 12 months.
   2. Voltage ratings as indicated on the Drawings or on the conduit schedule.
   3. Type MV-105:
      a. Rated for 105 degrees Celsius.
   4. Single-conductor:
      a. Stranding:
         1) In accordance with ASTM B3 and B8 Class B.
   5. Conductor screen:
      a. Extruded semiconducting thermosetting compound.
      b. Applied directly over the conductor.
      c. In accordance with:
         1) AEIC CS8.
         2) UL 1072.
   6. Insulation level:
      a. 133 percent.
      b. Insulation screen:
         1) Extruded semiconducting thermosetting compound.
         2) Applied directly over the insulation.
         3) In accordance with:
            a) ICEA S-93-639 and ICEA S-97-682.
            b) Free-striping.
         4) Provide color differentiation between semi-conducting layers and insulation.
   7. Shield:
      a. 5-mil annealed copper tape with an overlap of 25 percent.
   8. Applications:
      a. Suitable for use in wet and dry locations in conduit and underground duct systems.
      b. Cables larger than AWG 1/0 suitable for CT use in cable tray.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Manufacturer cable in accordance with the latest standards of the ASTM and ICEA and test full cable length by these standards:
   1. AC withstand partial discharge (corona) test per AEIC CS8 and ICEA S-94-649:
      a. Results not to exceed 5 picocoulombs.

B. Provide cable reels with both ends of cables available for high-potential testing before installation.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Install and terminate cable per manufacturer recommendations:
   1. Use proper stripping and terminating tools to ensure integrity of insulation.
   2. Ground shield at all terminations and splices.
   3. Maintain manufacturer's or NEC's minimum bending radius, whichever is larger.
   4. Do not bend, kink or nick cable jacket or insulation.
   5. Properly coat wires and cables with pulling compound recommended by cable manufacturer before pulling into conduits and prevent mechanical damage to conductors during installation:
      a. Other lubricants substituted must be accompanied by a statement from cable manufacturer as to its acceptable use with cables being installed.
   6. Do not exceed the pulling tension and sidewall pressures recommended by cable manufacturer. Install additional pull boxes as required to meet cable manufacturer's recommendations.
   7. Electrical identification: As specified in Section 16075 - Identification for Electrical Systems.
   8. Use only tools that are recommended by the termination or splice manufacturer.
   9. Use a dynamometer during cable pulling operations to monitor cable pulling tensions.

C. Do not install cables until the Engineer reviews the Contractor prepared cable-pulling calculations:
   1. Cable pulling crew shall have "in hand" all cable pulling calculations and cable pulling limitations.

D. Cable pulling requirements:
   1. Pull cable directly from reels into the ducts.
   2. Cable may not be laid on the ground or otherwise handled for cutting or sorting without protection from debris or physical damage.
   3. Follow cable manufacture installation instructions for proper handling.

4. Do not pull cables through more than one intermediate manhole on one pull.
5. Seal all cable ends against moisture after pulling.
6. Use non-metallic pull ropes to prevent cutting of duct materials.
7. Pull cables from conductor, do not use cable pulling socks that attach to the insulation.

E. Installation of cables in manholes and handholes:
   1. Install cables not utilizing the shortest route, but routed along those walls providing the longest route and the maximum spare cable lengths.
   2. Run all cables closely parallel to the walls, not interfering with duct entrances.
   3. Support cables on brackets and cable insulators spaced at a maximum of four feet.
   4. In existing manholes and handholes where new ducts are to be terminated or where new cables are to be installed, modify the existing installation of cables, cable supports, and grounding as required for a neat and workmanlike installation with all cables properly arranged and supported.

F. Splices:
   1. Provide continuous circuits from origin to termination:
      a. Provide where necessary when cable pulling tension or sidewall pressure exceeds manufacturer recommendation for the cable.
   2. Make splices in manholes or pull boxes only:
      a. Leave sufficient slack to make proper connections.
      b. Do not pull splices into conduit.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

B. After cable installation, test the cables as specified in Section 16950 - Field Electrical Acceptance Tests before energizing the circuits:
   1. Verify that no equipment is connected to the cables during tests.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16125

FIBER OPTIC CABLE AND APPURTENANCES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Fiber optic cable.
   2. Fiber splices and terminations.
   3. Accessories.

B. Furnish a complete fiber optic network as indicated on the Drawings.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Bellcore Standards:
   1. GR-409, “Generic Requirements for Indoor Fiber.”

C. Electronic Industry Association (EIA) 455B "Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components":
   1. FOTP-25 - Impact testing of Fiber Optic Cables and Cable Assemblies.
   2. FOTP-33 - Fiber Optic Cable Tensile Loading and Bending Test.
   3. FOTP-41 - Compressive Loading Resistance of Fiber Optic Cables.
   4. FOTP-81 - Compound Flow (Drip) Test for Filled Fiber Optic Cable.
   5. FOTP-104 - Fiber Optic Cable Cyclic Flexing Test.
   6. FOTP-181 - Lightning Damage Susceptibility Test for Fiber Optic Cables with Metallic Components.

D. Insulated Cable Engineer’s Association (ICEA):
   1. S-83-596, “Optic Fiber Premises Distribution Cables.”
   2. S-87-640, “Optic Fiber Outside Plant Communications Cable.”
   3. S-104-696, “Indoor-Outdoor Optic Fiber Cable.”

E. TIA/EIA Standards:
   1. 598 - “Optical Fiber Cable Color Coding.”
   2. 11801 – Information technology – Generic cabling for customer premises.

F. Underwriters Laboratories, Inc. (UL):
   1. 1666 - Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.
   2. 1685 - Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables.

1.03 DEFINITIONS

A. As specified in Sections 16050 - Common Work Results for Electrical and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Specific definition:
   1. N/Cm: Newtons per centimeter.
   2. OTLS: Optical Loss Test Set (Tier 1 test).
   3. OTDR: Optical Time Domain Reflectometer (Tier 2 test).

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Complete manufacturer's brochures that identify materials and options.
   2. Completed data sheets, including catalog number and source for determining catalog number.
   3. Manufacturer's installation instructions.
   4. Include the following:
      a. Manufacturer's data on testing equipment used on this project.
      b. Manufacturer's specifications and data sheets for all fiber types.
      c. Manufacturer's specifications and data sheets for all connectors, bulkheads, splicing kits, breakout devices, and appurtenances used connecting and terminating the fiber spans.
   5. Catalog data on all testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the NIST.
   6. Manufacturer's test procedures and quality assurance procedures:
      a. After review, the Engineer may require that additional tests be performed before installation.

C. Shop drawings:
   1. Interconnection cabling diagrams for the complete system including every fiber in each cable.
   2. Drawings indicating the locations of all pull boxes including pull box identifiers and lengths.
   3. Submit optical power budget calculations for all fiber segments. Include the following:
      a. Minimum transmit power of active devices.
      b. Minimum receive sensitivity.
      c. Available power, in dBm.
      d. Loss for each segment in dBm, including cable attenuation and connector losses. Use manufacturer's data for cable attenuation, at the wavelength to be used. Assume 0.5 dB per connector.
      e. Demonstrate that remaining power budget at each receiver is equal to or greater than 3.0 dBm.

D. Installation instructions:
   1. Submit a cable pulling and splicing work plan a minimum of 45 days before the planned initiation of cable pulling. The cable pulling and splicing work plan must be approved a minimum of 15 days before pulling cable. Include the following:
      a. Pull tension calculations.
      b. Detailed description of pull operation methods for all conduit runs.
      c. Tools and equipment to be used for cable installation and testing.
      d. Physical location of equipment setup and type.
      e. Exact locations of splice points.
      f. Safety and manual assist cable-pulling operations.
      g. Detailed schedule for pulling and testing cables.
      h. The name and qualifications of the supervisory personnel directly responsible for the installation of the conduit system.
      i. Sample fiber optic cable test sheets.
      j. All signed test sheet results.

E. Operation and maintenance manuals:
   1. Compile completed test reports, instruction manuals, and manufacturer's information into the operating manuals and submitted in accordance with Section 01782 - Operation and Maintenance Manuals.

F. Test reports:
   1. Submit the results of all specified tests to the Engineer.
   2. Submit 3 copies of all test reports showing the results of all tests specified herein or in Section 16950 - Field Electrical Acceptance Tests:
      a. Test forms shall include the following information at a minimum:
         1) Test type.
         2) Test location.
         3) Test date.
         4) Wavelength.
         5) Index of refraction.
         6) Cable identification.
         7) Fiber type.
         8) Fiber number.
         9) Fiber color.
         10) Result of the value of the tested parameter.
   3. Furnish hard copy and electronic copy for all OTDR traces.
   4. Submit certification that the fiber optic cable has passed each testing stage:
      a. Submit separate documentation for each testing stage result.

G. Record documents:
   1. Furnish updated electrical drawings, network diagrams, and fiber cable block diagrams at the end of construction and submit as Record Drawings.

H. Calculations:
   1. Cable pulling calculations for all conduit runs:
      a. Indicate on the submittal any additional pull boxes that are required, including pull box identifiers and a written description of the location.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Furnish all cable and appurtenances manufactured within 1 year of installation.

C. Proof test all optical fibers by the fiber manufacturer at a minimum load of 50 kpsi.

D. Provide 100 percent attenuation testing for all optical fibers:
   1. Include with each cable reel the attenuation of each fiber.

E. Provide information on at least 5 successful fiber optic cable installations of comparable size and complexity in the past 3 years with name, address, and telephone number of facility owner, name of project with completion date, and type of conduit system and length of cable pulled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Package the cable for shipment on wooden reels:
   1. Seal both ends of the cable to prevent the ingress of moisture.
   2. Place fiber cable assemblies on reels such that both cable ends are available for testing.
   3. Weatherproof cable reel markings shall include the following:
      a. Manufacturer.
      b. Date of manufacture.
      c. Shipping date.
      d. Cable identification.
      e. Cable configuration/fiber count.
      f. Cable length.
      g. Gross weight.
      h. Cable test date.
      i. Handling instructions.
      j. Direction to unreel.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

A. Testing:
   1. Perform testing of each fiber in each cable as follows:
      a. At the factory before shipment.
      b. At the project site upon delivery.
      c. After installation, before breakout and terminations.
      d. After installation is complete.
   2. Submit test reports following each set of tests as specified in this Section.

B. Notify the Engineer and Owner a minimum of 15 days before post-installation testing.

1.10 SCHEDULING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Acceptable manufacturers are indicated with each component type as listed in the remainder of this specification.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General fiber cable requirements:
   1. Suitable for the installed environment.
   2. Color-coded fibers according to EIA/TIA-598.
   3. Color-coded buffer tubes according to EIA/TIA-598.
   4. Furnish buffer tubes of a single layer nylon construction or of a material with similar mechanical performance.
   5. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.
   6. Apply binders with sufficient tension to secure the buffer tubes to the central member without crushing the buffer tubes:
      a. Provide binders that are:
         1) Non-hygroscopic.
         2) Non-wicking (or rendered so by the flooding compound).
         3) Dielectric with low shrinkage.
   7. Provide a minimum of 1 ripcord under the cable sheath.
   8. Provide the high tensile strength Aramid yarns, Kevlar, and/or fiberglass helically stranded evenly around the cable core:
      a. No metallic elements whatsoever are allowed in non-armored cable.
   9. The jacket or sheath shall be free of holes, splits, and blisters.
   10. Mark the jacket or sheath with:
      a. Manufacturer's name.
      b. The words "Optical Cable”.
      c. Year of manufacture.
      d. Sequential meter marks.
      e. Repeat markings every 1-meter.

f. The actual length of the cable to be within 1 percent of the length marking.
g. The marking must be in a contrasting color to the cable jacket.
h. The height of the marking:
1) Approximately 2.5 millimeters.

11. The shipping, storage, and operating temperature range of the cable shall be -40 degrees Celsius to +70 degrees Celsius.
12. General performance characteristics:
a. The rated tensile load of the cables:
1) Indoor/outdoor:
a) Short term: 1,330 N.
b) Long term: 400 N.
b. Non-armored fiber optic cables: Compressive load withstand of 220 N/cm applied uniformly over the length of the cable.
c. Armored fiber optic cables: Compressive load withstand of 440 N/cm applied uniformly over the length of the cable.
d. The average increase in attenuation for the fibers: Less than or equal to 0.10 dB at 1,550 nm for a cable subjected to this load:
1) With no measurable increase in attenuation after load removal.
e. Test in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cable," except that the load must be applied at the rate of 3 millimeters to 20 millimeters per minute and maintained for 10 minutes.
f. Capable of withstanding 25 cycles of mechanical flexing at a rate of 30 within 1 cycles/minute.
g. The average increase in attenuation for the fibers: Less than or equal to 0.10 dB at 1,550 nm at the completion of the test.
h. For armored cables, any visible cracks causing separation of the armor and propagating more than 5 millimeters constitutes failure.
i. Outer cable jacket cracking or splitting observed under 10X times magnification, constitutes failure.

B. Indoor/outdoor cable:
1. Cable construction:
a. General:
1) Cable type: Indoor/Outdoor - Flame retardant, low smoke, zero halogen, UV resistant.
2) Fiber count: As indicated on the Drawings.
3) Fiber type: As indicated on the Drawings.
4) Buffer tube: Tight buffer.
5) Armoring: None.
6) Waterproofing: Water blocking layer.
7) Strength member:
a) Tight buffer: For cables with more than 12 fiber strands, utilize a central, nonmetallic strength member with a coefficient of thermal expansion similar to the fibers.
8) Approvals and listings: UL 1666 and UL 1685.
9) Design and test criteria: In accordance with ICEA S-104-696.
b. Testing:
1) All fibers in the cable:
a) Proof test of 100 kpsi.
b) Each optical fiber: Bellcore GR-409 strip force testing.
c) No gaps are allowed between the coating material and the buffer material visible under a 50-power microscope.

c. Outer jacket material:
1) Linear low-density polyethylene.
2) Meet all requirements of the NEC for use in all indoor/outdoor areas (excluding plenums) without being enclosed in conduit.
3) Flame retardant OFNR riser rated conforming to UL 1666.
4) Printed with all necessary UL marks and manufacturer identification.
5) Sequential printing of footage in 2-foot increments.
6) With a ripcord incorporated under the cable jacket.

C. Single mode fibers:
1. All fibers in the cable must be usable fibers and meet required specifications.
2. Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.
3. Single mode fiber characteristics:
a. Category: OS2 compliant with ITU-G.657.A1.
b. Jacket color: Yellow .

D. Indoor/outdoor:
1. Tight buffer:
a. Corning Cable Systems, Freedm® One.
b. Optical Cable Corporation, DX-Series
c. CommScope, LazrSPEED/TerraSPEED.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Patch cords:
1. General:
a. Connector types to match supplied equipment and the patch panel terminations.
b. Maximum length of patch cords: 25 feet.
c. Provide 2 spare patch cords (or 1 duplex patch cord) of each type used at each PLC or network cabinet.
d. Factory assembled and optically tested.
e. Provide mode-conditioning cords for multimode fibers operating at 1310 nm.
2. Manufacturers: One of the following or equal:
a. CommScope.
b. Corning Cable Systems.

B. Fiber connectors:
1. As specified in Section 17733 - Control Systems: Network Materials and Equipment.

C. Fiber optic identification/warning tags:
1. Black letters on orange or yellow background.
2. UV resistant polyethylene or other suitable material:
a. Manufacturers: The following or equal:
1) Almetek.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify the condition of the conduit system before installation of the fiber optic cable or inner duct.

B. Pass a test mandrel through all fiber optic conduits prior to pulling fiber or installing inner duct:
   1. Run the mandrel in both directions.

C. Examine all materials and equipment before installation and verify they are free from physical damage and defects.

3.02 PREPARATION

A. Before fiber splicing terminating or testing activities, verify sufficient workspace is available to perform the activity without interferences from other trades.

B. Pre-installation test:
   1. Conduct pre-installation tests on all fiber optic cable.
   2. Upon arrival at the site:
      a. Inspect the cable and reel for damage.
      b. Test all fibers with an optical time domain reflectometer (OTDR) for fiber integrity.
      c. Verify that the fiber lengths are consistent with the cable manufacture.
      d. Verify that all traces yield no point discontinuities.
   3. Complete test sequence and obtain approval from the Engineer of submitted test results before cable installation:
      a. Replace any cable failing to meet the requirements of the required tests and test before installation.
   4. Submit copies of the test results to the Engineer within 5 days after the delivery to the site.

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Install fiber optic patch cords in open network trays or in dedicated conduits no longer than 25 feet in length.

C. Install all fiber optic system components in accordance with the recommendations of the manufacturer.

D. Install fiber optic cable in continuous lengths without intermediate splices, except where approved by the Engineer.

E. Installation:
   1. Utilize personnel certified by the manufacturer with specific knowledge of the cable manufacturer's recommended procedures:
      a. Schedule Engineer, 5 days before installation, to witness all cable installations.
   2. Properly attach the fiber optic cable's strength elements to a 600-pound breakaway swivel containing tension or shear pins using Kellums pulling grips that are a minimum of 18 inches long.
   3. Certify that cable tensile limits do not exceed cable pull tension and bend limits using tension monitoring devices.
   4. Leave an extra loop of fiber optic cable in each pull box.
   5. Conform with the cable manufacturer's specifications, practices, and the following requirements:
      a. When power equipment is used to install fiber optic cables, use low speeds and do not exceed a rate of 30 meters per minute.
      b. Do not exceed the tensile and bending limitation for fiber optic cables under any circumstances.
      c. Use large diameter wheels, pulling sheaves, and cable guides to maintain the specified bending radius.
      d. Use commercial dynamometers or load cells to monitor pulling tension.
      e. A nonfreezing type of swivel inserted between the pulling line and cable pulling grip to prevent twisting under strain.
      f. All cable to be installed using a breakaway swivel.
   6. Apply to all conduits a lubricant at each conduit ingress and egress location during the pull operation:
      a. Pour or pump lubricant into the end of the conduit at the feed location at a nominal application rate of 3 gallons per 1,000 feet of cable.
      b. If the conduit is open at intermediate locations, then apply the appropriate proportion of lubricant at each opening.
      c. Continuously lubricate the cable as it is being pulled by pouring or pumping the lubricant into the conduit at the feed location and at each intermediate location.
      d. Station workers at each intermediate location as required.
      e. Remove all excess lubricant that has collected.
      f. Remove and clean the surrounding area after cable installation.
   7. Install using a hydraulic capstan or winch equipped with a recording running line dynamometer graph which measures and records pulling tensions:
      a. Use pulling equipment with "slip-load" capability to allow the winch to maintain a constant pulling force without taking up the winch line.
      b. Use pulling equipment equipped with a hydraulic bypass set so that a maximum tension of 600 pounds is not exceeded.
      c. Use only equipment designed to prevent a preset pulling tension from being exceeded.
      d. Fiber optic cable manufacturer to provide the pulling tension setpoint.
      e. If during the pulling operation excessive tension is detected, cease all operations and notify the Engineer.

8. Position the cable reel at the feed point in alignment with the raceway and in such a position that the cable can be passed from the top of the reel in a long, smooth bend into the raceway system:
    a. The use of a cable feeder is required, unless the cable is hand-pulled.
9. Supply all bull wheels, blocks, split wheels, cable feeders, and necessary equipment required to provide a clean and safe operation:
    a. The cable shall not be allowed to travel over any wheel or block that has a radius less than the minimum radius allowed by the cable manufacturer.
10. Minimize the use of snatch blocks and rollers to guide the cable into the conduit at the feed point:
    a. Slack feed by hand the cable into the feed point and raceway without the use of rollers.
11. Tend the cable reel at all times and turn by hand to provide the required cable slack:
    a. Under no circumstances shall the cable tension be allowed to turn the cable reel.
12. Use a rim roller, with a wheel radius greater than the minimum cable bending radius placed at the manhole or vault opening to prevent the cable from dragging on the manhole rim or steps.
13. Perform a continuous thorough visual inspection for flaws, breaks, and abrasions in the cable sheath as the cable leaves the reel, and maintain a slow pulling speed to permit this inspection.
14. Damage to the sheath or finish of the cable is cause for rejecting the cable:
    a. Replace any cable damaged in any way during installation.
15. If the cable becomes damaged during installation, stop operations and notify the Engineer immediately:
    a. Engineer to determine whether to replace the entire reel of cable or to install a termination panel to eliminate the damaged section.
16. Document all pulls by a graph which is annotated with the following information:
    a. Reel number.
    b. Pull point ID.
    c. Date and time.
    d. Explanations for abnormalities in readings or interruptions.
    e. Sign-off by Contractor and Engineer.
17. Under no conditions shall the fiber optic cable be left exposed or unattended.

F. After the cables are installed and spliced:
    1. Rack the cables:
        a. Loosely secure in racked position with wire ties.
        b. Attach imprinted plastic coated cloth identification/warning tags to each cable in at least 2 locations in each handhole/manhole.

G. Splices:
    1. Submit all splice locations to the Engineer for approval before installation of the fiber cables.
    2. Provide field splices in a splice tray located in a waterproof splice enclosure:
        a. Manufacturers: The following or equal:
            1) Tyco/Raychem, FOSC style splice enclosure.
    3. Loop the individual fibers a minimum of 1 full turn within the splice tray to avoid macro/micro bending.
    4. After completion of cable terminations, neatly dress all cables.

5. Protect all splices with a thermal shrink sleeve.
6. Provide fusion type fiber optic cable splicing meeting the following requirements:
    a. Joins multimode or single mode fibers.
    b. Establishes a permanent fusion splice.
    c. Waterproof.
    d. Re-enterable, rearrangable, and reusable.
    e. Splice loss less than 0.10 dB.
    f. Protected by a splice enclosure.
7. Requirement for outdoor fiber splice enclosures:
    a. Seal.
    b. Bond.
    c. Anchor.
    d. Protect fiber optic cable splices.
    e. Stand-alone unit that does not require an outer enclosure.
    f. Provide for a maximum of 6 cable entries in a butt-end configuration.
    g. Used in aerial, underground, and direct buried applications.
8. Requirement for indoor fiber splice enclosures:
    a. Anchor.
    b. Protect fiber optic cable splices.
    c. Stand-alone unit that does not require an outer enclosure.
    d. Suitable for the minimum number of splices at that location plus additional capacity for reconfigurations.
9. Re-splice any splice that has a loss greater than 0.10 dB.
10. Leave a minimum of 20 feet of fiber optic cable at each end of splice.

H. Terminations:
1. Terminate all fiber inside a patch panel. Direct landing to equipment is not allowed.
2. Terminate cables that travel outdoors with a furcation kit to seal the cable and provide physical protection for the fiber strands.
3. Terminations and connectors shall be rated to same standard as network cable.
4. Factory-terminated pigtail:
    a. Terminate cables in rack mount and cabinet style fiber patch panels by fusion splicing to pigtails.
    b. 900 micron buffer tube.
    c. Factory-terminated connector.
    d. Color coded per TIA-598.
    e. Manufacturers: One of the following or equal:
        1) Belden.
        2) Corning Cable Systems.
5. Splice-on connector:
    a. Terminate cables in DIN rail mounted fiber patch panels with fuse-on connectors.
    b. Suitable for fusion splicing directly to fiber cable without the need for a splice tray or additional protection.
    c. Utilize a 900 micron fanout kit for loose tube cables.
    d. Maximum insertion loss: 0.3dB
    e. Manufacturers: One of the following or equal:
        1) Belden, FiberExpress Fusion.
        2) Corning Cable Systems, FuseLite™.

6. Labeling:
    a. Permanently label all cable terminations. Use labels produced by a wire printer using pressure sensitive polyester labels. Label patch panels as specified in Section 16075 - Identification for Electrical Systems.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Factory test:
    1. Before shipment and while on the shipping reel, test 100 percent of all fibers for attenuation:
        a. Copies of the results shall be:
            1) Maintained on file.
            2) Attached to the cable reel in a waterproof pouch.
            3) Submitted before the delivery of the cable to the job site to Engineer for approval.
    2. Conduct the flex test in accordance with FOTP-104 test condition I and III with a maximum sheave diameter of 20 times the cable OD.
    3. Verify that the cable withstands 25 impact cycles with:
        a. The average increase in attenuation for the fibers less than 0.20 dB at 1,550 nm.
        b. No evidence of cracking or splitting.
        c. Conduct the test in accordance with FOTP-25.
    4. Certify that the cable withstands a tensile load of 2,700 N (600 pounds):
        a. Without exhibiting an average increase in attenuation of greater than 0.10 dB.
        b. Test in accordance with FOTP-33 using a maximum mandrel and sheave diameter of 560 millimeters.
        c. Apply the load for 1 hour in Test Condition II.
    5. Certify that the cable withstands a simulated lightning strike:
        a. Peak value of the current pulse greater than 105kA.
        b. Use a test current with a damped oscillatory maximum time-to-peak value of 15 µs (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz.
        c. The time to half-value of the waveform envelope 40 to 70 µs.
        d. Conduct the test in accordance with the FOTP-181.
        e. In addition to the analysis criterion set forth in FOTP-181, the integrity of the buffer tubes (or analogous loose tube, i.e. core tube) and strength members must be intact after removal of the cable specimens from the test box.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

B. General:
   1. All test results shall meet or exceed manufacturer specifications:
      a. Test each fiber of each cable for breaks, abnormalities, and overall attenuation characteristics.
      b. Replace any fiber that does not meet or exceed manufacturer specifications.
   2. Conduct post-installation tests of the fiber optic system in accordance with Section 16950 - Field Electrical Acceptance Tests.
   3. Pre-installation tests and post-installation tests to be witnessed and signed off by Engineer and Owner.
   4. Perform OLTS test with equipment capable and calibrated to show anomalies of 0.1 dB as a minimum:
      a. Test multimode fibers at 850 nm and 1,300 nm.
      b. Test single mode fibers at 1,310 and 1,550 nm.
   5. Perform OTDR tests on fiber cables less than 100 meters with the aid of a launch cable:
      a. Adjust OTDR pulse width settings to a maximum setting of 1/1000th of the cable length or 10 nanoseconds.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. Clean all fiber optic connectors after termination and before testing. After cleaning, cover all un-terminated connectors with a protective boot.

B. At the completion of construction, touch up the finish on all fiber patch panels and enclosures.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Protect the fiber system from physical damage and the encroachment of dust, before, during, and after installation.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16130

CONDUITS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Metallic conduits.
   2. Nonmetallic conduits.
   3. Conduit bodies.
   4. Conduit fittings and accessories.
   5. Conduit installation.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. American National Standards Institute (ANSI):
   1. C80.1 - Electrical Rigid Steel Conduit.

C. National Electrical Manufacturer's Association (NEMA):
   1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
   2. TC2 - Electrical Polyvinyl Chloride (PVC) Conduit.
   3. TC3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.

D. Underwriters Laboratories (UL):
   1. 1 - Standard for Flexible Metal Conduit.
   2. 6 - Standard for Electrical Rigid Metal Conduit - Steel.
   3. 360 - Standard for Liquidtight Flexible Steel Conduit.
   4. 651 - Standard for Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions and abbreviations:
   1. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to, Shapes C, E, LB, T, X, etc.
   2. Conduit fitting: An accessory that primarily serves a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.
   3. GRC: Galvanized rigid steel conduit.
   4. PCS: Polyvinyl chloride (PVC) coated rigid steel conduit.
   5. PVC: Polyvinyl chloride rigid nonmetallic conduit.
   6. SLT: Sealtight-liquidtight flexible conduit.
   7. NPT: National pipe thread.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
   2. Furnish complete manufacturer's recommended special tools to be used for installation if required.
   3. Certified test results for PVC-coated metallic conduit showing the adhesive bond is stronger than the tensile strength of the PVC.

C. Certifications:
   1. Furnish PVC-coated conduit manufacturer's valid, unexpired certification for each installer.

D. Record Documents:
   1. Incorporate all changes in conduit routing on electrical plan drawings.
   2. Dimension underground and concealed conduits from building lines.
   3. Furnish hard copy drawings.

1.05 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. All conduits, conduit bodies, and fittings shall be UL listed and labeled.

C. Every installer of PVC-coated metallic conduit shall be certified by the manufacturer for installation of the conduit, and be able to present a valid, unexpired installer certification card prior to installation beginning.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Do not expose non-metallic conduit to direct sunlight.

C. Do not store conduit in direct contact with the ground.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 SEQUENCING

A. Before installing any conduit or locating any device box:
   1. Examine the complete set of Drawings and Specifications, and all applicable shop drawings.
   2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

1.09 SCHEDULING (NOT USED)

1.10 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.11 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Galvanized rigid steel conduit:
   1. One of the following or equal:
      a. Western Tube and Conduit.
      b. Allied Tube and Conduit.
      c. Wheatland Tube Co.

B. PVC-coated rigid steel conduit:
   1. One of the following or equal:
      a. Robroy Ind.
      b. Ocal, Inc.
      c. Calbond.
      d. Allied.
      e. NEC, Inc. BlackGuard.

C. Sealtight-liquidtight flexible conduit:
   1. One of the following or equal:
      a. Southwire.
      b. AFC Cable Systems.
      c. Electri-Flex Co.
      d. Anaconda.

D. Rigid nonmetallic PVC conduit:
   1. One of the following or equal:
      a. Carlon.
      b. Cantex.
      c. Triangle Conduit and Cable.

E. Inner duct:
   1. One of the following or equal:
      a. Carlon.
      b. Endot Ind.
      c. MaxCell.

F. Conduit bodies:
   1. One of the following or equal:
      a. Crouse-Hinds.
      b. Appleton.
      c. O-Z/Gedney.
      d. Ocal, Inc.
      e. Robroy Ind.
      f. Calbond.
      g. Carlon.

G. Joint compound:
   1. The following or equal:
      a. Thomas and Betts.

H. PVC-coated rigid steel conduit expansion fittings:
   1. One of the following or equal:
      a. Ocal, Inc.
      b. Robroy Ind.
      c. NEC, Inc. BlackGuard.

I. Conduit seals:
   1. One of the following or equal:
      a. Appleton.
      b. Crouse-Hinds.
      c. O-Z/Gedney.

J. Conduit hangers and supports:
   1. As specified in Section 16070 - Hangers and Supports.

K. Conduit through wall and floor seals:
   1. The following or equal:
      a. O-Z/Gedney:
         1) Type "WSK."
         2) Type “CSM.”

2.02 SYSTEM DESCRIPTION

A. Provide conduits, conduit bodies, fittings, junction boxes, and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

2.03 EXISTING PRODUCTS (NOT USED)

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. GRC:
   1. All threads: NPT standard conduit threads with a 3/4-inch taper per foot:
      a. Running conduit threads are not acceptable.
   2. Hot-dip galvanized inside and out:
      a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
      b. Electro-galvanizing is not acceptable.
   3. Manufactured in accordance with:
      a. UL-6.
      b. ANSI C80.1.

B. PCS:
   1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for Type GRC.
   2. Coated conduit NEMA Standard RN-1:
      a. The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
   3. Factory-bonded PVC jacket:
      a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
      b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictates otherwise.
      c. PVC coating on conduits and associated fittings shall have no sags, blisters, lumps, or other surface defects and shall be free of holes and holidays.
      d. The PVC adhesive bond on conduits and fittings shall be greater than the tensile strength of the PVC plastic coating:
         1) Confirm bond with certified test results.
   4. A urethane coating shall be uniformly and consistently applied to the interior of all conduits and fittings:
      a. Nominal thickness of 0.002 inch.
      b. Conduits having areas with thin or no coating are not acceptable.
      c. All threads shall be coated with urethane.
   5. The PVC exterior and urethane interior coatings applied to the conduits shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
   6. PCS conduit bodies and fittings:
      a. Malleable iron.
      b. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.
      c. The PVC coating on the outside of conduit bodies shall be 0.040-inch thick and have a series of ribs to protect the coating from tool damage during installation.
      d. 0.002-inch interior urethane coating.
      e. Utilize the PVC coating as an integral part of the gasket design.
      f. Stainless steel cover screw heads shall be encapsulated with plastic to ensure corrosion protection.

g. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening:
    1) The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
    2) The sleeve shall provide a vapor- and moisture resistant seal at every connection.
    3) Fittings shall be Form 8 and supplied with plastic encapsulated stainless steel cover screws. Fittings shall be UL Type 4X. Fittings shall be from the same manufacturer as the conduit in order to maintain system continuity and warranty.

C. SLT:
1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
    a. General purpose:
        1) Temperature range: -20 degrees Celsius to +80 degrees Celsius.
    b. Oil-resistant:
        1) Temperature range: -20 degrees Celsius to +60 degrees Celsius.
2. Sunlight-resistant, weatherproof, and watertight.
3. Manufactured from single strip steel, hot-dip galvanized on all 4 sides before conduit fabrication.
4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
5. Overall PVC jacket.
6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 1-1/4 inch.

D. PVC:
1. Extruded from virgin PVC compound:
    a. Schedule 40 unless otherwise specified.
    b. Schedule 80 extra-heavy wall where specified.
2. Rated for 90 degrees Celsius conductors or cable.
3. Rated for use in direct sunlight.

E. Inner duct:
1. HDPE and fabric inner duct are considered interchangeable.
2. HDPE inner duct:
    a. High-density polyethylene.
    b. Corrugated.
    c. Resin properties:
        1) Density, g/cm^3: 0.941 to 0.955.
        2) Melt index g/10 minute Condition E: 0.05 to 0.5.
        3) Flexural modulus, MPa (pounds per square inch): 80,000 minimum.
        4) Tensile strength at yield (pounds per square inch): 3,000 minimum.
        5) Environmental stress crack resistance condition B, F_{10}: 96 hours minimum.
        6) Brittleness temperature: -75 degrees Celsius.
    d. Size: 1.25 inch.
    e. Colors: orange, gray, white.
3. Fabric inner duct:
    a. White polyester and nylon resin polymer textile.

b. Standard outdoor textile inner duct:
    1) 3-inch multi-cell inner duct containing pull tape in each cell.
c. Color-coded.
d. Pull tape:
    1) 1,250 pound.
    2) Synthetic fiber polyester, flat woven.
    3) Printed sequential footage marks.

F. Conduit bodies:
1. Material consistent with conduit type:
    a. Malleable iron bodies and covers when used with Type GRC.
    b. PVC bodies and covers when used with Type PVC.
    c. PVC-coated malleable iron bodies and covers when used with Type PCS.
2. Conduit bodies to conform to Form 8, Mark 9, or Mogul design:
    a. Mogul design conforming to NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire-bending space.
3. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

2.08 ACCESSORIES

A. Connectors and fittings:
1. Manufactured with compatible materials to the corresponding conduit.

B. Insulated throat metallic bushings:
1. Construction:
    a. Malleable iron or zinc-plated steel when used with steel conduit.
    b. Positive metallic conduit end stop.
    c. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
    d. Use fully insulated bushings on nonmetallic conduit system made of high-impact 150 degrees Celsius rated non-combustible thermosetting phenolic.

C. Insulated grounding bushings:
1. Construction:
    a. Malleable iron or steel, zinc-plated, with a positive metallic end stop.
    b. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
    c. Tin-plated copper grounding saddle for use with copper or aluminum conductors.

D. Electrical unions (Erickson Couplings):
1. Construction:
    a. Malleable iron for use with steel conduit.
    b. PVC-coated malleable iron for use with PCS conduit.
    c. Concrete tight, 3-piece construction.

E. SLT fittings:
1. Construction:
    a. Malleable iron.
    b. Furnished with locknut and sealing ring.

c. Liquidtight, raintight, oiltight.
d. Insulated throat.
e. Furnish as straight, 45-degree elbows, and 90-degree elbows.
f. Designed to prevent sleeving:
    1) Verify complete bonding of the raceway jacket to the plastic gasket seal.
g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device, if inserted into raceway and directly in contact with conductors, shall have rolled-over edges for sizes under 5 inches.
h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture-resistant/oil-resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.

2. Corrosion-resistant and outdoor SLT fittings:
    a. Construction:
        1) PVC-coated liquidtight fittings with a bonded 0.040-inch thick PVC coating on the metal connector to form a seal around the SLT conduit.
        2) Insulated throat and an integral sealing ring.

F. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
1. Construction:
    a. Insulated throat.
    b. PVC-coated when used in corrosive areas.
    c. Bonding locknut.
    d. Recessed neoprene o-ring to ensure watertight and dusttight connector.
    e. 1/2-inch through 1-1/4-inch steel zinc electroplated.
    f. 1-1/2-inch through 6-inch malleable iron zinc plated.
2. Usage:
    a. All conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.

G. Sealing fittings:
1. Construction:
    a. 40-percent wire fill capacity.
    b. PVC-coated when used in corrosive areas.
    c. Malleable ductile iron with steel conduit.
    d. Aluminum with aluminum conduit.
    e. Type EYDX where drains are required.
    f. Type EYSX where drains are not required.
2. Sealing compound:
    a. Fiber filler and cement as recommended by the sealing fitting manufacturer.
    b. Approved for the conditions and use.
        1) Not affected by surrounding atmosphere or liquids.
    c. Melting point shall be 200 degrees Fahrenheit minimum.

H. PVC fittings:
   1. Materials:
      a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.
      b. All metal hardware shall be stainless steel.

I. Through wall and floor seals:
   1. Materials:
      a. Body: Casting of malleable or ductile iron with a hot-dip galvanized finish.
      a. Grommet: Neoprene.
      b. Pressure rings: PVC-coated steel.
      c. Disc material: PVC-coated steel.

J. Expansion/deflection couplings:
   1. Use to compensate for movement in any directions between 2 conduit ends where they connect.
   2. Shall allow movement of 3/4 inch from the normal in all directions.
   3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
   4. Constructed to maintain electrical continuity of the conduit system.
   5. Materials:
      a. End couplings: Bronze or galvanized ductile iron.
      a. Sleeve: Neoprene.
      b. Bands: Stainless steel.
      c. Bonding jumper: Tinned copper braid.

K. Expansion couplings:
   1. Shall allow for expansion and contraction of conduit:
      a. Permitting 8-inch movement, 4 inches in either direction.
   2. Constructed to maintain electrical continuity of the conduit system.
   3. Materials:
      a. Head: Malleable or ductile iron.
      a. Sleeve: Steel.
      b. Insulating bushing: Phenolic.
      c. Finish: Hot-dip galvanized.
      d. PVC-coated steel when used with Type PCS.

L. Inner duct couplings and fittings:
   1. HDPE inner duct:
      a. Couplings:
         1) Self-threading.
         2) Nonmetallic.
      b. Fittings:
         1) Multi-access fitting:
            a) 3-hole.
            b) Sized for conduit containing inner duct.
         2) Duct plugs:
            a) Sized for inner duct diameter.
            b) Install in both ends of all unused ducts.
         3) Split plugs:
            a) Sized for inner duct and cable diameters.
            b) Install at both ends of all utilized ducts.

2. Fabric inner duct:
    a. Termination bags:
        1) Inflation-type bags for sealing and securing around one or more textile inner ducts and cables within 2-inch outside diameter or larger conduit.

M. Conduit markers:
    1. As specified in Section 16075 - Identification for Electrical Systems.

2.09 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. General:
    1. Conduit routing:
        a. The electrical drawings are diagrammatic in nature:
            1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
            2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
                a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
                b) Make changes in conduit routing due to the relocation of equipment.
            3) The electrical drawings do not indicate all required junction boxes and pull boxes:
                a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
                    (1) To meet cable manufacturer’s pulling tension requirements.
                    (2) To limit total conduit bends between pull locations.
                b) Install junction boxes and pull boxes at locations acceptable to the Engineer.

b. The Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
    1) The Engineer is the sole source in determining whether the change is constituted as a deviation:
    2) Perform any changes resulting in additional conduits, or extra work from such deviations.
    3) Incorporate any deviations on the Record Documents.

2. Use only tools recommended by the conduit manufacturer for assembling the conduit system.
3. Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:
    a. Clearance of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
    b. Clearance of 12 inches from surfaces greater than 149 degrees Fahrenheit.
    c. Keep conduits at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings, and 12 inches from fuel lines and gas lines.
    d. Where it is necessary to route conduits close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
    a. Do not run conduits within water-bearing walls unless otherwise indicated on the Drawings.
5. Do not install 1-inch or larger conduits in or through structural members unless approved by the Engineer.
6. Run conduits exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
    a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
    b. Make changes in direction with long radius bends or with conduit bodies.
7. Install conduits with total conduit bends between pull locations less than or equal to 270 degrees.
8. Route all exposed conduits to preserve headroom, access space and work space, and to prevent tripping hazards and clearance problems:
    a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment-removal hatches.
    b. Route conduits to avoid drains or other gravity lines. Where conflicts occur, relocate the conduit as required.
9. Conduits may be run in concrete members or slabs with permission of the Engineer or as indicated on the Drawings:
    a. Refer to the typical details for conduit spacing and size requirements.
10. When installing conduits through existing slabs or walls, make provisions for locating any possible conflicting items where the conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into the existing conduits, piping, cables, post-tensioning cables, etc.
11. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
12. Install conduits through wall and floor seals where indicated on the Drawings.

13. For existing and new 2-inch and larger conduit runs, snake conduits with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit:
    a. Remove and replace conduits through which mandrel will not pass.
14. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
15. Install complete conduit systems before conductors are installed.
16. Provide metallic conduits terminating in transformer, switchgear, motor control center, or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
17. Underground conduits:
    a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
        1) As specified in Section 16133 - Duct Banks.
    b. Make underground conduit size transitions at handholes and manholes.
    c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.
    d. Seal around conduit penetrations of below grade walls with a mechanical seal.

C. Lighting and receptacle conduits:
1. Provide conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings:
2. Install conduits in accordance with the requirements of this Section unless otherwise indicated.
3. Minimum conduit size:
    a. 3/4-inch for exposed conduits.
    b. 1-inch for underground or in-slab conduits.
4. Provide conduit materials for the installed location as specified in Section 16050 - Common Work Results for Electrical.

D. Conduit usage:
1. Exposed conduits:
    a. Rigid conduit:
        1) Install the rigid conduit type for each location as specified in Section 16050 - Common Work Results for Electrical.
        2) Minimum size: 3/4-inch.
    b. Flexible conduit:
        1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment, or where required for equipment servicing:
            a) Use Type SLT with rigid metallic conduit.
        2) Minimum size: 3/4-inch:
            a) 1/2 when required for connection to instruments.
        3) Maximum length:
            a) Fixed equipment:

Conduit Trade Size	Flexible Conduit Length (inch)
3/4	18
1	18
1-1/4	18
1-1/2	18
2	36
2-1/2	36
3	36
3-1/2	38
4	40

b) Removable instruments or hinged equipment:
(1) As required to allow complete removal or full movement without disconnecting or stressing the conduit.

2. Concrete-encased and embedded conduits:
   a. Straight runs and bends less than 45 degrees:
      1) Type PVC Schedule 40.
   b. Bends with total deflection greater than 45 degrees:
      1) PCS.
   c. Entering and exiting duct bank, underground or embedded conduit runs a minimum 12 inches above and below grade, finished floor, or entering equipment:
      1) PCS.
   d. Minimum size:
      1) 2-inch in duct banks.
      2) 1-inch for in-slab conduits.
      3) Provide conduit fittings to enlarge the conduit from the exposed size in the conduit schedule as required.
3. Direct-buried and sand-bedded duct bank conduits:
   a. Type PCS.
   b. Minimum size: 1-inch.
4. Below-slab conduits:
   a. Type PCS.
   b. Minimum size: 1-inch.
5. PVC-coated rigid metallic conduit:
   a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket. Repair damage to PVC coatings with manufacturer supplied touchup compound or PVC Coating Repair Kit for PVC Coated Raceway Systems.
6. Inner duct (applicable for fiber optic cable only):
   a. Install inner duct in PVC conduit for all fiber conduits.
   b. Each inner duct conduit shall be a separate color.

E. Conduit joints and bends:
   1. General:
      a. Where conduit is underground, under slabs on grade, exposed to the weather, or in NEMA Type 4 or NEMA Type 4X locations, make joints liquidtight.
      b. Keep bends and offsets in conduit runs to an absolute minimum.
      c. All bends shall be symmetrical.
      d. For all types of high-voltage conductors, provide bends as required for lead-covered conductors of equivalent outside diameter.
      e. The following conduit systems shall use large-radius sweep elbows:
         1) Underground conduits.
         2) Conduits containing medium-voltage cables.
         3) Conduits containing fiber optic cables.
      f. Provide large-radius factory-made bends for 1-1/4-inch trade size or larger.
      g. Make field bends with a radius of not less than the requirements found in the NEC:
         1) The minimum bending radius of the cable must be less than the radius of the conduit bend.
         2) Make all field bends with power bending equipment or manual benders specifically intended for the purpose:
            a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
            b) For the serving utilities, make bends to meet their requirements.
      h. Replace all deformed, flattened, or kinked conduit.
   2. Threaded conduit:
      a. Cut threads on rigid metallic conduit with a standard conduit-cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench-tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
      b. Thoroughly ream conduit after threads have been cut to remove burrs.
      c. Use bushings or conduit fittings at conduit terminations.
      d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing “Galvabar™,” or CRC “Zinc It.”
      e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
         1) Apply to the male threads and tighten joints securely.
         2) Clean excess sealant from exposed threads after assembly.
      f. Securely tighten all threaded connections.
      g. Any exposed threaded surfaces must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.
   3. PVC:
      a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray-type cement is not allowed.
      b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to ensure full inside diameter at all bends:
         1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

F. Conduit sealing and drainage:
   1. Conduit drainage and sealing other than required for hazardous and classified areas:
      a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above-grade conduit runs at the points at which the conduit enters buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
      b. Provide seal fittings with drains in vertical drops directly above grade for exterior and above-grade conduit runs that are extended below grade.
      c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
         1) Where portions of an interior raceway pass through walls, ceilings, or floors that separate adjacent areas having widely different temperatures.
      d. Provide conduit seals similar to O-Z/Gedney (Type CSM) on all conduits between corrosive and non-corrosive areas.
      e. Seal one end only of all underground conduits at highest point with O-Z/Gedney sealing (non-hazardous) filling, or equal.
   2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: control panels, junction boxes, pullboxes, or low points of the conduit.

G. Conduit supports:
   1. General:
      a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
         1) As specified in Section 16070 - Hangers and Supports.
         2) Provide support materials consistent with the type of conduit being installed as specified in Section 16050 - Common Work Results for Electrical.
      b. Support conduit at the intervals required by the NEC.
      c. Perforated strap and plumbers tape are not acceptable for conduit supports.
   2. Conduit on concrete or masonry:
      a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
      b. Use preset inserts in concrete when possible.
      c. Use pipe spacers (clamp backs) in wet locations.
      d. On plaster or stucco, use 1-hole malleable iron straps with toggle bolts.
   3. Conduit on metal decking:
      a. Use 1-hole malleable iron straps with 1-inch long cadmium-plated Type A panhead sheet-metal screws. Fully or partially hammer-driven screws are not acceptable.
   4. Suspended conduit:
      a. Use malleable-iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.
      b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2-feet long, provide rigid sway bracing.

5. Supports at structural steel members:
    a. Use beam clamps.
    b. Drilling or welding may be used only as specified or with approval of the Engineer.
6. PVC-coated rigid metal systems:
    a. Provide right-angle beam clamps and “U” bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide "U" bolts with PVC-encapsulated nuts that cover the exposed portions of the threads.
    b. Securely fasten exposed conduits with Type 316 stainless steel clamps or straps.

H. Expansion or expansion/deflection fittings:
1. General:
    a. Align expansion coupling with the conduit run to prevent binding.
    b. Follow manufacturer’s instructions to set the piston opening.
    c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
    d. Furnish fittings of the same material as the conduit system.
2. For metallic conduit, provide expansion or expansion/deflection couplings, as appropriate, where:
    a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.

I. Empty conduits:
1. Provide a polyethylene rope rated at 250 pounds tensile strength in each empty conduit more than 10 feet in length.
2. Seal ends of all conduits with approved, manufactured conduit seals, caps, or plugs immediately after installation:
    a. Keep ends sealed until immediately before pulling conductors.

J. Miscellaneous:
1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer’s instructions and as indicated on the Drawings.
2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
    a. Running threads and threadless couplings are not allowed.
3. Replace any conduits installed that the Engineer determines do not meet the requirements of this Specification.
4. Provide conduit housekeeping curb around all embedded or below-grade conduits exiting or entering the slab, per the Typical Details.

3.04 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16133

DUCT BANKS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Electrical underground duct banks.
   2. Duct bank installation requirements.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Provide trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.

B. Provide reinforced concrete duct banks for all conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. PVC conduit spacers.
   2. Detectable underground marking tape.
   3. Pull line.

C. Shop drawings:
   1. Submit site plan drawings of duct banks including underground profiles indicating all underground utilities.
   2. For duct bank routings crossing under building footers or foundations alternative to designed routings indicated on the Drawings:
      a. Submit shop drawings detailing the new building footer crossing locations and plan drawings labeling all equipment to be installed on top of the new routing for approval by the project Structural Engineer.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Field conditions and related requirements:
   1. Underground water table may be near or above the location of new duct banks.
   2. Include cost for necessary dewatering, and cleaning equipment to perform work in underground duct banks, pullboxes and manholes, before installation.

1.09 SCHEDULING (NOT USED)

1.10 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.11 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Conduit spacers:
   1. One of the following or equal:
      a. Carlon Snap-Loc.
      b. Cantex.
      c. Osburn Associates, Inc.

B. Detectable underground marking tape:
   1. One of the following or equal:
      a. Blackburn Manufacturing Co.
      b. Pro-Line Safety Products.
      c. Panduit.

C. Pull line:
   1. One of the following or equal:
      a. Arnco.
      b. Greenlee.
      c. Osburn Associates, Inc.

D. Duct seal:
    1. The following or equal:
        a. OZ Gedney type DUX.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Provide conduit as specified in Section 16130 – Conduits:

B. B. Provide minimum Number 4 reinforcing steel.

2.04 MANUFACTURED UNITS

A. Conduit spacers:
    1. Provide conduit spacers recommended by the conduit manufacturer or specified above.
    2. Saddle type.
    3. Non-metallic, non-corrosive, non-conductive.
    4. Interlocking type:
        a. Vertical interlocking.
        b. Horizontal interlocking.
    5. Suitable for concrete encasement.
    6. Molded-in rebar holder.
    7. Accommodates 2-inch through 6-inch conduit sizes.
    8. Relieves the conduit from both horizontal and vertical stresses.

B. Pull line:
    1. Minimum 1/4-inch wide, flat design.
    2. Polyester.
    3. Minimum pulling strength 1,200 pounds.

C. Detectable marking tape:
    1. Provide a detectable tape, locatable by a cable or metal detector from above the undisturbed grade.
    2. Aluminum core laminated between polyethylene film.
    3. 6-inch wide red tape imprinted with black lettering stating "CAUTION - BURIED ELECTRIC LINE BELOW" or equivalent.

D. Duct seal:
    1. Non-hardening sealing compound.
    2. Flexible, can be applied by hand.
    3. UL Listed for use with installed conductors.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES

A. Concrete mix requirements as specified in Section 03301 – Concrete Work.

B. Provide a red-oxide conduit encasement coloring agent as specified in Section 03301 – Concrete Work.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Duct banks:
   1. Install duct banks encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
   2. Damage minimization:
      a. Conduit should not be left exposed in an open trench longer than is necessary.
      b. Protect all underground duct banks against damage during pouring of concrete or backfilling.
   3. All plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
   4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system at each end of the duct bank.
   5. Install underground ducts to be self-draining:
      a. Slope duct banks away from buildings to manholes, handholes, or pullboxes.
      b. Slope duct banks uniformly from manholes, handholes, or pullboxes to manholes, handholes, or pullboxes or both ways from high points between manholes, handholes, or pullboxes.
      c. Slope a minimum of 1/4 inch per 10 feet.
   6. Where new duct banks join to existing manholes, handholes, or pullboxes, make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.
   7. Install pull line in spare conduits:
      a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
      b. Cap above ground spare conduit risers at each end with screw-on conduit caps.

C. Trenching:
   1. Perform trenching as specified in Section 02318 - Trenching.
   2. Trench must be uniformly graded with the bottom, rock free and covered with select material.

3. Whenever possible, use the walls of the trench as forms for concrete encasement:
    a. Forms are required where the soil is not self-supporting.
4. Avoid damaging existing ducts, conduits, cables, and other utilities.

D. Duct spacing:
1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 2 inches, unless otherwise indicated on the Drawings:
    a. Separate medium voltage ducts a minimum of 7.5 inches on center.
2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
    a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
        1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
            a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
3. Spacers shall not be located at the center of a bend:
    a. Locate spacer in the tangent, free of the coupling on fabricated bends.
    b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.

E. Terminating:
1. Use bell ends in duct at entrances into cable vaults.
2. Make conduit entrances into cable vaults tangential to walls of cable vault.
3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
4. Install duct seal in all conduits including spare conduits, at building/equipment stub-ups. Form by hand to conduit and around cables to develop moisture barrier.
5. New manhole or handhole applications, provide a single opening or “window” per duct bank, sized to accommodate the duct bank envelope.

F. Concrete:
1. Install concrete as specified in Section 03301 – Concrete Work.
2. Provide tie wires to prevent displacement of the conduits during pouring of concrete:
    a. Tie wire shall not act as a substitute for spacers.
3. Install minimum 3-inch cover around conduit and rebar.
4. Consolidation of encasement concrete around duct banks shall be by hand puddling. Mechanical vibrators are acceptable for use outside of the rebar cage.
5. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.

G. Marking tape:
1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

H. For conduit installations beneath building slabs:
   1. Duct banks shall be continued under building slabs to the final destination of the conduits.
      a. Construct separate duct banks as required.
      b. Concrete for encasement under building slabs need not be colored red.
      c. For duct banks crossing under building footers or foundations, install the top of the duct bank a minimum of 6 inches below the footer.
      d. Where duct banks enter through building walls, foundation walls, stem walls, etc. make connections as indicated on the Drawings.
      e. Where duct banks terminate with conduit risers entering building walls, install an expansion/deflection fitting or a flat-wise elbow (elbow parallel to building wall) in order to accommodate differential movement between the conduits and structure.

I. Restore all surfaces to their original condition as specified in Section 02952 - Pavement Restoration and Rehabilitation, unless otherwise specified.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Provide shoring and pumping to protect the excavation and safety of workers.

C. Protect excavations with barricades as required by applicable safety regulations.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16134

BOXES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Device boxes.
   2. Raceway system boxes.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

C. ASTM International (ASTM):
   1. A47 - Standard Specification for Ferritic Malleable Iron Castings.
   2. D149 - Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
   3. D495 - Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
   4. D570 - Standard Test Method for Water Absorption of Plastics.
   5. D648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
   6. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
   7. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

D. Joint Industry Conference (JIC).

E. Underwriters Laboratories, Inc. (UL):
   1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions:
   1. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
   2. Raceway system boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.

1.04 SYSTEM DESCRIPTION

A. Provide outlet boxes for devices such as switches, receptacles, telephone and computer jacks, security systems, junction, and pullboxes for use in the raceway systems, etc.

B. Provide boxes as indicated on the Drawings or as needed to complete the raceway installation.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Manufacturer.
   2. Materials.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
      d. Weight.
      e. NEMA rating.
   4. Conduit entry locations.
   5. Catalog cutsheets.
   6. Installation instructions.

C. Shop drawings:
   1. Include identification and sizes of pullboxes.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Regulatory requirements:
   1. Outlet boxes shall comply with all applicable standards of:
      a. JIC.
      b. NEC.
      c. NEMA.
      d. UL.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Plastic coated boxes:
      a. Rob Roy.
      b. OCAL.
   2. Cast device boxes:
      a. Appleton.
      b. Crouse - Hinds.
      c. OZ/Gedney.
   3. Formed steel enclosures:
      a. Hoffman.
      b. Thomas and Betts.
      c. Stahlin.
      d. Rittal.
   4. Stainless steel enclosures:
      a. Hoffman.
      b. Stahlin.
      c. Rittal.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Cast device boxes:
   1. Construction:
      a. With internal green ground screw.
      b. Furnished with a suitable gasketed cover.
      c. With integral cast mounting lugs when surface mounted.
      d. Conduit sizes range from 3/4 inch to 1 inch.
      e. Tapered threaded hubs with integral bushing.
   2. Malleable iron boxes:
      a. Conforming to ASTM A47 Grade 32510.

B. Plastic coated cast device boxes:
   1. Construction:
      a. With internal green ground screw.
      b. Furnished with a suitable gasketed cover.
      c. With integral cast mounting lugs when surface mounted.
      d. Conduit sizes range from 3/4 inch to 1 inch.
      e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
      f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
      g. With pressure sealing sleeve to protect the connection with conduit.

C. Formed steel enclosures:
   1. Steel:
      a. NEMA Type 12.
      b. Fabricated from 14-gauge steel, minimum.
      c. All seams continuously welded ground smooth.
      d. Door:
         1) Rolled lip around 3 sides.
         2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
      e. Neoprene door gasket to provide a watertight, dusttight, oiltight seal:
         1) Attached with an adhesive.
         2) Retained by a retaining strip.
      f. Fabricate all external removable hardware for clamping the door to the enclosure body from zinc-plated heavy gauge steel:
         1) With a hasp and staple for padlocking.
      g. Provide large enclosures with door and body stiffeners for extra rigidity.
      h. No holes or knockouts.
      i. Finish:
         1) ANSI-61 gray electrostatically applied polyester powder inside and out over cleaned and primed surfaces.
         2) White electrostatically applied polyester powder mounting plate.
      j. Heavy gauge steel external mounting brackets when surface mounted.
   2. Stainless steel:
      a. NEMA Type 4X:
         1) Boxes in locations subject to flooding or temporary submersion:
            a) NEMA Type 6.
      b. Fabricated from 14-gauge Type 316 stainless steel.
      c. All seams continuously welded.
      d. Door:
         1) Rolled lip around 3 sides.
         2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
      e. Neoprene door gasket to provide a watertight seal:
         1) Attached with an adhesive.
         2) Retained by a retaining strip.
      f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
         1) With a hasp and staple for padlocking.
      g. Provide large enclosures with door and body stiffeners for extra rigidity.
      h. No holes or knockouts.

i. Finish:
1) Brushed.
j. Stainless steel external mounting brackets when surface mounted.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Fasteners:
1. Electroplated or stainless steel in boxes with wiring devices.
2. Screws, nuts, bolts, and other threaded fasteners:
a. Stainless steel.

B. Provide breather and drain fittings where appropriate.

C. Internal panels:
1. Provide internal panels where required for mounting of terminal strips or other equipment.
2. With plated steel shoulder studs.
3. Steel with white polyester powder finish.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. General:
1. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 16050 - Common Work Results for Electrical.
2. Provide outlet box materials to match the conduit system:
a. GRC - Cast ferrous boxes.
b. PCS - PVC coated cast ferrous boxes.
3. Solid type gang boxes:
a. For more than 2 devices.
b. For barriered outlets.

4. Support all wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
    a. Use machined spacers to maintain air space; built-up washers are not acceptable.
    b. Use stainless steel or nylon materials for spacers.
5. Use cast malleable iron boxes when box must support other devices.
6. Boxes serving luminaires or wiring devices:
    a. Use as pullboxes wherever possible.
7. Fit all cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
8. In terminal boxes, furnish terminals as indicated on the Drawings, with a minimum of 50 percent spare terminals:
    a. Furnish wireways for discrete and analog/DC wiring.
    b. Separate analog wiring from 120 V discrete or power wiring.
9. Size boxes in accordance with NEC requirements and to provide sufficient room for the future components and cables indicated on the Drawings.

C. Outlet boxes:
1. Locate outlet boxes as indicated on the Drawings:
    a. Adjust locations so as not to conflict with structural requirements or other trades.
2. Use deep threaded-hub malleable iron or aluminum boxes:
    a. In hazardous areas.
    b. Where exposed to the weather.
    c. In unheated areas.
    d. Where subject to mechanical damage:
        1) Defined as exposed boxes less than 10 feet above the floor.
    e. To act as a pullbox for conductors in a conduit system.
    f. Accommodate wiring devices.
3. Use deep threaded-hub plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the exposed conduit system is PVC coated steel.
4. Outlet boxes may be used as junction boxes wherever possible.

D. Pullboxes and junction boxes:
1. Size pullboxes in accordance with NEC requirements and to provide sufficient room for any future conduits and cables as indicated on the Drawings.
2. Install pullboxes such that access to them is not restricted.

E. For boxes not indicated:
1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 16050 - Common Work Results for Electrical.
2. Outlet, switch, and junction boxes for flush-mounting in general purpose locations:
    a. One-piece, galvanized, pressed steel.
3. Ceiling boxes for flush mounting in concrete:
    a. Deep, galvanized, pressed steel.
4. Outlet, switch, and junction boxes where surface mounted in exposed locations:
    a. Cast ferrous boxes with mounting lugs, zinc or cadmium plating finish.

5. Outlet, control station, and junction boxes for installation in corrosive locations:
   a. Plastic coated steel to match the conduit system.
   b. Furnished with mounting lugs.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16140

WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Switches.
   2. Receptacles.
   3. Plates.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Federal Specifications (FS):
   1. W-C 596 - Connector, Electrical, Power, General Specification.
   2. W-S 896/2 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).

C. National Electrical Manufacturers Association (NEMA):
   1. WD1 - General Color Requirements for Wiring Devices.
   2. ICS 5 - Industrial Control and Systems, Control Circuit and Pilot Devices.
   3. OS1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
   4. WD6 - Wiring Devices Dimensional Specifications.

D. Telecommunications Industry Association:
   1. T568A - Eight-position jack pin/pair assignment.
   2. T568B - Optional eight-position jack pin/pair assignment.

E. Underwriters Laboratories, Inc. (UL):
   1. 20 - General Use Snap Switches.
   2. 498 - Standard for Attachment Plugs and Receptacles.
   3. 514D - Cover Plates for Flush-Mounted Wiring Devices.
   4. 943 - Ground-Fault Circuit-Interrupters.
   5. 1472 - Solid State Dimming Controls.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions:
   1. GFCI: Ground fault circuit interrupter.

1.04 SYSTEM DESCRIPTION

A. Switches, receptacles, and plates as indicated on the Drawings wired and operable to form a complete system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Catalog cutsheets.

C. Shop drawings:
   1. Engraving schedule:
      a. Furnish complete engraving schedule for engraved nameplates.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Wiring devices shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Switches:
   1. One of the following or equal:
      a. Hubbell.
      b. Leviton.
      c. Cooper Wiring Devices.

2. Dimmer switches:
    a. One of the following or equal:
        1) Lutron.
        2) Cooper Wiring Devices.

B. Receptacles:
1. General purpose receptacles:
    a. One of the following or equal:
        1) Hubbell.
        2) Leviton.
        3) Cooper Wiring Devices.

C. Plates:
1. General location:
    a. One of the following or equal:
        1) Legrand.
        2) Cooper Wiring Devices.
2. Wet or corrosive areas:
    a. One of the following or equal:
        1) Hubbell.
        2) Cooper Wiring Devices.
        3) Thomas and Betts.
        4) Pass and Seymour.
3. In-use covers:
    a. One of the following or equal:
        1) TayMac.
        2) Cooper Wiring Devices.
        3) Pass and Seymour.
        4) Thomas and Betts.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Switches:
1. General:
    a. 120-277 VAC.
    b. 20 ampere.
    c. Listed in accordance with UL 20.
    d. Designed and constructed in accordance with FS W-S-896/2.
    e. Back and side wired unless otherwise indicated.
    f. Integral grounding terminal.
    g. Totally enclosed:
        1) Color-coded body with color corresponding to ampere rating.
    h. Provide switches with the operator style and contact arrangement as indicated on the Drawings and as required for proper operation.
    i. Color:
        1) Ivory in finished areas.
        2) Brown in all other areas.

2. General purpose switches:
    a. Toggle type.
3. Dimmer switches:
    a. Shall be rectangular design with LED light level indicators.
    b. Suitable for use with type of lamp switched.

B. Receptacles:
1. General purpose receptacles:
    a. Single or duplex as indicated on the Drawings.
    b. 125 VAC.
    c. 20 ampere or as indicated on the Drawings.
    d. NEMA Type 5-20R configuration for 20 ampere receptacles.
    e. Other NEMA configurations as indicated on the Drawings.
    f. Listed in accordance with UL 498.
    g. Designed and constructed in accordance with FS W-C-596.
    h. Back and side wired.
    i. 1-piece, rivet-less mounting strap.
    j. Color:
        1) Ivory in finished areas.
        2) Brown in all other areas.
        3) Orange when powered by a UPS.
2. Ground fault interrupter receptacles (GFCI):
    a. 125 VAC.
    b. 20 ampere.
    c. Trip level 4-6 milliamperes.
    d. Individual and feed through protection.
    e. UL 943 and UL 498 listed.
    f. NEMA Type 5-20R configuration.
    g. For damp or wet locations:
        1) Weather resistant, in accordance with UL 498.

C. Plates:
1. General location:
    a. Type 302 or 304 stainless steel.
    b. Brushed satin finish.
    c. Minimum thickness: 0.032 inches.
    d. Rectangular or square shape.
    e. Engraving:
        1) Engrave each switch plate with the following:
            a) Area served.
            b) Panelboard and Circuit.
        2) Engrave each receptacle plate with the following:
            a) Panelboard and Circuit.
        3) Treat engraving to improve visibility.
        4) Characters shall be block letter pantograph engraved with a minimum character height of 1/8-inch.
    f. Coordinate the number of gangs, number, and type of openings with the specific location.
2. Outdoor and wet areas requiring NEMA Type 4 or NEMA Type 4X enclosures:
    a. General:
        1) UL listed for wet locations.
        2) Gasketed.

3) Die cast metal:
a) Match material to box material.
b. Switches:
1) Lever operated:
a) Provide toggle switch.
c. Receptacles:
1) Weather proof in-use cover:
a) Die cast metal construction with electrostatic powder coating for corrosion resistance.
b) Gasketed.
c) Lockable.
d) UL listed and in accordance with NEC.
3. Corrosive areas:
a. Neoprene.
b. Gasketed.
c. Weatherproof.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Mounting heights:
1. Process and production areas:
a. Switches and receptacles 48 inches from finished floor to top of plate.
2. Offices and finished areas:
a. Switches: 48 inches from finished floor to top of plate.
b. Receptacles: 18 inches from finished floor to center of plate.

C. Receptacles:
1. Provide GFCI receptacles as indicated on the Drawings:
a. Provide weather resistant GFCI receptacles in all wet or damp areas:
1) As specified in Section 16050 - Common Work Results for Electrical.

2. Mount non-weatherproof receptacles vertically:
   a. Ground slot down.
3. Mount weatherproof receptacles horizontally:
   a. Neutral slot up.
4. 3-phase receptacles shall be consistent with respect to phase connection at the receptacle terminals. Correct errors in phasing at the source and not the receptacle.

D. Ensure all plates make a firm seal with wall for recessed mounted devices:
   1. Outside edges of plates parallel with building lines.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16150

LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Wire connecting devices.
   2. Terminations.
   3. Splices.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. ASTM International (ASTM):
   1. D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.

C. CSA International (CSA):
   1. C22.2 - No.197-M1983 (R2208) - PVC Insulating Tape.

D. Underwriters Laboratories, Inc. (UL):
   1. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Provide a complete system of wiring connectors, terminators, fittings, etc. for a complete wiring system suitable for the cables and conductors used.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Catalog cutsheets.
   2. Installation instructions.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. All materials shall be UL listed.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Control connections:
   1. Use insulated ring type wire terminators for connections to all screw terminals:
      a. With chamfered/funneled terminal barrel entry.
      b. Deep internal serrations.
      c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
      d. Electroplated-tin copper conductor.
      e. Manufacturers: The following or equal:
         1) Thomas and Betts, Stakon.
   2. For process equipment connections work from manufacturer's drawings.

B. Joints, splices, taps, and connections:
   1. 600-volt conductors:
      a. Use solderless connectors.
      b. Use only plated copper alloy connectors or lugs:
         1) Aluminum connectors or lugs are not acceptable for copper conductors.
      c. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.
      d. For wire Number 10 AWG and smaller use compression splice caps, with insulating caps:
         1) Manufacturers: The following or equal:
            a) Buchanan, 2006S or 2011S, with 2007 or 2014 insulating caps.
      e. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
         1) Manufacturers: One of the following or equal:
            a) Burndy.
            b) Thomas and Betts.
      f. Heat shrink tubing:
         1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
         2) Minimum shrink ratio: 4 to 1.
         3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
         4) Internally applied adhesive sealant.
         5) Cross-linked polyolefin:
            a) Manufacturers: One of the following or equal:
               (1) 3M, ITCSN.
               (2) Thomas & Betts, Shrink-Kon.
   2. Instrumentation class cable splices:
      a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
      b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
      c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
      d. Two-part mold body with tongue and groove seams and built in spacer webbing.
      e. Manufacturers: The following or equal:
         1) 3M, Scotchcast 72-N.

C. Insulating tape:
   1. General purpose insulating tape:
      a. Minimum 7 mil vinyl tape.
      b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
      c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
      d. Flame retardant, hot- and cold- weather resistant, UV resistant.
      e. For use as a primary insulation for wire cable splices up to 600 VAC.
      f. Meeting and complying with:
         1) ASTM D3005 Type I.
         2) UL 510.
         3) CSA C22.2.

g. Manufacturers: The following or equal:
    1) 3M, Scotch Number Super 33+.

2. General-purpose color-coding tape:
    a. Minimum 7 mil vinyl tape.
    b. Suitable for application on PVC and polyethylene jacketed cables.
    c. For use indoors and outdoors in weather protected enclosures.
    d. Available with the following colors:
        1) Red.
        2) Yellow.
        3) Blue.
        4) Brown.
        5) Gray.
        6) White.
        7) Green.
        8) Orange.
        9) Violet.
    e. For use as phase identification, marking, insulating, and harnessing.
    f. Meeting and complying with:
        1) UL 510.
        2) CSA C22.2.
    g. Manufacturers: The following or equal:
        1) 3M, Scotch Number 35.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Load connections:
    1. Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 16123 - 600-Volt or Less Wires and Cables.

C. Zero to 600-volt systems:
    1. Make all connections with the proper tool and die as specified by the device manufacturer.

2. Use only tooling and dies manufactured by the device manufacturer.
3. Insulate all connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
4. Number all power and control wires before termination.

D. Motor connections (600 volts and below):
1. Terminate all leads and wires with compression type ring lugs.
2. Terminations on all motor leads, including leads that are connected together to accommodate the motor voltage, and the machine wires entering the motor terminal box from the power source, shall have ring type compression lugs.
3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
   a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
   b. Shrink cap with low heat as recommended by manufacturer.
4. Wire markers shall be readable after boot installation.
5. Manufacturers: The following or equal:
   a. Raychem, MCK.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16151

MEDIUM VOLTAGE CABLE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Terminations.
   2. Splices.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 48 - IEEE Standard for Test Procedures and Requirements for Alternating -Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 KV.
   2. 386 - Standard for Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5kV through 35kV.
   3. 404 - IEEE Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2.5 kV to 500 kV.

C. Underwriters Laboratories, Inc. (UL).

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Provide a complete system of cables connectors, terminators, fittings, etc. for a complete cabling system suitable for the cables and conductors used.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Catalog cutsheets.
   2. Installation instructions.
   3. Medium voltage systems:
      a. Documentation demonstrating compliance with the required tests.
      b. Characteristics and installation procedures for all splices, terminators, and junction modules.

C. Shop drawings:
   1. Drawings showing the installation of junction modules, splices, and terminators.

D. Operation and maintenance manuals:
   1. Drawings and data for medium voltage cable connectors, splices, and junction modules.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. All materials shall be UL listed.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Tape:
   1. Fire and electric arc proofing tape:
      a. Minimum 30-mil, flexible, elastomer tape that expands in fire to form an insulating firewall between flame and cable.
      b. Bind in place with glass cloth electrical tape.
      c. Manufacturers: The following or equal:
         1) 3M, Scotch Number 77.
   2. Glass cloth electrical tape:
      a. Thermosetting, 7.4-mil silicone adhesive that performs at Class H temperatures 180 degrees Celsius (356 degrees Fahrenheit).
      b. Use for the following applications:
         1) To secure non-PSA insulations such as glass in high-temperature areas.
         2) Splice wire rated at 150 degrees Celsius, 180 degrees Celsius, and 200 degrees Celsius.
         3) For binding fire and electric arc proofing tape.
      c. Meeting and complying with:
         1) UL recognized component listing for 200 degrees Celsius (Guide OANZ2, File E17385).
      d. Manufacturers: The following or equal:
         1) 3M, Scotch Number 69.
   3. Self-fusing silicone rubber tape:
      a. High-temperature, 12-mil, track resistant, insulating tape.
      b. Composed of fully cured inorganic silicone rubber.
      c. Use as a protective overwrap for terminating medium voltage cables.
      d. Manufacturers: The following or equal:
         1) 3M, Scotch Number 70.

B. Cable splices and terminations:
   1. Splices:
      a. Permanent in-line splice.
      b. Suitable for submersible, direct burial applications.
      c. Electrical requirements:
         1) Continuous current rating equal to cable.
         2) 5 to 8 kilovolts (kV) voltage class:
            a) Maximum voltage phase-ground.
            b) Minimum partial discharge voltage (less than 3 pC) 7 kV.
            c) AC withstand, 1 minute: 23 kV.
            d) AC withstand, 1 hour: 35 kV.
            e) AC withstand, 5 hour: 23 kV.
            f) DC withstand, 15 minutes: 45 kV.
            g) Impulse withstand, 1.2 by 50 microsecond 95 kV (crest).
         3) 15 kV voltage class:
            a) Minimum partial discharge voltage (less than 3 pC): 13 kV.
            b) AC withstand, 1 minute: 35 KV.
            c) AC withstand, 1 hour: 53 kV.
            d) AC withstand, 5 hour: 35 kV.
            e) DC withstand, 15 minutes: 70 kV.
            f) Impulse withstand, 1.2 by 50 microsecond 110 kV (crest).

d. Power cable splices for shielded solid dielectric plastic-insulated cables shall utilize factory engineered kits containing all necessary components to maintain primary cable insulation level and metallic shielding/grounding systems.
e. Splice insulation shall be of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system, a high dielectric strength insulating material, and an integrally bonded outer conductive layer for shielding. The splice shall be covered with a heavy-wall heat-shrinkable sleeve overlapping the cable insulation, with a waterproof mastic seal on both ends.
f. The splice shall accommodate a range of cable sizes and be completely independent of cable manufacturer's tolerances. When assembled on cables the splice shall be capable of passing the electrical test in accordance with:
    1) IEEE 48.
    2) IEEE 404.
g. Manufacturers: The following or equal:
    1) Raychem.

2. Live front terminators:
    a. Terminators for shielded solid dielectric plastic-insulated cables shall utilize factory engineered kits containing all necessary components to terminate the primary cables and shield systems.
    b. All locations exterior of buildings shall be considered outdoors and appropriate heat-shrinkable skirts of a non-tracking material shall be installed.
    c. Terminators shall be of a material that will relieve the voltage stresses at the point of termination.
    d. Non-tracking.
    e. Ultraviolet, ozone, sulfur dioxide resistant.
    f. Terminator insulation shall be of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system.
    g. Electrical requirements:
        1) Continuous current rating equal to cable.
        2) 5 to 8 kV voltage class:
            a) Minimum partial discharge voltage (less than 3 pC) 9 kV.
            b) AC withstand, 1 minute: 35 kV.
            c) DC withstand, 15 minutes: 65 kV.
            d) Impulse withstand, 1.2 by 50 microsecond (outdoor) 95 kV (crest).
            e) Impulse withstand, 1.2 by 50 microsecond (indoor) 80 kV (crest).
            f) Wet withstand, 10 seconds: 30 kV RMS.
            g) Dry withstand, 6 hours: 25 kV RMS.
        3) 15 KV voltage class:
            a) Minimum partial discharge voltage (less than 3 pC) 13 kV.
            b) AC withstand, 1 minute: 50 kV.
            c) DC withstand, 15 minutes: 75 kV.
            d) Impulse withstand, 1.2 by 50 microsecond (outdoor) 110 kV (crest).
            e) Impulse withstand, 1.2 by 50 microsecond (indoor) 95 kV (crest).
            f) Wet withstand, 10 seconds: 45 kV RMS.
            g) Dry withstand, 6 hours: 35 kV RMS.

h. The terminator kit shall accommodate a range of cable sizes and be completely independent of cable manufacturer's tolerances. When assembled on cables the terminator shall be capable of passing the electrical test in accordance with:
    1) IEEE 48.
i. Manufacturers: The following or equal:
    1) Raychem.

3. Dead front terminators (600 Amperes):
    a. Terminators for shielded solid dielectric plastic-insulated cables shall be factory engineered kits containing all necessary components to terminate the primary cables and shield systems.
    b. Modular, pre-molded, fully shielded dead front system.
    c. Submersible.
    d. Capable of mating with any manufacturer's interface in accordance with IEEE 386.
    e. Crimp connector suitable for copper conductors using standard compression tools to join the conductor to the interface.
    f. To be used as an elbow or a "T".
    g. Cable stress relief adapters to connect the cable insulation to the dead front terminator.
    h. Heat shrink seal over the junction between the cable insulation and the terminator body.
    i. Conductor shield shall be grounded near the termination and connected to the conductive shield of the terminator.
    j. Terminator shall be bolted to the bushing or connector plug, with an insulating plug to cover the connection.
    k. Conductive cap covering the insulating plug.
    l. Conductive shield to provide reliable continuity between jacket of cable and connector.
    m. Conductive insert around connector to prevent corona.
    n. With a capacitive test point on the insulating plug to allow circuit testing without disturbing the connection.
    o. Electrical requirements:
        1) Voltage class: 15 kV:
            a) Maximum voltage:
                (1) Phase to Ground: 8.3 KV RMS.
                (2) Phase to Phase: 14.4 KV RMS.
            b) Withstand voltage:
                (1) Impulse (1.2 by 50 microseconds) 95 KV Crest.
                (2) AC 1 minute: 34 KV.
                (3) DC 15 minutes: 53 KV.
            c) Minimum corona extinction level:
                (1) 11 kV RMS.
            d) Continuous current rating:
                (1) 600 amps RMS.
            e) Momentary rating:
                (1) 25,000 amps RMS at .17 seconds.
                (2) 10,000 amps RMS at 3.0 seconds.
    p. Manufacturers: One of the following or equal:
        1) Elastimold.
        2) 3M.
        3) Cooper.

4. Dead front terminators (200 Amperes):
    a. Terminators for shielded solid dielectric plastic-insulated cables shall be factory engineered kits containing all necessary components to terminate the primary cables and shield systems.
    b. Modular, pre-molded, fully shielded dead front system.
    c. Loadbreak type.
    d. Submersible.
    e. Capable of mating with any manufacturer’s interface in accordance with ANSI 386.
    f. Crimp connector suitable for copper conductors using standard compression tools to join the conductor to the interface.
    g. To be used as an elbow or a "T".
    h. Heat shrink seal over the junction between the cable insulation and the terminator body.
    i. Conductor shield shall be grounded near the termination and connected to the conductive shield of the terminator.
    j. Conductive shield to provide reliable continuity between jacket of cable and connector.
    k. Conductive insert around connector to prevent corona.
    l. With a capacitive test point with protective cover to allow circuit testing without disturbing the connection.
    m. With hold-down bail to hold connector to terminal or junction bushing.
    n. Electrical requirements:
        1) Voltage class 15 kV.
        2) Withstand voltage:
            a) Impulse (1.2 by 50 microsecond) 95 kV Crest.
            b) AC 1 minute: 34 kV.
            c) DC 15 minutes: 53 kV.
        3) Minimum corona extinction level:
            a) Eleven kV RMS.
        4) Continuous current rating:
            a) 200 A RMS.
        5) Momentary rating:
            a) 10,000 A RMS, symmetrical at 0.17 seconds.
            b) 3,500 A RMS, symmetrical at 3.0 seconds.
    o. Manufacturers: One of the following or equal:
        1) Elastimold.
        2) 3M.
        3) Cooper.
5. Cap all unused taps with an insulating cap approved for the application:
    a. Manufacturers: One of the following or equal:
        1) Elastimold.
        2) 3M.
        3) Cooper.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Medium voltage systems:
   1. Ground shield at all terminators and splices.
   2. Install cable terminators and splices in conformance with the manufacturer's specifications.
   3. Fireproof all exposed portions of cables.
      a. Half-lapped layer of fire and electric arc proofing tape, secured with double-wrapped band of glass cloth electrical tape at each end.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16264

VARIABLE FREQUENCY DRIVES 60 - 500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Clean power 18 pulse variable frequency drives (VFD), 60 to 500 horsepower for control of standard NEMA Design B squirrel cage induction motors.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. National Electrical Manufacturers Association (NEMA).

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. 519 - IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

D. Underwriters' Laboratories (UL):
   1. 50 - Standards for Enclosures for Electrical Equipment.
   2. 508A - Standard for Safety for Industrial Control Panels.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Each VFD system shall consist of all components required to meet the performance, protection, safety, testing and certification criteria of this Section.
   2. The VFD system:
      a. Is a fully integrated package.
      b. Includes all material necessary to interconnect VFD system elements, even if shipped separately.
   3. Any modifications to a standard product necessary to meet this Section shall be made only by the VFD manufacturer.
   4. Each VFD shall be completely factory pre-wired, assembled and then tested as a complete package by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.
   5. The VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics:
      a. The VFD manufacturer shall furnish equipment necessary to mitigate potential damage to motor insulation.

b. Coordinate bearing protection methods with the supplier of the driven equipment.

B. Performance:
1. Operating envelope:
a. Speed and torque requirements:
1) Provide a variable torque or constant torque VFD as required by the driven load.
2) The VFD shall be capable of producing a variable alternating voltage/frequency output to provide continuous operation over the 40 to 110 percent (25 to 66 hertz) speed range.
b. Current requirements:
1) Provide 100 percent of rated output current on a continuous basis.
2) Variable torque VFD:
a) Minimum 110 percent current overload for 1 minute.
3) Constant torque VFD:
a) Minimum 150 percent current overload for 1 minute.
2. Harmonics:
a. The VFD shall meet the following distortion limits:
1) Voltage harmonics: Individual or simultaneous operation of the VFD(s) shall not add more than 3 percent total harmonic voltage distortion THD, at the input terminals of the VFD system.
2) Current harmonics: The maximum allowable total harmonic current distortion limit, TDD, for each VFD shall not exceed 5 percent as measured at the input terminals of the VFD system.
3. Efficiency:
a. VFD system minimum efficiency shall be 93 percent at rated kilowatt output of the VFD. VFD system efficiency shall be calculated as follows:

$$Efficiency\ (\%) = \frac{Power\ (Load)}{Power\ (Supply)}\ x\ 100$$

b. Power:
1) Load power is the total 3-phase power measured at the output terminals of the drive system, including the output filter.
2) Supply power is the total power measured at the input terminals of the VFD including phase shifting transformer, harmonic distortion attenuation equipment and auxiliary equipment (e.g., controls, fans) for complete system operation.
4. Total power factor:
a. Minimum of 0.96 lagging across the entire speed range.
b. Under no operating conditions shall the VFD have a leading power factor.
5. Frequency accuracy:
a. Minimum of within 0.01 percent.
6. Speed regulation:
a. Minimum of within 0.5 percent across the entire speed range.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical:
   1. Custom prepared by the VFD manufacturer and specific for the equipment furnished.

B. Product data:
   1. Manufacturer of the VFD.
   2. Manufacturer of all components of the VFD.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
   4. Weight.
   5. Nameplate schedule.
   6. Bill of material.
   7. Ratings:
      a. Voltage.
      b. Phase.
      c. Input current.
      d. Output current.
      e. Interrupting rating.
      f. Momentary current rating.
   8. Catalog cutsheets for major components.
   9. Surge protection data.
   10. Design data:
      a. Efficiency and power factor values.
      b. Certification that the drive is sized for the full nameplate motor horsepower and current (at rated RPM) of the driven load at the installed altitude.
      c. Certification that based upon VFD design, cable length to motor, and motor dielectric insulation level that the VFD will not damage motor insulation due to carrier frequency, reflected wave, dv/dt, or other VFD produced characteristics.
      d. Certification that all electronic circuits and printed circuit boards are conformally coated.
   11. List of recommended spare parts.
   12. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050 - Common Work Results for Electrical:
      a. Manufacturer’s statement of seismic qualification with substantiating test data.
      b. Manufacturer’s special seismic certification with substantiating test data.

C. Shop drawings:
   1. Complete plan and elevation drawings showing:
      a. All dimensions.
      b. Panel, sub-panel and component layout indexed to the bill of material.
      c. Conduit connections.
      d. Required clearance around equipment.

2. Block diagram showing the basic control and protection systems identifying the protection, control, trip and alarm functions, the reference signals and commands and the auxiliary devices.
3. Complete schematic, wiring and interconnection diagrams showing connections to both internal and external devices:
    a. Wiring diagrams shall include terminal number and wire numbers.
4. Complete 1-line and 3-line diagrams including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system:
    a. Device electrical ratings shall be clearly indicated on the Drawings.

D. Control descriptions and control logic program:
1. Provide control descriptions describing the full control functionality to be incorporated into the programming of the drive including the following:
    a. Functionality in local and remote.
    b. Software and hardware interlocks.
    c. Control response upon loss and restoration of power.
2. Provide complete register list of all IO available to the Plant PCS.
3. Submit the completed control logic program for each and every device supplied.
4. Submit a list of all networking address tables.
5. Submit configuration settings in accordance with actual motor and field equipment being supplied.

E. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
2. For equipment installed in structures designated as seismic design category C, D, E, or F:
    a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050 - Common Work Results for Electrical.
    b. Submit anchoring drawings with supporting calculations.
    c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

F. Calculations:
1. Harmonic study:
    a. A preliminary harmonic analysis shall be performed. A power system short circuit ratio of 20 shall be used. All VFDs shall be assumed to be operating at maximum speed and maximum load. The short circuit current (ISC) utilized for the harmonic analysis calculations is defined as:
        1) ISC = 20 * (Sum Total Full Load Amps of all VFDs).
2. Detailed calculations or details of the actual physical testing performed on the VFD to prove the VFD is suitable for the seismic conditions at the Project Site.

G. Test forms and reports:
   1. Submit complete factory acceptance test procedures and all forms used during the test:
      a. For VFD units less than 250 horsepower, provide certified test results for the actual VFD being furnished or prototype units. For VFD units 250 horsepower and larger, provide certified test results for the actual VFD being furnished.
      b. Provide the following certified test reports:
         1) Efficiency at rated power output and output frequency of 60 hertz.
         2) Power factor at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent speed.
         3) Harmonics at the input terminals of the VFD at 100 percent speed and 100 percent load:
            a) Voltage distortion: Measure individual harmonics up to and including the 50th harmonic and total harmonic distortion.
            b) Current distortion: Measure individual harmonics up to and including the 50th harmonic and total demand distortion.
      c. Submit complete field acceptance test procedures and all forms used during the test:
         1) Certification that the actual measured harmonic distortion for both voltage and current is within the specification limits at the installed site.
         2) Certification that the actual measured peak voltage at the motor terminations is less than 90 percent of the motor insulation dielectric withstand level.
   2. Submit complete control description checklist and IO checklist organized by VFD for use during the control logic portion of the witnessed factory acceptance testing as well as the witnessed field acceptance testing.

H. Record documents:
   1. Certified record documents of all equipment with information listed above.

I. Manufacturer's field reports:
   1. Certification letter from the VFD manufacturer that the VFD(s) has been inspected and installed in accordance with the manufacturer's requirements.
   2. Report listing the setting of all VFD adjustable parameters and their values after start-up.

J. Operation and maintenance manuals:
   1. Spare parts list with supplier names and part numbers.
   2. Start-up and commissioning instructions and data.
   3. Complete bill of material indexed to the drawings, identifying the catalog or part numbers, manufacturer, and quantities of components of the VFD system.
   4. Operating manuals:
      a. Submit operating instructions and a maintenance manual presenting full details for care and maintenance of each model of VFD provided under this Contract.
   5. Operating instructions:
      a. The written descriptions shall detail the operational functions of all controls on the front panel including keypad functions and parameters.

6. Maintenance manual:
    a. Furnish maintenance manuals with instructions covering all details pertaining to care and maintenance of all equipment as well as identifying all parts.
    b. Manuals shall include but are not limited to the following:
        1) Adjustment and test instructions covering the steps involved in the initial test, adjustment and start-up procedures.
        2) Detailed control instructions that outline the purpose and operation of every control device used in normal operation.
        3) All schematic wiring and external diagrams:
            a) Furnish drawings in a fully legible reduced 11-inch by 17-inch format.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Qualifications:
1. Any third party certification, safety or protection requirements shall be applied to the VFD system as a whole. Certification or protection of system elements or individual components by themselves is not acceptable.
2. VFDs shall be UL 508C listed and labeled.
3. VFD systems (packaged VFD panels) shall be UL 508A listed and labeled.
4. VFDs shall be manufactured by the VFD manufacturer at its own facility, which shall have a quality assurance program that is certified in accordance with ISO 9001.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Ship VFDs to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize on site offloading equipment:
1. VFDs shall be delivered to the site pre-assembled and wired.
2. Ship each VFD with 2 tamperproof accelerometers that record the maximum shock and vibration experienced by the VFD during shipping and handling.

C. Furnish temporary equipment heaters within the VFD to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

A. Conduct Programming and Data Exchange Coordination Meeting.

B. Conduct factory acceptance test and submit certified test results for Engineer’s review.

C. Ship equipment to Project Site after successful completion of factory acceptance test.

D. Assemble equipment in the field.

E. Conduct field acceptance tests including harmonic testing and submit results for Engineer's review.

F. Submit manufacturer's certification that equipment has been properly installed and is fully functional for Engineer's review.

G. Conduct Owner's training sessions.

H. Commissioning and process start-up as specified in Section 01756 - Commissioning.

1.10 SCHEDULING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

B. The VFD manufacturer shall be responsible for start-up of the VFDs in the presence of the equipment suppliers, Contractor, Engineer, and Owner.

1.13 OWNERS INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Maintenance service: Manufacturer shall describe the field service system available to support the proposed VFD system. As a minimum describe:
   1. Type of technical support available (e.g., system engineering and technician).
   2. Location of field service personnel.
   3. Field service daily rates in dollars per hour and dollars per day.
   4. Guaranteed response times to service requests.

C. Spare parts:
   1. The following spare parts shall be furnished:
      a. 2 sets of ventilation filters for each VFD unit (if applicable in VFD cabinet louvers).
      b. Any special dedicated tools for emergency service and troubleshooting.
      c. All hardware and software required for configuration, maintenance, troubleshooting and inquiry of all drive parameters.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Eaton, no substitution or equal.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. General:
   1. Sinusoidal pulse width modulated, (PWM), voltage source type drive shall consist of the following:
      a. Integral phase shifting auto-transformer:
         1) Converts 3-phase utility power to 3 sets of 3 power circuits with each set phase shifted and powering its own 3-phase bridge rectifier.
      b. Direct current link with capacitors.
      c. Minimum 18-pulse diode rectifier section consisting of 3 three-phase bridge rectifiers.
         1) Specifically designed as a system to share currents between the bridges to within 1 percent.
      d. Insulated gate bipolar transistor (IGBT), inverter section.
      e. Microprocessor based controls.
      f. Output filter.
   2. VFDs that have an active input section for either harmonic or voltage control are not acceptable.

B. Ratings:
   1. Voltage:
      a. Input voltage: 480 Volts plus or minus 10 percent, 3-phase 60 hertz.
   2. Short-circuit rating:
      a. 65 kA RMS symmetrical.

C. Operational features:
   1. Protective features:
      a. Include the following protective features:
         1) Motor overload protection.
         2) Instantaneous overcurrent.
         3) Instantaneous overvoltage.
         4) Undervoltage.
         5) Power unit overtemperature.
         6) Phase loss.
         7) VFD output short circuit.
         8) VFD output ground fault.
         9) Blown fuse.
         10) Motor overtemperature protection indicated on the Drawings.
   2. Control mode:
      a. The VFD shall operate in a either a constant volts/hertz or sensorless vector mode. Selectable using the programming keypad.

3. Frequency control:
    a. Minimum of 3 selectable skip frequencies with adjustable bandwidths.
    b. Programmable minimum frequency.
    c. Programmable maximum frequency.
4. Acceleration/Deceleration:
    a. Separately adjustable acceleration and deceleration rates.
    b. Each rate shall be adjustable from 0.01 to 1,800 seconds.
5. Spinning load:
    a. Capable of determining the speed and direction of a spinning load, “catch” the load and accelerate or decelerate it without damage to the load.
6. Programmable loss of signal:
    a. Upon loss of reference speed signal the VFD shall be programmable to either stop, maintain current speed, or default to preselected speed.
7. Power interrupt ride through:
    a. Capable of continuous operation in the event of a power loss of 5 cycles or less.
8. Hardwired inputs and outputs:
    a. Manufacturer’s standard number the following:
        1) Analog inputs:
            a) Configurable as either 0 to 10 volts or 4 to 20 milliamperes.
        2) Analog outputs:
            a) Programmable 4 to 20 milliamperes isolated.
        3) Discrete inputs:
            a) Programmable.
        4) Discrete outputs:
            a) Programmable.
            b) Form C relay contacts.
        5) Potentiometer 3-wire input.
    b. Provide additional inputs and outputs as required to meet the control functions indicated on the Drawings.
9. Communications:
    a. Provide each VFD with an integral EtherNet/IP communications interface module.
10. Diagnostics:
    a. Minimum of 4 fault conditions in memory on a first in - first out basis.
    b. Operating frequency, drive status and power mode shall also be stored at the time of the fault.
    c. Fault memory shall be maintained in the event of a power outage.
    d. The fault memory shall be accessible via RS-232, RS-422 or RS-485.
11. Automatic restart:
    a. User selectable, automatic restart feature allowing the VFD to restart following a momentary power failure or other VFD fault:
        1) Programmable for up to 9 automatic restart attempts with an adjustable time delay between restart attempts.

2.06 COMPONENTS

A. Enclosure:
    1. NEMA Type 12.
    2. Provide cooling devices required to maintain the VFD within the manufacturer’s specified temperature limits for the Project conditions:
        a. Provide cooling device alarm.

B. Power disconnect:
   1. Flange mounted thermal magnetic circuit breaker:
      a. Lockable in the OFF position.

C. Phase shifting transformer:
   1. Auto-transformer.
   2. Integral part of the VFD assembly and factory mounted and wired within the VFD enclosure.
   3. Rated for rectifier duty.
   4. Copper or aluminum windings with 180-degree Celsius insulation.

D. Output filter:
   1. 3 percent load reactor.

E. Keypad:
   1. Furnished with a keypad for programming and control.
   2. Password security to protect drive parameters.
   3. Mounted on the door of the VFD.
   4. Back-lit LCD with a minimum of 2 lines of a minimum of 16 characters each.
   5. Programming and display features language: English.
   6. Capable of displaying the following parameters:
      a. Speed (percent).
      b. Input current (amperes).
      c. Output current (amperes).
      d. Output frequency (hertz).
      e. Input voltage.
      f. Output voltage.
      g. Total 3-phase kilowatt.
      h. Kilowatt hour meter.
      i. Elapsed run time meter.
      j. Revolutions per minute.
      k. Direct current bus voltage.
   7. In addition to all keys required for programming, the keypad shall have the following:
      a. Automatic/Manual selector.
      b. Start pushbutton.
      c. Stop pushbutton.
      d. Jog pushbutton.
      e. Speed increment.
      f. Speed decrement.
      g. Forward/Reverse selector.
      h. RUN indicator.
      i. PROGRAM indicator.
      j. FAULT indicator.
      k. DRIVE READY indicator.
      l. Diagnostics.
   8. Provide the VFD with the hardwired controls indicated on the Drawings.

F. Control power transformer:
   1. Furnish a control power transformer mounted and wired inside the drive enclosure:
      a. Primary and secondary fusing.
   2. Size the transformer to supply power to all VFD controls and options as well as any external devices indicated on the Drawings including the motor winding heater.

2.07 ACCESSORIES

A. Surge protection:
   1. Metal oxide varistors:
      a. Provide protection for the VFD against:
         1) Line transients: 5,000 volt peak minimum.
         2) Line to ground transients: 7,000 peak minimum.

B. Conformal coating:
   1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as protection against moisture, dust, temperature extremes, and chemicals such as H_2S and chlorine.

C. Air filters:
   1. Mounted on the outside of the VFD enclosure:
      a. Replaceable without requiring that the VFD be turned off or the door opened.
   2. Located on the front or top of the VFD enclosure.
      a. Side or rear mounted air filters are not acceptable.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Enclosure finish shall be manufacturer's standard gray.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:
1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories needed to complete installation of the VFD (free-standing).
2. Assemble and install the VFD in the locations and with the layouts indicated on the Drawings.
3. Perform Work in accordance with the manufacturer's instructions and shop drawings.
4. Furnish components, and equipment as required to complete the installation.
5. Replace any hardware lost or damaged during the installation or handling to provide a complete installation.
6. Install free-standing enclosures on a raised concrete housekeeping pad:
   a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
   b. Weld and/or bolt the VFD frame to the leveling channels.
7. Provide openings in top or bottom of the VFD (free-standing) enclosure for conduit only, no additional openings will be allowed:
   a. Improperly cut holes will require that the entire panel be replaced:
      1) No hole closers or patches will be allowed.
8. Bundle circuits together and terminate in each unit:
   a. Tie with nylon wire ties. As specified in Section 16123 - 600-Volt or Less Wires and Cables.
   b. Label all wires at each end with wire numbers shown on the approved Control Drawings.
   c. All connections to and from the VFD (free-standing) enclosure must be made via terminal blocks.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Factory testing:
1. Owner and Engineer will witness the factory acceptance test as specified in Section 16050 - Common Work Results for Electrical.
2. General:
   a. All VFDs furnished under this Section shall be tested and inspected as specified below.
   b. The testing procedures specified are the minimum acceptable requirements. The manufacturer may perform additional tests at its discretion.
3. Failure of any component during testing requires replacement of the faulted component and a complete retest.
4. Testing sequence:
   a. Submit a detailed test procedure for the VFD factory test:
      1) A minimum of 8 weeks in advance of the proposed testing date.
      2) No tests shall be performed until the test procedure is reviewed and accepted by the Engineer.

5. Component tests:
    a. Preliminary inspection:
        1) Verify that all components are correct.
        2) Verify that all connections are properly torqued.
    b. Printed circuit boards:
        1) Test each printed circuit board per the manufacturer's standard testing procedure.
    c. Wiring:
        1) Control and power wiring continuity verified point-to-point.
        2) Hi-pot power and control wiring at manufacturer's recommended levels.
        3) Verify ground bond resistance.
    d. Load testing:
        1) No load testing in accordance with the manufacturer's standard factory test procedure.
        2) Full load testing:
            a) Test each VFD and all control logic with a representative motor or dynamometer load to simulate field operation conditions at 25 percent, 50 percent, and 100 percent full load current.
            b) Tests shall be conducted in a manner in which the inverter (IGBT) section supplies all the output power (kW) of the VFD system. Control strategies using a contactor or other means of bypassing the VFD when operating at the line frequency shall not be permitted.
            c) Tests shall be conducted using a minimum output frequency of 60 hertz, and a minimum switching frequency of 2.5 kHz.

C. Owner training:
    1. As specified in Sections 01756 - Commissioning and 16050 - Common Work Results for Electrical.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Provide the services of a VFD manufacturer representative for start-up assistance and training:
    1. Inspection and field adjustment:
        a. Supervise the following and submit written certification that the equipment and controls have been properly installed, aligned, adjusted, and readied for operation.
    2. Start-up field testing:
        a. Provide technical direction for testing, checkout, and startup of the VFD equipment in the field.
        b. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.
        c. Compliance with the following specified parameters shall be verified by the VFD manufacturer:
            1) Motor terminal voltage:
                a) Make field measurements at the motor connection box.
                b) Make measurements of the full speed range of the VFD.
                c) Make measurements with a recording type oscilloscope.

2) Harmonics:
    a) Make field measurements at the input terminals of the VFD with and without the VFD in operation.
    b) Make measurements with a recording type harmonic analyzer displaying individual and total harmonic currents and voltages:
        (1) Record currents and voltages for a minimum of 10 minutes.
        (2) Analyzers using snapshots are not acceptable.

3.09 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

B. Provide the services of a VFD manufacturer factory technician to make all drive parameter and protective device settings:
    1. Protective device settings provided by the VFD manufacturer in accordance with the manufacturer of the driven equipment requirements.
    2. Provide documentation of VFD settings included but not limited to:
        a. Minimum speed.
        b. Maximum speed.
        c. Skip speeds.
        d. Current limit.
        e. Acceleration time.
        f. Deceleration time.
        g. Carrier frequency.

C. Programming:
    1. Manufacturer/supplier may contract with the project Programmer for portions of the tasks below.
    2. Provide all gateway communications between the drive to the Owner's control system as required.
    3. Provide all control logic as indicated in the control descriptions.
    4. Configure all network communications with applicable security settings, IP addresses and any other addressing tables required to provide a fully functioning system.
    5. Coordinate all IP addresses with the Owner.
    6. Coordinate data exchange approach for efficient communications to the Owner's control and maintenance systems. This effort will include a coordination meeting to discuss the data exchange approach including formatting and mapping.
    7. Provide witnessed source testing to prove out all Overload control logic as well as interaction with Owner’s control and maintenance systems at the supplier's facility. ICSC/Programmer shall attend witnessed testing.

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16272

DRY-TYPE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Enclosed dry-type transformers:
      a. Rated 1 to 1,000 kilovolt-amperes, single and 3-phase.
      b. Primary voltage 600 volts and below.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 389 - IEEE Recommended Practice for Testing Electronics Transformers and Inductors.
   2. C57.12.01 - IEEE Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin Encapsulated Windings.
   3. C57.96 - IEEE Guide for Loading Dry-Type Distribution and Power Transformers.

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

D. Underwriters Laboratory (UL):
   1. 1561 - Standard for Dry-Type General Purpose and Power Transformers.

E. U.S. Department of Energy (DOE):
   1. 10 CFR Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. NEMA:
   1. Type 2 enclosure in accordance with NEMA 250.
   2. Type 3R enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTIONS

A. Provide 3-phase or 1-phase, 60 hertz dry-type with voltage ratings, kilovolt-ampere capacities, and connections as indicated on the Drawings:
   1. Transformers shall provide full capacity at the Project elevation and environmental conditions as specified in Section 16050 - Common Work Results for Electrical after all derating factors have been applied.
   2. Suitable for continuous operation at full rating with normal life expectancy in accordance with IEEE C57.96.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Catalog cutsheets.
   2. Nameplate data.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
   4. Inrush current.
   5. Insulation system and temperature constraints.
   6. Number and rating of taps.
   7. Sound levels.
   8. Connection diagrams:
      a. Primary.
      b. Secondary.
   9. BIL rating.
   10. Required clearances.
   11. Percent impedance.
   12. Efficiency.
   13. Certification of full capacity capability at the Project elevation and ambient conditions.
   14. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section16050 - Common Work Results for Electrical:
      a. Manufacturer’s statement of seismic qualification with substantiating test data.
      b. Manufacturer’s special seismic certification with substantiating test data.

C. Installation instructions:
   1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
   2. For equipment installed in structures designated as seismic design category C, D, E, or F:
      a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050 - Common Work Results for Electrical.

b. Submit anchoring drawings with supporting calculations.
c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
1. GE by ABB.
2. Jefferson.
3. Schneider Electric.
4. Eaton.
5. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Cores:
1. Non-aging, grain-oriented silicon steel.
2. Magnetic flux densities below the saturation point.

B. Windings:
   1. High-grade magnet wire.
   2. Impregnated assembly with non-hydroscopic, thermo-setting varnish:
      a. Cured to reduce hot-spots and seal out moisture.
   3. Material electrical grade:
      a. Copper.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. General:
   1. 10 kilovolts BIL for 600-volt class windings.
   2. Sound levels, in accordance with IEEE 389 test conditions, not to exceed:

Kilovolt-Amperes Range	Audible Sound Level (db)
1-9	40
10-50	45
51-150	50
151-300	55
301-500	60
501-700	62
701-1000	64

   3. Taps:
      a. 15 kilovolt-amperes and less:
         1) Two 5 percent full capacity primary taps below rated voltage.
      b. 25 kilovolt-amperes and larger:
         1) Four 2.5 percent full capacity primary taps below rated voltage.
         2) Two 2.5 percent full capacity primary taps above rated voltage.
      c. Operated by a tap changer handle or tap jumpers accessible through a panel.
   4. Terminals:
      a. UL listed for either copper or aluminum conductors.
      b. Rated for 75 degrees Celsius.
   5. Daily overload capacities, at rated voltage and without reduction in life, in accordance with IEEE C57.96.

B. Transformers less than 15 kilovolt-amperes:
   1. Insulation class: 185 degrees Celsius.
   2. Temperature rise: 115 degrees Celsius.

C. Energy efficient transformers 15 kilovolt-amperes and larger:
   1. Insulation class: 220 degrees Celsius.
   2. Temperature rise: 150 degrees Celsius, except as noted below:
      a. 150 degree Celsius rise for dry-type transformers located in motor control centers and in the maintenance building.
   3. Efficiency:
      a. In accordance with DOE 10 CFR Part 431.

D. Enclosures:
    1. Heavy gauge steel:
        a. Indoor: NEMA Type 2.
    2. Louvers to limit coil temperature rise to the value stated above, and case temperature rise to 50 degrees Celsius.
    3. Built-in vibration dampeners to isolate the core and coils from the enclosure:
        a. Neoprene vibration pads and sleeves.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Nameplates:
    1. Non-corrosive metal or UL listed non-metallic:
        a. Stamped, engraved or printed with the following information:
            1) Phases.
            2) Frequency.
            3) Kilovolt-ampere rating.
            4) Voltage ratings.
            5) Temperature rise.
            6) Impedance.
            7) Insulation class.
            8) BIL rating.
            9) Connection diagram.
            10) Weight.
            11) Manufacturer.
            12) The identification “transformer”.
            13) Classes of cooling.
            14) Tap voltage(s).
            15) Vector diagram.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finish to consist of de-greasing, phosphate cleaning, and an electrodeposited manufacturer’s standard gray enamel rust-inhibiting paint.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:
   1. Floor, wall, platform, motor control center, packaged power supply, or roof mounted, as indicated on the Drawings.
   2. Install where not in direct contact with building structure.
   3. Install on single layer vibration pad under the entire mounting surface.
      a. Manufacturers: The following or equal:
         1) Korfund.
   4. Make any necessary connections to the enclosure with liquidtight flexible conduit having neoprene gaskets and insulated ground bushings.
   5. Ground the enclosure:
      a. To an equipment ground conductor in the conduit.
      b. To the facility grounding electrode system.
   6. Floor mounted transformers:
      a. Install transformers on a housekeeping pad.
      b. Install transformers with adequate space from walls or other enclosures for proper ventilation in accordance with the manufacturer's recommendations.

3.04 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Factory tests:
   1. Applied voltage test to each winding and from each winding to the core:
      a. 600-volt class winding 4.5 kilovolt.
   2. Induced voltage test at 2 times normal voltage and 400 hertz for 1,080 cycles.
   3. Voltage ratio and polarity.
   4. Sound level, performed in a test room with ambient sound level not exceeding 24 db.
   5. Perform all tests in accordance with UL 1561.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING

A. Set the transformer taps as required to obtain nominal output voltage on the secondary terminals.

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16273

LIQUID FILLED PAD MOUNTED TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Medium voltage, outdoor, liquid-filled pad mounted transformers.

1.02 REFERENCES

A. General:
   1. As specified in Section 16050 - Common Work Results for Electrical.

B. American National Standards Institute (ANSI).

C. Institute of Electrical and Electronic Engineers (IEEE):
   1. C57.12.00 - IEEE Standard General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers.
   2. C57.12.10 - IEEE Standard Requirements for Liquid-Immersed Power Transformers.
   3. C57.12.26 - IEEE Standard for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers.
   4. C57.12.28 - IEEE Standard for Pad-Mounted Equipment-Enclosure Integrity.
   5. C57.12.70 - IEEE Standard Terminal Markings and Connections for Distribution and Power Transformers.
   6. C57.12.80 - IEEE Terminology for Power and Distribution Transformers.
   7. C57.12.90 - IEEE Standard Test Code for Liquid-Immersed Distribution, Power and Regulating Transformers.
   8. C57.91 - IEEE Guide for Loading Mineral-Oil-Immersed Power Transformers up to and including 100 MVA with 65 degrees or 55 degrees Average Winding Rise.
   9. C57.93 - IEEE Guide for Installation of Liquid-immersed Power Transformers.
   10. C57.98 - IEEE Guide for Transformer Impulse Tests.
   11. C57.106 - IEEE Guide for Acceptance and Maintenance of Insulating Mineral Oil in Electrical Equipment.
   12. C57.147 - IEEE Guide for Acceptance and Maintenance of Natural Ester Fluids in Transformers.

D. National Electrical Manufacturers Association (NEMA):
   1. TR-1 - Transformers, Regulators, and Reactors.

E. U.S. Department of Energy (DOE):
   1. 10 CFR Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. As listed in IEEE C57.12.80.

1.04 SYSTEM DESCRIPTION

A. Outdoor oil-filled, pad mounted transformers for operation on a 60 hertz system with voltage and kilovolt-ampere ratings as indicated on the Drawings:
   1. Suitable for continuous operation at full load at the Project location and elevation after applying any derating factors.
   2. Pad mounted transformers shall be compartmental type, designed for outdoor installation on a concrete pad.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Complete installation instructions.
   2. Complete storage and handling instructions.
   3. Kilovolt-ampere rating, including derating calculations.
   4. Primary/secondary connections.
   5. Primary voltage and available taps.
   6. Secondary voltage.
   7. BIL rating.
   8. Temperature rise.
   9. Lightning arrester data.
   10. %Z, %X, %R, X/R.
   11. Efficiency.
   12. Gross weight.
   13. Torque values for all bolted connections for secondary cable connections.
   14. Manufacturer’s suggested hi-potential test procedures and test levels for field-testing:
      a. Initial field test.
      b. Subsequent maintenance tests.
   15. Certification from the manufacturer stating the transformer design complies with IEEE C57,12,00.
   16. Type of oil.
   17. Gallons of oil.
   18. Weight of oil.
   19. Complete MSDS sheets. There is no C57 standard for ANSI or IEEE.
   20. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050 - Common Work Results for Electrical:
      a. Manufacturer’s statement of seismic qualification with substantiating test data.
      b. Manufacturer’s special seismic certification with substantiating test data.

C. Shop drawings:
   1. Complete detailed, dimensioned drawings showing the equipment being furnished, with all pertinent information, including the following:
      a. Dimensions and locations of conduit entrance windows.
   2. Complete nameplate schedule, except impedance.

D. Installation instructions:
   1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
   2. For equipment installed in structures designated as seismic design category C, D, E, or F:
      a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050 - Common Work Results for Electrical.
      b. Submit anchoring drawings with supporting calculations.
      c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

E. Operation and maintenance manuals:
   1. Complete as-built dimensioned and scaled drawings for transformer.
   2. Recommended periodic maintenance requirements.
   3. Maintenance instructions including schedules, parts identification, troubleshooting, assembly instructions, parts list, and predicted life of parts subject to wear and deterioration.
   4. Recommended field test levels and procedures before installation and for maintenance purposes after being placed in service.
   5. Periodic and preventative maintenance torque values for all bolts.
   6. List of recommended preventative maintenance tests, test frequencies, test procedures, acceptable test result ranges and disposal recommendations for utilized mineral oil in accordance with IEEE C57.106 or natural ester fluids in accordance with IEEE C57.147.
   7. Copies of factory test reports.

F. Test reports:
   1. Certified copies of test reports from factory tests.

G. Record documents.

H. Calculations:
   1. Detailed calculations or details of the actual physical testing performed on the transformers to prove the transformers are suitable for the seismic requirements at the Project Site.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Ship transformers to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize onsite off-loading equipment:
   1. Each transformer shall be shipped with a global positioning system (GPS) unit to record the shipping route.
   2. Provide monitoring of the acceleration the transformer experiences during shipment:
      a. The GPS unit can record the acceleration.
      b. Utilize a G-force gauge that indicates that the acceleration has exceeded allowed values.
   3. Transformers that experience vertical accelerations greater than 3 G or horizontal accelerations greater than 5 G shall not be accepted.

C. Furnish temporary equipment heaters within the transformer to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

A. Make all necessary field measurements to verify the equipment will fit in the allocated space in full compliance with the minimum clearances required by the NEC and local codes.

B. Conduct factory acceptance test and submit certified test results for Engineer's review.

C. Ship equipment to Project Site after successful completion of factory acceptance test.

D. Assemble equipment in the field.

E. Conduct field acceptance test and submit certified test results for Engineer's review.

F. Verify installation is in accordance with IEEE C57.93.

G. Submit manufacturer's certification that equipment has been properly installed and is fully functional for Engineer's review.

H. Set taps.

I. Commissioning as specified in Section 01756 - Commissioning.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Provide the services of a manufacturer's authorized representative:
   1. Inspect installation before start-up.
   2. Witness energization.

C. Energize transformer according to manufacturer's recommended procedure and in accordance with IEEE C57.91.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Asea Brown Boveri (ABB).
   2. Eaton/Cooper Power Systems.
   3. Schneider Electric.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Windings:
   1. Primary and secondary windings shall be high conductivity copper.

B. Insulating fluid:
   1. Envirotemp FR3 oil.
   2. Insulating fluid shall meet or exceed the requirements of the appropriate IEEE and ASTM fluid standards.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. The transformer and associated terminal compartments designed and constructed to be tamper-resistant:
   1. No externally removable screws, bolts, or other devices.

B. Ratings:
   1. 3-phase, 60 hertz.
   2. Self-cooled.
   3. 65-degree Celsius rise.
   4. Primary voltage as indicated on the Drawings.
   5. Primary connection as indicated on the Drawings.
   6. Secondary voltage as indicated on the Drawings.
   7. Secondary connection as indicated on the Drawings.
   8. Kilovolt-ampere rating as indicated on the Drawings.
   9. Basic impulse insulation level (BIL) in accordance with IEEE C57.98:
      a. 15 kV Class: 95 kV.

10. Sound levels:
    a. In accordance with NEMA TR1.
    b. Measurement procedure in accordance with IEEE C57.12.90.
11. Efficiency:
    a. Transformers 2,500 kVA and less shall have an efficiency rating in accordance with DOE 10 CFR Part 431.
12. Short-circuit capacity:
    a. Mechanical short-circuit capability in accordance with IEEE C57.12.90.
13. Thermal short-circuit capability in accordance with IEEE C57.12.00.

2.06 COMPONENTS

A. Core and coil:
    1. Manufactured from burr-free, grain-oriented silicon steel laminations and stacked to eliminate gaps in the corner joints.
    2. Insulated with B-stage, epoxy coated, diamond pattern, insulating paper, thermally cured under pressure to ensure proper bonding of conductor and paper.
    3. Clamped and braced to resist distortion caused by short-circuit stresses within ratings or by shipping and handling and to prevent the shifting of core laminations.
    4. Vacuum processed to ensure maximum penetration of insulating fluid into the coil insulation system:
        a. Energize the windings under vacuum to heat the coils and drive out moisture.
        b. While under a vacuum and the coils are heated, fill the tank with preheated, filtered and degassed insulating fluid.

B. Tank:
    1. Conforming to the enclosure integrity requirements in accordance with IEEE C57.12.28.
    2. Equipped with extra-heavy duty, welded-in-place lifting lugs and jacking pads.
        a. Provide adequate cross-bracing of the base to allow skidding or rolling in any direction.
    3. Capable of withstanding a pressure of 7 pounds per square inch gauge without permanent distortion, and 15 pounds per square inch gauge without rupturing.
    4. Provide a pressure relief valve as a means to relieve pressure in excess of pressure resulting from normal operation:
        a. Cracking pressure: 10 pounds per square inch gauge within 2 psig.
        b. Resealing pressure: 6 pounds per square inch gauge minimum.
        c. Zero leakage from reseal pressure to 8 pounds per square inch gauge.
        d. Flow at 15 pounds per square inch gauge: 35 scfm minimum.

C. Terminal compartments:
    1. Conforming to the enclosure integrity requirements in accordance with IEEE C57.12.28.
    2. Full-height, air filled primary and secondary terminal compartments with hinged doors shall be located side-by-side separated by a steel barrier, with the primary compartment on the left, complete with tamper resistant hardware.
    3. Hinges and pins to be passivated Type 304 stainless steel or equivalent corrosion-resistant metal.

4. Doors and compartment hood shall be removable:
    a. Removable doorsill on compartments shall be provided to permit rolling or skidding of unit into place over conduit stubs in foundations.
5. The doors in both the high voltage section and the low voltage section shall be able to be latched in the open position.
6. The entire terminal compartment for the transformer shall be bolted to the transformer so that the terminal compartment may be unbolted from the transformer and the transformer removed without disturbing conduits that enter the compartment from the side or top.
7. Minimum of 18 inches deep.
8. Secondary compartment:
    a. The secondary compartment shall enclose the low voltage bushings and provide for incoming cable from below the compartment.
    b. This compartment shall also house:
        1) Liquid level indicator.
        2) Drain valve with sampling device.
        3) Dial type thermometer.
        4) Pressure relief valve.
        5) Vacuum pressure gauge.
    c. Door to low voltage section shall have a 3-point latching mechanism with pad-locking provision.
9. Primary compartment:
    a. The primary line compartment shall enclose the high voltage bushings and provide for incoming cables from below the compartment:
        1) Coordinate primary bushing size with incoming cables size as indicated on the Drawings.
    b. This compartment shall also house:
        1) Dead front lightning arresters.
        2) No-load tap changer.
        3) Parking stands for 6 elbows.
    c. The primary compartment shall be accessible only after the door for the secondary compartment has been opened. The door shall be held closed by a captive bolt; access to this bolt shall be provided only when the door to the low voltage section is opened.
10. Primary terminals:
    a. Dead front construction, in accordance with IEEE C57.12.26, utilizing high voltage elbows for connections to primary cable and lightning arresters.
    b. Terminal arrangement with 6-bushing wells:
        1) 3 for terminating primary power cables.
        2) 3 for connecting lightning arresters.
    c. Supporting structure within cabinet to support cables and eliminate mechanical stress on insulators.
11. Secondary terminals:
    a. 4 low voltage spade bushings with 2 holes for each cable, in accordance with IEEE C57.12.26.
    b. Extend low voltage bushings as necessary to accommodate the cable arrangement indicated on the Drawings or indicated on the conduit schedule:
        1) Extension via a fully rated, tin-plated, copper bus system braced to withstand the available fault current.
    c. Neutral brought out through an insulated bushing and externally grounded to the tank with a removable ground strap.

d. Supporting structure within cabinet to support cables and eliminate mechanical stress on insulators.

D. De-energized tap changer:
1. Furnish with full capacity high-voltage taps:
a. Two 2-1/2 percent taps above and below rated voltage.
2. Labeled to indicate that the transformer must be de-energized before operating the tap changer as required by IEEE C57.12.10.
3. Externally operated no-load tap changer switch with snap action switch and lever handle.
4. Padlocking provision in each tap position.
5. Position indication.

2.07 ACCESSORIES

A. Lightning arresters:
1. High voltage dead front design for elbow connection.
2. Metal oxide varistor arresters.
3. Distribution class arresters.
4. Rating as indicated on the Drawings and/or consistent with the distribution voltage.

B. Tank ground pads:
1. 2 stainless steel pads, welded to the tank wall, with unpainted surfaces:
a. 1 pad in primary compartment.
b. 1 pad in secondary compartment:
1) If additional load ground connections are required, a tin-plated, copper equipment ground bus shall be bolted to the pad.

C. Dial-type thermometer:
1. Direct stem mounted in a closed well so that the thermometer can be removed without breaking the tank seal:
a. The well shall be threaded into a fitting that is welded to the transformer tank wall.
2. The thermometer shall have a slave hand which is moved by the indicating hand to indicate maximum oil temperature. The slave hand shall be externally resettable.

D. Sampling device:
1. Allow for sampling of the transformer insulating fluid.
2. Threaded into a fitting that is welded to the transformer tank wall.

E. Liquid level gauge:
1. Dial-type liquid level gauge.

F. Vacuum pressure gauge:
1. 10 pounds per square inch gauge vacuum to plus 10 pounds per square inch gauge scale:

G. Pressure relief device:
1. Located in the air space in the transformer tank to provide a method of relieving internal tank pressure.
2. Self-relieving.

3. Indicating.
4. Operating pressure: 10 within 2 pounds per square inch gauge.

H. Nameplates:
1. Provide nameplate as specified in Section 16075 - Identification for Electrical Systems and the following:
   a. Provide complete nameplates identifying equipment, caution, voltage, etc.
   b. Provide complete nameplates for both inside and outside of the transformer terminal compartments.
   c. Provide diagrammatic nameplate.

I. Bolted 8-inch (minimum) diameter round handhold on cover.

J. Lifting lugs at each corner of tank for lifting complete transformer.

K. Jacking facilities at each corner of base for jacking the complete transformer.

L. Base designed for rolling or skidding in any direction.

M. Bayonet-type fuse:
1. Oil immersed expulsion type fuse with an interrupting rating of 3,800 amperes at 8.3 kilovolts; 2,000 amperes at 15.5 kilovolts.
2. Hook stick-operable.
3. Drawout.
4. Load break design.
5. 2 types of fuse links:
   a. Overload sensing.
   b. Fault sensing.

2.08 MIXES (NOT USED)

2.09 FABRICATION

A. Tanks:
1. Construction: Sealed tank construction with welded cover. Permanently locate an inorganic gasket between the cover and the tank flange during the welding of the transformer cover to prevent the entrance of weld spatter into the tank.
2. Large handhole with bolted cover and protected with a weather cover.
3. 4 lifting hooks.
4. Jacking pads.
5. Fluid sample valve.
6. Designed for 7 pounds per square inch gauge without permanent distortion; 12 pounds per square inch gauge when silicone oil insulating fluid is specified.

2.10 FINISHES

A. In accordance with IEEE C57.12.28 including the following performance requirements:
1. Salt spray test.
2. Crosshatch adhesion test.
3. Humidity test.
4. Impact test.
5. Oil resistance test.

6. Ultraviolet accelerated weathering test.
7. Abrasion resistance: Taber® Abraser.

B. Procedure:
1. Clean with an alkaline cleaning agent to remove grease and oil.
2. Chemically bond iron phosphate coating to metal surface to ensure coating adhesion and retard corrosion.
3. Prime metal surface with an electrodeposited powder epoxy to provide a barrier against moisture, salt, and corrosives.
4. Coat with an electrostatically applied, oven-cured polyester powder coat to enhance abrasion and impact resistance.
5. Topcoat: Liquid polyurethane coating to seal and add ultraviolet protection.
   a. Color: Munsell Green 7GY.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:
1. Furnish concrete pad and all lugs, bolts, anchors, sealants, and other accessories needed to complete the installation of the transformer.
2. Assemble and install the transformer in the location and layout indicated on the Drawings.
3. Perform Work in accordance with manufacturer's instructions and shop drawings.
4. Raise the tank above the pad to protect the bottom finish during installation and to minimize corrosion due to moisture accumulation.
5. Furnish components and equipment as required to complete the installation.
6. Replace any hardware lost or damaged during installation or handling.
7. Position the transformer so all required working space and clearance requirements of the National Electrical Code and the local building authorities are met.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Perform the following factory tests as required by IEEE C57.12.00 and in accordance with IEEE C57.12.90:
   1. No-load (85 degrees Celsius) losses at rated current. (Maximum allowable no load losses: 10 percent).
   2. Total (85 degrees Celsius) losses at rated current. (Maximum allowable total losses: 6 percent).
   3. Percent impedance (85 degrees Celsius) at rated current.
   4. Excitation current (100 percent voltage) test.
   5. Winding resistance measurement tests.
   6. Turns ratio tests using all tap settings.
   7. Polarity and phase relation tests.
   8. Temperature test.

C. Verification of performance:
   1. Submit manufacturer's certified test results before shipping the transformer.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16950 - Field Electrical Acceptance Tests.

B. Provide the services of a qualified manufacturer’s representative to:
   1. Install all transformer equipment shipped separately from the transformer.
   2. Fill the transformer with insulating fluid.
   3. Install the nitrogen blanket.

C. Any and all other Work required to make the transformer ready for testing and energization.

3.09 ADJUSTING

A. Set the transformer taps as required to obtain nominal output voltage on the secondary terminals.

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16285

SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. High-energy surge protective devices.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
   2. C62.41.2 - Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.
   3. C62.45 - Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
   4. C62.62- Standard Test Specifications for Surge Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1000 V and less) AC Power Circuits.

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

D. Underwriters Laboratory:
   1. 1449, 4th Edition, Standard for Surge Protective Devices.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. NEMA:
   1. Type 1 enclosure in accordance with NEMA 250.
   2. Type 12 enclosure in accordance with NEMA 250.

C. Specific definitions:
   1. SPD: Surge protective device.
   2. SAD: Silicon avalanche diode.
   3. MOV: Metal oxide varistor.
   4. MCOV: Maximum continuous operating voltage.
   5. I_n: Nominal discharge current.
   6. VPR: Voltage protection rating.
   7. SCCR: Short circuit current rating.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Furnish complete product data confirming detailed compliance or exception statements to all provisions of this Section.
   2. Manufacturer's catalog cutsheets indicating:
      a. Manufacturer and model numbers.
      b. Ratings of each SPD including but not limited to:
         1) Short circuit current rating.
         2) Nominal discharge current.
         3) Maximum continuous operating voltage.
         4) Voltage protection rating.
         5) System voltage.
         6) System frequency.
         7) Surge current capacity.
   3. Submit independent test data from a nationally recognized testing laboratory verifying the following:
      a. Overcurrent protection.
      b. UL 1449.

C. Shop drawings:
   1. Provide electrical and mechanical drawings by the manufacturer that detail:
      a. Unit dimensions.
      b. Weights.
      c. Components.
      d. Field connection locations.
      e. Mounting provisions.
      f. Connection details.
      g. Wiring diagram.

D. Operation and maintenance manuals:
   1. Provide the manufacturer's manual with installation, start-up, spare parts lists, and operating instructions for the specified system.

1.05 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Provide SPD units that are designed, manufactured, tested and installed in compliance with the following codes and standards:
   1. Institute of Electrical and Electronics Engineers (IEEE C62.41.1, C62.41.2, C62.45, C62.62).
   2. Federal Information Processing Standards Publication 94 (FIBS PUB 94).
   3. National Electrical Manufacturer Association.
   4. National Fire Protection Association (NFPA 20, 75 and 780).
   5. National Electric Code (NFPA 70).
   6. Underwriters Laboratories (UL 1449 4th Edition and UL 1283).
   7. International Electrotechnical Commission (IEC 801).

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 SEQUENCING

A. Coordinate with and provide SPD equipment to the electrical equipment manufacturer before final assembly and factory testing.

1.09 SCHEDULING (NOT USED)

1.10 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Extended warranty:
   1. Furnish a manufacturer’s full 5-year parts and labor warranty from date of shipment against any part failure when installed in compliance with manufacturer's written instructions, UL listing requirements, and any applicable national, state, or local electrical codes.
   2. Warranty shall include:
      a. Direct, factory trained employees must be available within 48 hours for assessment of the problem.
      b. A 24-hour toll-free 800-number for warranty support.

1.11 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Southern Tier Technologies.
   2. Eaton.
   3. Schneider Electric.
   4. GE by ABB.

2.02 SYSTEM DESCRIPTION

A. Surge protective devices as mounted as indicated on the Drawings.

2.03 EXISTING PRODUCTS (NOT USED)

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

A. Provide Type 1 or Type 2 SPD units as required for the locations indicated on the Drawings.

B. Electrical requirements:
   1. SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
   2. MCOV:
      a. For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): Greater than 115 percent of the nominal system operating voltage.
   3. Operating frequency:
      a. 47 to 63 hertz.
   4. SCCR:
      a. 65 kAIC minimum, but not less than the equipment it is connected to as indicated on the Drawings.
      b. The SCCR shall be marked on the SPD in accordance with UL 1449 and the NEC.
   5. Nominal discharge current I_n:
      a. 20 kA.
   6. Maximum VPR:

Modes	240/120	208Y/120	480Y/277	480V
L-N, L-G, N-G	900	900	1,500	1,500
L-L	1,200	1,200	2000	2,000

   7. Peak surge current:
      a. Service entrance locations:
         1) 240 kA per phase minimum.
         2) 120 kA per mode minimum.
      b. Branch locations:
         1) 120 kA per phase, minimum.
         2) 60 kA per mode minimum.

C. Protection modes:
   1. Provide SPD protection modes as follows:
      a. Line to Neutral (L-N) where applicable.
      b. Line to Ground (L-G).
      c. Neutral to Ground (N-G), where applicable.

D. Environmental requirements:
   1. Storage temperature:
      a. -40 degrees to 122 degrees Fahrenheit.
   2. Operating temperature:
      a. 32 degrees to 140 Fahrenheit.
   3. Relative humidity:
      a. 5 percent to 95 percent.
   4. Audible noise:
      a. Less than 45 dBa at 5 feet (1.5 m).

5. Operating altitude:
    a. Zero to 12,000 feet above sea level.

E. Provide surge protective devices that are suitable for application in IEEE C62.41.1, C62.41.2 Category A, B and C3 environments, as tested to IEEE C62.45.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. Enclosure:
    1. Located in electrical equipment as indicated on the Drawings.

B. Internal connections:
    1. Provide low impedance copper plates for intra-unit connections:
        a. Attach surge modules using bolted connections to the plates for low impedance connections.
    2. Size all connections, conductors, and terminals for the specified surge current capacity.

C. Surge diversion modules:
    1. MOV:
        a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer's defects.

D. Overcurrent protection:
    1. Individually fuse all components, including suppression, filtering, and monitoring components:
        a. Rated to allow maximum specified nominal discharge current capacity.
        b. Overcurrent protection that limits specified surge currents is not acceptable.

E. Connections:
    1. Provide terminals to accommodate wire sizes up to #2 AWG.

2.08 ACCESSORIES

A. Unit status indicators:
    1. Provide red and green solid-state indicators, with printed labels, on the front cover to redundantly indicate on-line unit status:
        a. The absence of the green light and the presence of the red light indicate that surge protection is reduced and service is needed to restore full operation.
        b. Indicates the status of protection on each mode or phase.

B. Dry contacts for remote monitoring:
    1. Electrically isolated Form C dry contacts (1 A/125 VAC) for remote monitoring of system integrity, and indication of under voltage, phase and/or power loss.

C. Provide an audible alarm which activates under any fault condition:
    1. Provide an alarm On/Off switch to silence the alarm.
    2. A visible LED will confirm whether alarm is On or Disabled.
    3. Locate both switches and the audible alarm on the unit’s front cover.

2.09 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL

A. Permanently affix surge rating to the SPD.

B. Perform manufacturer's standard factory test:
   1. Perform testing in accordance with UL 1449.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Follow the manufacturer's recommended installation practices and comply with all applicable codes.

C. Special techniques:
   1. Install the SPD with as short and straight conductors including ground conductor as practically possible:
      a. Twist the input conductors together to reduce input conductor inductance.
   2. Do not subject SPD to insulation resistance testing.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16950 - Field Electrical Acceptance Tests.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16290

ELECTRICAL POWER MONITORING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Power meters.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. American National Standard Institute (ANSI):
   1. C12.20 - Electricity Meters - 0.2 and 0.5 Accuracy Classes.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. C57.13.6 - Standard for High Accuracy Instrument Transformers.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions:
   1. FS - Full Scale.
   2. RDG - Of Reading.
   3. SSM - Solid State Multifunction Power Meter.
   4. THD - Total Harmonic Distortion.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Power meter data including but not limited to:
      a. Power requirements.
      b. Communications protocols.
      c. Input/outputs.
      d. Dimensions.
      e. Measurement functions.
      f. Front panel controls.
      g. Display characteristics.

C. Operation and maintenance manuals:
   1. Descriptive and technical bulletins and sales aids edited to reflect only the equipment to be provided and covering each of the components in the system.

2. A maintenance section including all instruction leaflets and technical data necessary to setup, change setup and maintain the power meters.
3. Original licensed copies of all software and software manuals.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
1. Allen-Bradley.
2. Eaton.
3. Schneider Electric.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Power meters:
   1. Power meter type 2 (SSM2) device which shall include at a minimum:
      a. Individual phase currents, plus or minus 0.3 percent FS.
      b. Phase-to-phase and phase-to-neutral voltages, plus or minus 3 percent FS.
      c. Watts, VARs, VA, plus or minus 6 percent FS.
      d. Watt-hours 0.6 percent FS; VAR-hours 0.6 percent FS; VA-hours 0.6 percent FS.
      e. PF apparent 1 percent FS; PF displacement 1 percent FS.
      f. Frequency 0.17 percent FS.
      g. THD:
         1) Voltage - 31st harmonic.
         2) Current - 31st harmonic.
      h. Demand:
         1) Ampere, plus or minus 0.3 percent FS.
         2) Watt, VAR, VA, plus or minus 0.6 percent FS.
      i. Minimum and maximum values:
         1) Volts (L-L), volts (L-N), current (L), watts, VARs, VA.
         2) PF (apparent and displacement).
         3) Frequency.
         4) THD-amps, THD-volts.
         5) Demand:
            a) Ampere, watt, VAR, VA.
      j. Trend analysis:
         1) 2 selectable parameters.
      k. Other features:
         1) 3 form C relays, rated 10 amps.
      l. Synch-input kilowatt utility.
      m. Graphic LCD with LED backlight:
         1) Seven lines, 147 characters.
      n. Communications:
         1) Modbus TCP to PLC panel.

2.07 ACCESSORIES

A. Current transformers:
   1. Ring type current transformers:
      a. Suitable for service within low or medium voltage equipment as indicated on the Drawings.
      b. Designed to have a mechanical and thermal rating to withstand short-circuit current, stresses, and heating effects equal to the rating of the equipment of the application.
   2. Current ratio: As indicated on the Drawings, for use as a guideline:
      a. It is the manufacturer’s responsibility to size the current transformers to ensure that they will not saturate under the maximum available fault current at the installed location based upon the fault current study as specified in Section 16305 - Electrical System Studies.
   3. Rated in accordance with IEEE C57.13.6 with accuracy of the current transformers suitable for relay accuracy class and rated for 200 percent burden for the required connected devices.

4. Identify polarity with standard marking or symbols.
5. Capable of carrying rated primary current continuously without damage.
6. Install secondary wiring from current transformers in a suitable wiring trough, or conduit to proper short-circuiting type terminal blocks for connection to relays, instruments, and other devices.

B. Potential transformers:
1. Indoor dry type, single-phase, 60 hertz, with a minimum thermal capacity of not less than 400 volt-amperes at 55 Celsius rise above 40 Celsius ambient.
2. Accuracy classification determined in accordance with IEEE C57.13.6, suitable for relay accuracy class, and 200 percent burden, for the required connected devices, with the secondary voltage 120 volts.
3. Insulation levels as required for the equipment system voltage but not less than:
   a. 600 VAC, 10 kV BIL for 480 VAC systems.
   b. 5.6 KV, 60 kV BIL for 2300 and 4160 VAC systems.
   c. 15.5 KV, 110 kV BIL for 12.47 kV and 13.2 kV systems.
4. Identify polarity with standard markings or symbols.
5. Connect transformer secondary to potential buses as required.
6. Protect medium voltage potential transformers on the primary side with medium voltage current-limiting fuses.
7. Protect low voltage potential transformers on the primary side and secondary side with current-limiting fuses.
8. Mount medium voltage potential transformers in a separate compartment on a drawout device which, when in the FULLY WITHDRAWN position, disconnects both primary and secondary terminals of the transformer and grounds the primary potential fuses.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Install power meters in the electrical equipment as indicated on the Drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16305

ELECTRICAL SYSTEM STUDIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Short-circuit fault analysis study.
   2. Protective device coordination study.
   3. Arc-flash hazard study.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 1584 - IEEE Guide for Specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculations Study in Accordance with IEEE Std 1584(TM).

C. National Fire Protection Association (NFPA).

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. General study requirements:
   1. Scope:
      a. The short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall include all new and modified equipment in the power distribution system including, but not limited to:
         1) All electrical equipment including:
            a) New MCC-EPS.
            b) Modified MCC-A and modified panelboard in MCC-A.
            c) New Raw Sewage PS VFDs.
            d) New Effluent Pump VFDs.
            e) New pad mounted transformer XFMR-1.
            f) Modified medium voltage feeder to XFMR-1.
            g) Modified panelboards in maintenance building.
            h) Dry-type transformers.
            i) 240 and 208 volt panelboards.
         2) Motors.
         3) Vendor control panels.
         4) HVAC equipment.

b. Study scenarios:
1) The studies shall include all possible electrical system configurations, for example:
a) Operation on normal (utility) source.
b) Operation on generator source.

2. Obtain, for all equipment, the required data for preparation of the study including, but not limited to:
a. Transformer kilovolt-ampere (kVA) and impedances.
b. Generator impedances.
c. Generator decrement curves.
d. Bus withstand ratings.
e. Cable and bus data.
f. Protective device taps, time dials, instantaneous pickups, and time-delay settings.

3. Obtain the Electric Utility information on the minimum and maximum available fault current, minimum and maximum utility impedances, utility protective device settings including manufacturer and model number, interrupting ratings, X/R ratios, and model information one level above the point of connection:
a. Utility tolerances and voltage variations.

4. The individual performing the studies shall visit the site and collect all necessary field data in order to perform and complete comprehensive electrical system studies.

5. Obtain equipment layouts and configurations from the manufacturer's final submittal requirements and project layout drawings as required.

6. Bus and conductor data:
a. Use impedances of the actual installed or specified conductors, unless otherwise indicated.
b. Use cable and bus impedances calculated at 25 degrees Celsius, unless otherwise indicated.
c. Use 600-volt cable reactance based on typical dimensions of actual installed or specified conductors, unless otherwise indicated.
d. Use bus withstand values for all equipment having buses.
e. Use medium-voltage cable reactances based on typical dimensions of shielded cables with 133-percent insulation levels, unless otherwise indicated.

7. Motors:
a. Each motor shall be individually modeled:
1) Grouping of motors for fault contribution current is not acceptable.
b. Motors with variable frequency drives may be assumed to have no contribution to fault current.

8. Use the equipment, bus, and device designations as indicated on the Drawings for all studies.

B. Short-circuit fault analysis study additional requirements:
1. The short-circuit fault analysis shall be performed and submitted in 2 phases:
a. Initial short-circuit fault analysis:
1) Based on the Contract Documents and Electric Utility information.
2) The initial short-circuit fault analysis study shall indicate the estimated available short-circuit current at the line side terminals of each piece of equipment covered by the scope of the study.
3) Provide a list of assumptions used in the initial study.

b. Final short-circuit fault analysis:
1) The final short-circuit fault analysis shall modify the initial analysis as follows:
a) Utilize the actual equipment provided on the project.
b) Utilize conductor lengths based on installation.

2. Calculate 3-phase bolted fault, line-to-line fault, line-to-ground fault, double line-to-ground fault, short-circuit 1/2 cycle momentary symmetrical and asymmetrical RMS, 1-1/2 to 4 cycle interrupting symmetrical RMS, and 30-cycle steady-state short-circuit current values at each piece of equipment in the distribution system.
3. Evaluate bus bracing, short-circuit ratings, fuse interrupting capacity and circuit-breaker-adjusted interrupting capacities against the fault currents, and calculate X/R values:
a. Identify and document all devices and equipment as either inadequate or acceptable.
4. Calculate line-to-ground and double line-to-ground momentary short-circuit values at all buses having ground-fault devices.
5. Provide calculation methods, assumptions, one-line diagrams, and source impedance data, including utility X/R ratios, typical values, recommendations, and areas of concern.

C. Protective device coordination study additional requirements:
1. Furnish protective device settings for all functions:
1) Provide settings for all motor and generator protective relays based on the manufacturer's recommended protection requirements.
2. Provide log-log form time-current curves (TCCs) graphically indicating the coordination proposed for the system:
a. Include with each TCC a complete title and one-line diagram with legend identifying the specific portion of the system covered by the particular TCC:
1) Typical TCCs for identical portions of the system, such as motor circuits, are acceptable as allowed by the Engineer.
b. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics:
1) These details can be included on the TCC.
c. Include a detailed description of each protective device tap, time dial, pickup, instantaneous, and time delay settings:
1) These details can be included on the TCC.
3. TCCs shall include all equipment in the power distribution system where required to demonstrate coordination. Include utility relay and fuse characteristics, medium-voltage equipment protective relay and fuse characteristics, low-voltage equipment circuit breaker trip device characteristics, transformer characteristics, motor and generator characteristics, and characteristics of other system load protective devices:
a. Include all devices down to the largest branch circuit and largest feeder circuit breaker in each motor control center, main breaker in branch panelboards, and fused disconnect switches.
b. Provide ground fault TCCs with all adjustable settings for ground fault protective devices.
c. Include manufacturing tolerances and damage bands in plotted fuse and circuit breaker characteristics.

d. On the TCCs, show transformer full load currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and transformer damage curves.
e. Cable damage curves.
f. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed based on the short-circuit fault analysis study.
g. Coordinate time interval medium-voltage relay characteristics with upstream and downstream devices to avoid nuisance tripping.

4. Site generation: When site generation (including cogeneration, standby, and emergency generators) is part of the electrical system, include phase and ground coordination of the generator protective devices:
   a. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices.
5. Suggest modifications or additions to equipment rating or settings in a tabulated form.

D. Arc-flash hazard study additional requirements:
1. Include the calculated arc-flash boundary and incident energy (calories/square centimeter) at each piece of equipment in the distribution system:
   a. Perform study with 15 percent arcing fault variation as defined by IEEE 1584.
   b. Perform arc-flash calculations at minimum and maximum utility and generator fault contributions.
   c. Perform arc-flash calculations for both the line side and load side of the switchgear, switchboard, motor control center, and panelboard main breakers.
   d. Perform arc-flash calculations for all short-circuit scenarios with all motors on for 3 to 5 cycles and with all motors off.
2. Provide executive summary of the study results:
   a. Provide summary based upon worst case results.
3. Provide a detailed written discussion and explanation of the tabulated outputs:
   a. Include all scenarios.
4. Provide alternative device settings to allow the Owner to select the desired functionality of the system:
   a. Minimize the arc-flash energy by selective trip and time settings for equipment maintenance purposes.
   b. Identify the arc-flash energy based upon the criteria of maintaining coordination and selectivity of the protective devices.

E. Electrical system study meetings:
1. The individual conducting the short-circuit fault analysis, protective device coordination, and the arc-flash hazard studies shall meet with the Owner and Engineer 2 times.
2. The purpose of the 2 meetings is as follows:
   a. Initial meeting:
      1) Meet with the Owner and Engineer to discuss the scope of the studies:
         a) Confirm assumptions to be used in the electrical system study with the Owner including but not limited to:
            (1) Maximum protective device fault clearing time.

2) Discuss the Owner's operational requirements for both normal operation and maintenance.

b. Preliminary results meeting:
1) This meeting will be held after the studies have been completed, reviewed, and accepted by the Engineer.
2) The purpose of this meeting is to inform the Owner of the results of the study and impacts on normal operation and maintenance including:
a) Protective device coordination problems and recommended solutions.
b) Explanation of the arc-flash hazard study results and its potential impact on operations.
c) Recommendations for reduction of arc-flash category levels including reduction of protective device settings or changes in operational practices.

c. Deliver the final electrical system studies report.

3. The meetings will be at the Owner's facility or on a virtual meeting platform of the Owner's choice:
a. Provide a minimum of 3-weeks notice to the Owner and Engineer in advance of the projected meeting date.
b. Submit a draft of the meeting agenda when each meeting is requested.

4. Meeting materials:
a. Prepare and provide the following materials:
1) Meeting agenda. Include, at a minimum, the scope of the meeting, estimated time length for the meeting, and meeting goals.
2) 4 copies of the project one-line diagrams for the initial meeting.
3) 4 copies of the submitted studies.

F. By virtue of the fact that this is a professional study, the Owner reserves the right to modify the requirements of the study to comply with its operational requirements. The protective device coordination study and the arc-flash hazard study shall be modified based on the results of the meetings with the Owner.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Initial studies and reports:
1. Include the following in the initial short-circuit current report:
a. List of all devices included in the studies.
b. A description of all operating scenarios.
c. Form and format of arc-flash labels.

C. Final studies and reports:
1. Format and quantity:
a. Provide 6 bound copies of all final reports.
b. Provide 3 complete sets of electronic files on CD or DVD media, including the electrical system model(s), configuration files, custom libraries, and any other files used to perform the studies and produce the reports. Also provide an electronic version of the bound reports in PDF format.

c. Provide the number of copies specified in Section 01330 - Submittal Procedures.

2. Include the sections below in the final report:
   a. Copies of correspondence and data obtained from the electric utility company.
   b. Letter certifying the inspection and verification of existing equipment.
   c. One-line diagrams:
      1) The following information shall be included at a minimum:
         a) Motor horsepower.
         b) Transformer data:
            (1) kVA.
            (2) Configuration.
         c) Cable data:
            (1) Insulation.
            (2) Size.
            (3) Length.
      2) One-line diagrams shall be fully legible at 11-inch by 17-inch size.
   d. Include in the short-circuit fault analysis study:
      1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
      2) Normal system connections and those that result in maximum fault conditions.
      3) Tabulation of circuit breaker, fuse, and other protective device ratings compared to maximum calculated short-circuit duties.
      4) Fault current calculations for the cases run including a definition of terms and guide for interpretation of computer software printouts.
   e. Protective device coordination study shall include:
      1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
      2) List all requirements used in the selection and setting criteria for any protective devices.
      3) Manufacturer’s time-current curves for circuit breakers, fuses, motor circuit protectors, and other protective devices for all new equipment.
      4) TCCs graphically indicating the coordination proposed for the system on log-log graphs:
         a) All TCCs shall be in color.
      5) Tabulation of relay, fuse, circuit breaker, and other protective devices in graphical form with a one-line diagram to display area coordination.
      6) Where coordination could not be achieved, an explanation shall be included in the report to support the statement along with recommendations to improve coordination. Recommended equipment modifications or settings shall be in a tabulated form.
   f. Include in the arc-flash hazard study:
      1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
      2) Normal system connections and those that result in maximum arc-flash conditions.
      3) Arc-flash raw data, calculations, and assumptions.
      4) Arc-flash label data:
         a) Identifying the content of each label.
         b) Identifying the location of each label.

D. Certification:
   1. Submit written certification, sealed and signed by the professional engineer conducting the study, equipment supplier, and electrical subcontractor stating that the data used in the study is correct.

E. Submit the credentials of the individual(s) performing the study and the individual in responsible charge of the study.

F. The Engineer will review all studies and reports. After review, the Engineer will make recommendations and/or require changes to be made to the short-circuit fault analysis, protective device coordination, or arc-flash hazard studies. These changes shall be provided as part of the scope of work.

G. Submit course outline for Owner's training.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Qualifications of the entity responsible for electrical system studies:
   1. The studies shall be performed, stamped, and signed by a professional engineer registered in the state where the project is located.
   2. A minimum of 5 years of experience in power system analysis is required for the individual in responsible charge of the studies.
   3. The short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall be performed with the aid of a digital computer program:
      a. Point-to-point calculations are not acceptable.

C. The study shall be performed by an independent firm or the equipment manufacturer of MCC-EPS.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT/SITE CONDITIONS (NOT USED)

1.09 SEQUENCING

A. Site visit to gather data on the existing facility systems for all studies:
   1. Make multiple trips as required to obtain all data for the short-circuit fault analysis, protection device coordination, and arc flash hazard studies.

B. Submit the initial short-circuit fault analysis study before submittal of any electrical equipment.

C. Initial electrical system study meeting.

D. Submit the preliminary short-circuit fault analysis, protective device coordination, and arc-flash hazard studies.

E. Second electrical system study meeting for preliminary results.

F. Final arc-flash meeting and final short-circuit fault analysis, protective device coordination, and arc-flash hazard studies.

G. Label equipment with approved arc-flash labels.

H. Owner's training.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Update the Owner's existing SKM Systems Analysis, Powertools electrical system studies.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Arc-flash hazard labels:
   1. Dimensions:
      a. Minimum 5 inches by 3.5 inches.
   2. Materials:
      a. Polyester with polyvinyl polymer over-laminate.
      b. Self-adhesive.
      c. Resistant to:
         1) UV.
         2) Chemicals and common cleaning solvents.
         3) Scuffing.
         4) Wide temperature changes.
   3. Contents:
      a. Short-circuit bus identification.
      b. Calculated incident energy (calories/square centimeter) range:
         1) Based on worst-case study results.
      c. Arc-flash protection boundary.
      d. Shock hazard boundary:
         1) The Contractor may provide separate labels for indication of the shock hazard boundary.

4. Color scheme:
    a. For locations above 40 calories/square centimeter:
        1) White label with red “DANGER” strip across the top.
        2) Black lettering.
    b. For locations below 40 calories/square centimeter:
        1) White label with orange “WARNING” strip across the top.
        2) Black lettering.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. After review and acceptance of the arc-flash hazard study by the Engineer, install all arc-flash hazard labels:
    1. Install labels at all locations required by NFPA, ANSI, or IEEE standards.
    2. At a minimum, install labels in the following locations:
        a. The front of each main or incoming service compartment.
        b. The front of each low-voltage switchgear section.
        c. The front of each medium-voltage circuit breaker door.
        d. The front of each accessible auxiliary or conductor compartment.
        e. Each accessible rear or side vertical section.
        f. Each motor control center vertical section.
        g. Each panelboard covered by the study.
        h. Each control panel, individual starter or VFD, or other equipment covered by the scope of the study.
    3. Install labels prior to equipment energization.

C. After review and acceptance of the arc-flash hazard study and protective device coordination study by the Engineer, adjust protective device settings per final study prior to equipment energization.
    1. Devices that require power for configuration may be set during energization, but before any subfed loads are energized.
    2. Ensure that settings for upstream equipment are set prior to energizing downstream devices.

3.04 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

B. The individual performing the arc-flash hazard study shall direct the installation of the arc-flash hazard labels:
   1. Remove and replace any improperly applied labels.
   2. Repair the equipment finish damaged by removal of any label.
   3. Install labels level or plumb across the entire dimension of the label.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16411

DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Fusible and non-fusible disconnect switches.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. National Electric Manufacturer's Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment.
   2. KS 1-2001 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

C. Underwriters Laboratories Inc. (UL):
   1. 20 - General-Use Snap Switches.
   2. 98 - Enclosed and Dead-Front Switches.
   3. 508 - Standard for Industrial Control Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions:
   1. Safety switches and disconnect switches are to be considered synonymous.

1.04 SYSTEM DESCRIPTION

A. Provide heavy-duty type disconnect switches as indicated on the Drawings and specified in the Contract Documents.

B. Provide disconnect switches with the number of poles, voltage, current, short circuit, and horsepower ratings as required by the load and the power system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Manufacturer.
   2. Manufacturer's specifications and description.
   3. Ratings:
      a. Voltage.
      b. Current.

c. Horsepower.
d. Short circuit rating.
4. Fused or non-fused.
5. NEMA enclosure type.
6. Dimensions:
a. Height.
b. Width.
c. Depth.
7. Weight.

C. Shop drawings:
1. Manufacturer's installation instructions:
a. Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance, Regulatory Requirements below.
b. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
2. For each switch, indicate nameplate inscription, including voltage, circuit, fuse size (if applicable), and equipment served.

D. Installation instructions:
1. Provide anchorage instructions and requirement based on the seismic requirements at the Project Site as specified in Section 16050 - Common Work Results for Electrical and calculations:
a. Stamped by a professional engineer registered in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Regulatory requirements:
1. NEMA KS1- Enclosed and Miscellaneous Distribution Switches (600 V Maximum).
2. UL 98 - Enclosed and Dead-Front Switches.

C. Disconnect switches shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

A. Conduct the initial fault current study as specified in Section 16305 - Electrical System Studies and submit results for Engineer’s review.

B. After successful review of the initial fault current study, submit complete equipment submittal.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Schneider Electric.
   2. Eaton.
   3. GE by ABB.
   4. Siemens.
   5. Appleton.
   6. Crouse-Hinds.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Switch mechanism:
   1. Quick-make, quick-break heavy-duty operating mechanisms:
      a. Provisions for padlocking the switch in the OFF position.
      b. A minimum of 90-degree handle travel position between OFF and ON positions:
         1) Provide handle position indicators to identify the handle position.
      c. Full cover interlock to prevent opening of the switch door in the ON position and to prevent closing the switch mechanism with the door open:
         1) With an externally operated override.

B. Switch interior:
   1. Switch blades visible when the switch is OFF and the cover is open.
   2. Lugs:
      a. Front accessible.
      b. Removable.
      c. UL listed for 60/75-degree Celsius copper conductors.
   3. Current carrying parts completely plated to resist corrosion.
   4. Removable arc suppressors to facilitate easy access to line side lugs.

5. Furnish equipment ground kits for every switch.

C. Fused switches:
   1. Furnish with fuses as indicated on the Drawings:
      a. Provide fuses as specified in Section 16494 - Low Voltage Fuses.
   2. UL approved for field conversion from standard Class H fuse spacing to Class J fuse spacing:
      a. Ratings 100 amperes through 600 amperes at 240 volts.
      b. Ratings 30 amperes through 600 amperes at 600 volts.
      c. Provide spring reinforced and plated fuse clips.

D. Ratings:
   1. UL horsepower rated for AC or DC with the rating not less than the load served.
   2. Current:
      a. 30 to 1,200 amperes.
   3. Voltage:
      a. 250 volts AC, DC.
      b. 600 volts (30 A to 200 A, 600 volts DC).
   4. Poles:
      a. 2, 3, 4, and 6 poles.
   5. UL listed short circuit ratings:
      a. 10,000 RMS symmetrical amperes when used with or protected by Class H or K fuses (30-600 amperes).
      b. 200,000 RMS symmetrical amperes when used with or protected by Class R or J fuses (30-600 amperes employing appropriate fuse rejection).
      c. 200,000 RMS symmetrical amperes when used with or protected by Class L fuses (800-1,200 amperes).
   6. Where not indicated on the Drawings, provide switches with the NEMA ratings specified in Section 16050 - Common Work Results for Electrical for the installed location.

E. Size, fusing and number poles as indicated on the Drawings or as required:
   1. Provide solid neutral where indicated on the Drawings.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Disconnect switches to have provisions for a field installable “B” type electrical interlock for position indication as indicated on the Drawings.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:
   1. Use Myers hubs or bolt-on hubs for all conduit penetrations on NEMA Type 12, Type 4, and Type 4X enclosures.
   2. Provide all mounting brackets, stands, supports and hardware as required:
      a. Match finish and materials for all brackets, stands, and hardware with the switch installed.
      b. Provide adequate supporting pillar(s) for disconnect switches in accordance with the approved seismic calculations, and locate aboveground or above decks, where there is no structural wall or surface for box.
   3. When possible, mount switches rigidly to exposed building structure or equipment structural members:
      a. For NEMA Type 4 and Type 4X locations, maintain a minimum of 7/8 inch air space between the enclosure and supporting surface.
      b. When mounting on preformed channel, position channel vertically so that water may freely run behind the enclosure.
   4. Provide a nameplate for each disconnect switch:
      a. Provide per requirements specified in Section 16075 - Identification for Electrical Systems.
      b. Identify voltage, circuit, fuse size, and equipment served on the nameplate.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16412

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Low voltage molded case circuit breakers.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. National Electrical Manufacturers Association (NEMA):
   1. AB 3. - Molded Case Circuit Breakers and Their Application.

C. Underwriter's Laboratories (UL):
   1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
   2. 943 - Ground Fault Circuit Interrupters.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. In accordance with UL 489.

1.04 SYSTEM DESCRIPTION

A. Molded case thermal magnetic or motor circuit protector type circuit breakers as indicated on the Drawings and connected to form a completed system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Catalog cutsheets.
   2. Manufacturer's time-current curves for all molded case circuit breakers furnished.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Low voltage molded case circuit breakers shall be UL listed and labeled.

1.07 DELIVERY, STORAGE AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Eaton.
   2. GE by ABB.
   3. Schneider Electric.
   4. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. Conforming to UL 489.
   2. Operating mechanism:
      a. Quick-make, quick-break, non-welding silver alloy contacts.
      b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
      c. Mechanically trip free from the handle.
      d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
      e. Lockable in the "OFF" position.

3. Arc extinction:
    a. In arc chutes.
4. Voltage and current ratings:
    a. Minimum ratings as indicated on the Drawings.
    b. Minimum frame size 100A.
5. Interrupting ratings:
    a. Minimum ratings as indicated on the Drawings.
    b. Modify as required to meet requirements of the short circuit fault analysis - as specified in Section 16305 - Electrical System Studies.
    c. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.).

B. Motor circuit protectors:
1. Instantaneous only circuit breaker as part of a listed combination motor controller.
2. Each pole continuously adjustable in a linear scale with 'LO' and 'HI' settings factory calibrated.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Terminals:
1. Line and load terminals suitable for the conductor type, size, and number of conductors in accordance with UL 489.

B. Case:
1. Molded polyester glass reinforced.
2. Ratings clearly marked.

C. Trip units:
1. Provide thermal magnetic or solid-state trip units as indicated on the Drawings.
2. Thermal magnetic:
    a. Instantaneous short circuit protection.
    b. Inverse time delay overload.
    c. Ambient or enclosure compensated by means of a bimetallic element.
3. Solid state:
    a. With the following settings as indicated on the Drawings:
        1) Adjustable long time current setting.
        2) Adjustable long time delay.
        3) Adjustable short time pickup.
        4) Adjustable short time delay.
        5) Adjustable instantaneous pickup.
        6) Adjustable ground fault pickup as indicated on the Drawings.
        7) Adjustable ground fault delay as indicated on the Drawings.
        8) Energy reducing maintenance switch on breakers 1200 amps and above and on additional breakers as indicated in the Drawings.
            a) Indication on the breaker.

D. Provide ground fault trip devices as indicated on the Drawings.

E. Molded case circuit breakers for use in panelboards:
   1. Bolt-on type:
      a. Plug-in type breakers are not acceptable.
   2. Ground fault trip devices as indicated on the Drawings.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Test breakers in accordance with:
   1. UL 489.
   2. Manufacturer's standard testing procedures.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install breakers to correspond to the accepted shop drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING

A. Adjust trip settings in accordance with Protective Device Coordination Study as accepted by the Engineer and in accordance with manufacturer's recommendations.

B. Adjust motor circuit protectors in accordance with NEC and the manufacturer's recommendation based on the nameplate values of the installed motor.

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16422

MOTOR STARTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Motor starters and contactors.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. International Electrotechnical Commission (IEC):
   1. 60 947-4 - Low-Voltage Switchgear and Control Gear.
   2. 801-1 - Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment - Part 1: General Information.

C. National Electrical Manufacturer's Association (NEMA):
   1. ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 V.

D. Underwriters Laboratories (UL):
   1. 508 - Standard for Industrial Control Equipment.
   2. 508A - Standard for Industrial Control Panels.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions and abbreviations:
   1. FVNR: Full voltage non-reversing.
   2. RVSS: Reduced voltage solid state.
   3. Overload relay class: A classification of an overload relay time current characteristic by means of a number which designates the maximum time in seconds at which it will operate when carrying a current equal to 600 percent of its current rating.

1.04 SYSTEM DESCRIPTION

A. General requirements:
   1. Starters for motor control centers, individual enclosed starters, or control panels.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical:
   1. Submit motor starter data with equipment submittal.

B. Product data:
    1. Manufacturer.
    2. Catalog cutsheets.
    3. Technical information.
    4. Complete nameplate schedule.
    5. Complete bill of material.
    6. List of recommended spare parts.
    7. Confirmation that the overload relay class for each starter meets the requirements of the equipment and motor supplier.
    8. Electrical ratings:
        a. Phase.
        b. Wire.
        c. Voltage.
        d. Ampacity.
        e. Horsepower.
    9. Furnish circuit breaker submittals as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.

C. Shop drawings:
    1. Elementary and schematic diagrams:
        a. Provide 1 diagram for every starter and contactor.
        b. Indicate wire numbers for all control wires on the diagrams:
            1) Wire numbering as specified in Section 16075 - Identification for Electrical Systems.
        c. Indicate interfaces with other equipment on the drawings.

D. Operation and maintenance manuals:
    1. Submit complete operating and maintenance instructions presenting full details for care and maintenance of equipment furnished or installed under this Section. Including but not limited to:
        a. Electrical ratings:
            1) Phase.
            2) Wire.
            3) Voltage.
            4) Ampacity.
        b. Complete bill of material.
        c. Manufacturer’s operating and maintenance instructions starter and/or contactor component parts, including:
            1) Protective devices (fuses, breakers, overload relays, heater elements, etc.).
            2) Pilot devices.
        d. Complete renewal parts list.
        e. As-built drawings:
            1) Furnish as-built drawings for each starter and contactor indicating final:
                a) Wire numbers.
                b) Interfaces with other equipment.
            2) 11-inch by 17-inch format.

E. Certifications:
   1. Provide manufacturer's certification that the reduced voltage solid state starter will reliably control the acceleration and deceleration of the driven load at the installed conditions:
      a. Failure of the manufacturer to provide said certification will be interpreted to mean that the manufacturer has agreed that the reduced voltage solid state starter is matched to the driven load at the installed conditions and will function without fault.
      b. If the reduced voltage solid-state starter fails to perform as desired, replace or modify the reduced voltage solid-state starter in order to achieve the desired operational conditions, as directed by the Engineer.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Regulatory requirements:
   1. All starters and components shall be UL listed and labeled:
      a. UL 508 - Industrial Control Equipment.
      b. UL 508A - Industrial Control Panels.
   2. NEMA ICS 2 - Industrial Control and System Controllers; Contactors and Overload Relays Rated: 600 Volts.
   3. Combination starters shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

A. Conduct the initial fault current study as specified in Section 16305 - Electrical System Studies and submit results for Engineer's review.

B. After successful review of the initial fault current study, as specified in Section 16305 - Electrical System Studies, submit complete equipment submittal.

C. Conduct factory acceptance test.

D. Submit Manufacturer's Certificate of Installation and Functionality Compliance.

E. Ship equipment to the Project Site after successful completion of factory acceptance test.

F. Assemble equipment in the field.

G. Conduct field acceptance test and submit results for Engineer's review.

H. Submit manufacturer's certification that the equipment has been properly installed and is fully functional for Engineer's review.

I. Conduct Owner’s training sessions.

J. Commissioning and process start-up as specified in Section 01756 - Commissioning.

1.10 SCHEDULING

A. Reduced voltage solid state starters:
   1. Submit certification that the RVSS will reliably accelerate and decelerate the driven load at the installed conditions as part of the equipment submittal.
   2. RVSS start-up and testing by manufacturer after connection to equipment.
   3. RVSS training by manufacturer after start-up and testing, and before plant commissioning.

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

B. RVSS:
   1. Provide the services of the manufacturer's technical representative for start-up, adjustment, and troubleshooting, a minimum of 2 hours per starter at the Owner's facility.

1.13 OWNER’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Spare parts:
   1. Provide the following spare parts, suitably packaged and labeled with the corresponding equipment number:
      a. 1 spare fuse of each size and type per starter.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. NEMA starters and contactors:
      a. Eaton, no substitution or equal.
   2. Reduced voltage solid state starters:
      a. Eaton, no substitution or equal.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. Provide combination type starters with motor circuit protector or thermal-magnetic circuit breaker and control power transformer with ratings as indicated on the Drawings.
   2. NEMA size, design, and rated:
      a. NEMA Size 1 minimum.
   3. Coordinate motor circuit protector, thermal magnetic circuit breaker, or fusible disconnect, and overload trip ratings with nameplate horsepower and current ratings of the installed motor:
      a. If motors provided are different in horsepower rating than those specified or indicated on the Drawings, provide starters coordinated to the actual motors furnished.
   4. Provide starters NEMA Size 2 and larger with arc quenchers on load breaking contacts.
   5. Mount extended overload reset buttons to be accessible for operation without opening starter enclosure door.

B. Full voltage starters (FVNR):
   1. Across-the-line full voltage magnetic starters.
   2. Rated for 600 volts.
   3. Electrical characteristics as indicated on the Drawings.
   4. Provide positive, quick-make, quick-break mechanisms, pad lockable enclosure doors.
   5. Furnish starter with solid state electronic overload relays.
   6. Double-break silver alloy contacts.

C. RVSS:
   1. Manufactured and tested in accordance with the applicable requirements of IEEE, UL, and NEMA, including the following:
      a. Dielectric withstand per UL 508.
      b. Noise and RF immunity per NEMA ICS-2-230.
   2. Furnish with a motor circuit protector or thermal magnetic circuit breaker as indicated on the Drawings.
   3. Provide protection against internal faults and high SCR temperature during operation of the motor including starting, running (except when bypassed), and stopping modes.
   4. Capable of continuously delivering full rated current of the motor plus the motor service factor in ambient temperatures from 0 degrees Celsius to 40 degrees Celsius at the installed altitude.
   5. Provide a magnetically operated bypass contactor in parallel with the solid state starter:
      a. The bypass contactor to energize when the motor has reached full speed:
         1) The electronic overload protection circuits must be fully functional with the bypass contactor closed.
   6. RVSS control module requirements:
      a. Microcomputer based, and contains the required circuitry to drive the power semiconductors in the power section of the starter.
      b. Integrally mounted on the power section and requires no additional panel space or wiring.
      c. Mounted for easy wiring, testing, service, and replacement.

d. Provide 3-phase current sensing.
e. Quick disconnect plug-in connectors for current transformer inputs, line and load voltage inputs, and SCR gate firing output circuits.
f. Operates on power supplied from a control power transformer.
g. Phase insensitive or with phase rotation protection.
h. Control modes:
    1) Soft start with adjustable linear ramp time and a “kick start” or “boost” feature to provide a short time (typically 0.1 seconds) application of approximately full voltage.
    2) Soft start with adjustable linear ramp time, with a current limit:
        a) The current limit shall be adjustable over the range of 2 to 4 times normal full load current.
    3) Reverse voltage ramp (line voltage to zero voltage):
        a) Adjustable from 2 to 30 seconds to provide smooth stop.
        b) Automatic shutdown at end of voltage ramp.
i. Protective functions:
    1) Single phase protection.
    2) Under voltage protection.
    3) Short circuit electronic trip overcurrent protection. Time not to exceed 3 cycles.
    4) Inverse time running overcurrent protection.
    5) Auxiliary trip circuitry.
    6) Gate firing circuit lockout protection on trip.
    7) Jam and stall detection.
    8) Fault relay lockout protection.
    9) 100 percent to 130 percent full load running current trip adjustment.
    10) 100 percent to 450 percent of starting current limit adjustment.
    11) Dwell time at current limit with ramp continuation after acceleration.
    12) Individual light emitting diodes (LEDs) for trip and phase loss.
    13) Minimum and maximum initial starting voltage adjustments.
    14) Initial torque adjustment.

7. RVSS power section requirements:
    a. 3 sets of back-to-back phase controlled power semiconductors:
        1) Minimum repetitive peak inverse voltage of 1,500 volts at 480 VAC.
        2) Resistor/capacitor snubber networks to prevent false firing of the SCRs.
        3) Equipped with individual heat sink assemblies.
        4) Provide high-speed fuses for protection of the SCR stacks against short circuit conditions.
    b. Provide metal oxide varistors for surge protection on the line side power terminal connections:
        1) Rated for a minimum of 120 joules.
    c. Capable of supplying the following current levels:
        1) 600 percent of full load current for a minimum of 10 seconds.
        2) 450 percent of full load for a minimum of 30 seconds.
    d. Furnish ground lugs, one for incoming and one for outgoing ground connections.
    e. Furnish pressure type terminals for top or bottom entry power terminations.
8. Remote indicators:
    a. Provide Form C dry contacts for remote indication of:
        1) Internal fault error.

2) Undervoltage.
3) Overvoltage.
4) Phase reversal.
5) Phase loss.
6) Overload.
7) Frequency out of range.
8) Excessive starts per hour.
9) Drive electronics over temperature.
10) Stall.
11) Jam.
12) System failure.
13) Starter failure.
14) Run status.
15) Full speed.

9. Network communications: EtherNet/IP.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Molded case circuit breakers:
1. Circuit breaker type and ratings as indicated on the Drawings.
2. Provide as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.

B. Contactors:
1. NEMA size as indicated on the Drawings.
2. Electrically held:
a. For lighting loads designed to withstand the initial inrush currents of ballast and lamp loads.
3. Factory adjusted and chatter free.
4. Auxiliary contacts:
a. Contact ratings as per NEMA A 600 rating:
1) Auxiliary contacts rated 10 amps at 600 volts.
b. Provide all contacts indicated on the Drawings, and any additional contacts required for proper operation.
c. Provide at least 1 normally open and 1 normally closed spare auxiliary contact.
5. Constructed in accordance with the following standards:
a. UL 508.
b. IEC 947-4:
1) Type 1 coordination when protected by a circuit breaker.
2) Type 2 coordination when protected by a suitable UL listed fuse.
c. IEC 801-1 parts 2 through 6.

C. Overloads:
1. Solid state electronic with communications:
a. Selectable Class 5, 10, 20, 30 protection.
b. Motor current range:
1) As required by the equipment:
a) Provide current transformers external to the overload where required.

c. Protective functions:
    1) Load protection:
        a) Under current: Adjustable from 50 to 90 percent of motor full load amps with an adjustable 1 to 60 second delay.
        b) Low power: Adjustable from 20 to 80 percent of rated kW with an adjustable 1 to 60 second delay.
        c) High power: Adjustable from 50 to 110 percent of rated kW with an adjustable 1 to 60 second delay.
    2) Supply protection:
        a) Over voltage: Adjustable from 323 to 528 VAC with an adjustable 1-20 second delay.
        b) Under voltage: Adjustable from 323 to 528 VAC with an adjustable 1-20 second delay.
        c) Voltage imbalance: Adjustable from 1 to 20 percent with an adjustable 1 to 20 second delay.
    3) Motor protection:
        a) Jam: Adjustable from 150 to 400 percent of motor full load amps with an adjustable 1 to 20 second delay.
        b) Current imbalance: Adjustable from 1 to 30 percent with an adjustable 1 to 20 second delay.
        c) Current phase loss: Set at 60 percent an adjustable 1 to 20 second delay.
        d) Ground fault:
            (1) Adjustable from 0.3 to 2 amps for motor currents up to 5 amps.
            (2) Adjustable from 3 to 20 amps for motor currents from 5 to 90 amps.
            (3) Time delay based on the percentage of ground fault current:
                (a) Less than 150 percent: adjustable from 1 to 60 seconds.
                (b) Greater than 150 percent: 2 seconds.
                (c) Greater than 25 percent: 1 second.
        e) Phase reversal.
d. Manual or automatic reset:
    1) Automatic reset shall have an adjustable time delay and from 2 to 500 minutes and an adjustable fault reset attempts from 0 to 4 for motor protection and load protection faults.
    2) Supply faults shall have an adjustable 1 to 500 second reset delay.
e. Monitoring functions:
    1) Current:
        a) Per phase RMS with 2 percent accuracy.
        b) Average RMS with 2 percent accuracy.
        c) Imbalance percent.
    2) Voltage:
        a) Per phase RMS with 2 percent accuracy.
        b) Average RMS with 2 percent accuracy.
        c) Imbalance percent.
    3) Power:
        a) Motor kW with 5 percent accuracy.
        b) Power factor with 1 percent accuracy.
    4) Thermal capacity.

5) Motor run hours.
6) Frequency: 47 to 63 hertz with 1 percent accuracy.

f. User interface:
1) Provide the ability to set typically used parameters.
2) Trip pushbutton.
3) Reset pushbutton:
a) Shall have ability to be manually reset external to the overload.
4) LED status indicators.
5) Power, voltage, and current display LED display.

g. 120 VAC powered.

h. Output contacts:
1) B300 pilot duty.
2) Form C fault relay.
3) Form A ground fault relay.

i. Communications module:
1) Mounts to the side of the overload.
2) Provides network connection for programming and monitoring of the overload.
3) 4 discrete inputs:
a) 120 VAC.
4) 2 discrete outputs:
a) 1 form C, 1 form A.
b) Rated for 3A at 120 VAC.

2. Network communications: EtherNet/IP.

D. Control power transformer:
1. Furnish integral control power transformer capacity to power:
a. All motor controls; Motor and starter accessories indicated on the Drawings or specified.
2. Primary and secondary fusing as indicated on the Drawings:
a. Fusing sized by the manufacturer for the rating of the transformer furnished.
3. Control power transformer secondary voltage:
a. As indicated on the Drawings.

2.07 ACCESSORIES

A. Lugs and terminals:
1. For all external connections of No. 6 AWG and larger.
2. UL listed for either copper or aluminum conductors.

B. Surge protective devices:
1. Furnish surge protection devices across the coil of each starter, contactor, and relay.

C. Pilot devices:
1. Provide pilot lights, switches, elapsed time meters, and other devices as specified or as indicated on the Drawings.
2. As specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.

D. Nameplates and wire markers:
   1. As specified in Section 16075 - Identification for Electrical Systems.

E. Conformal coating:
   1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as protection against moisture, dust, temperature extremes, and chemicals such as H_2S and chlorine.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. RVSS starters:
   1. The manufacturer of the respective RVSS starter shall supply certified test results to confirm that the controller has been tested to substantiate designs according to applicable ANSI and NEMA standards.
   2. The tests shall verify not only the performance of the unit and integrated assembly, but also the suitability of the enclosure venting, rigidity, and bus bracing. In addition, the unit shall be factory tested in accordance with ANSI standards.
   3. The RVSS starter manufacturer shall test for noise immunity on both input and output power connections and provide test results to the Engineer. Noise testing shall be performed in accordance with NEMA ICS 2-230.40.

B. Programming and Data Exchange Coordination Meeting:
   1. Supplier shall on at least one occasion conduct a programming and data exchange coordination meeting at the Owner's facility.
   2. Coordination meeting shall include, but not be limited to, the following topics:
      a. Review of control descriptions.
      b. Power loss and restoration response.
      c. System networking and communication approach and data exchange include any specific requirements relating to Gateway supply and configuration.
      d. Ethernet switch configuration, IP Addressing and IP addressing scheme.
      e. Data exchange approach including data mapping criteria and formatting requirements.
      f. Factory acceptance testing procedures and expectations.
      g. Field services, support and testing procedures and expectations.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. Starters in motor control centers:
   1. Install as specified in Section 16444 - Low Voltage Motor Control Centers.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Factory testing:
   1. Owner and Engineer will witness the factory acceptance test as specified in Section 16050 - Common Work Results for Electrical.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

B. Set all overloads and motor circuit protectors based on the nameplate values of the installed motor.

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16444

LOW VOLTAGE MOTOR CONTROL CENTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Low voltage motor control centers.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. National Electrical Manufacturer's Association (NEMA):
   1. ICS 18-2001 - Motor Control Centers.

C. Underwriters Laboratories (UL):
   1. 845 - Motor Control Centers.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Factory assembled, factory wired and factory tested motor control centers:
   1. Motor control centers and major components to be products of a single manufacturer.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Manufacturer of motor control center.
   2. Manufacturer of motor control center parts.
   3. Nameplate schedule.
   4. Bill of material.
   5. Enclosure:
      a. NEMA rating.
      b. Finish color.
   6. Ratings:
      a. Voltage.
      b. Phase.
      c. Current:
         1) Horizontal bus ampacity.
         2) Vertical bus ampacity.
         3) Ground bus ampacity.

d. Short circuit withstand rating.
e. Protective device interrupting rating.

7. List of recommended spare parts.
8. Catalog cutsheets:
    a. Submit complete manufacturer's catalog information:
        1) Clearly indicate the features of the equipment including any options necessary to meet the required functionality.
9. Furnish component submittals as specified in the appropriate Section.
10. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050 - Common Work Results for Electrical:
    a. Manufacturer's statement of seismic qualification with substantiating test data.
    b. Manufacturer's special seismic certification with substantiating test data.

C. Shop drawings:
1. Layout drawings:
    a. Provide fully dimensioned and to scale layout drawings which include:
        1) Dimensions:
            a) Overall length.
            b) Overall width.
            c) Overall height.
            d) Overall weight and weight of individual shipping splits.
2. Interfaces to other equipment.
3. Shipping splits.
4. Allowable top and bottom conduit windows.
5. Complete component and unit layout drawings, including all control, networking and metering components.
6. Indicate lug sizes, type, and manufacturer based on the cable size specified in the Contract Documents and as indicated on the Drawings.
7. Elementary schematics:
    a. Provide one custom schematic diagram for each compartment:
        1) Include all remote devices.
        2) Show wire numbers on the schematics:
            a) Provide wire numbering as specified in Section 16075 - Identification for Electrical Systems.
8. External connection diagram showing the wiring to the external controls and devices associated with the motor control center.
9. One-line diagrams:
    a. Provide complete one-line diagrams for each motor control center, including but not limited to: protective devices, starters, drives, metering, and other equipment.

    Indicate electrical ratings of the equipment shown on the one-line diagrams.

D. Control descriptions and control logic program:
1. Provide control descriptions describing the full control functionality to be incorporated into the programmable overloads including the following:
    a. Functionality in local and remote.
    b. Software and hardware interlocks.
    c. Control response upon loss and restoration of power.
2. Provide complete register list of all IO available to the Plant PCS.

3. Submit the completed control logic program for each and every device supplied.
4. Submit a list of all networking address tables.
5. Submit configuration settings in accordance with actual motor and field equipment being supplied.

E. Installation instructions:
   1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
   2. For equipment installed in structures designated as seismic design category A or B:
      a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
   3. For equipment installed in structures designated as seismic design category C, D, E, or F:
      a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050 - Common Work Results for Electrical.
      b. Submit anchoring drawings with supporting calculations.
      c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

F. Operation and maintenance manuals:
   1. Provide complete operating and maintenance instructions presenting full details for care and maintenance of all types of equipment furnished and/or installed under this Section. Include the following:
      a. Electrical ratings:
         1) Phase.
         2) Wire.
         3) Voltage.
         4) Ampacity.
         5) Bus bracing and protective device interrupting ratings.
      b. Manufacturer's operating and maintenance instructions for the motor control center and all component parts, including:
         1) Starters.
         2) Overload relays and heater elements.
         3) Variable frequency drives.
         4) Protective devices including, but not limited to, fuses, circuit breakers and protective relays.
         5) Pilot devices.
      c. Complete renewal parts list.

G. Test forms and reports:
   1. Submit complete factory acceptance test procedures and all forms used during the test.
   2. Submit complete control description checklist and IO checklist organized by individual starter for use during the control logic portion of the factory acceptance testing as well as the witnessed field acceptance testing.

H. Manufacturer's Certificate of Installation and Functionality Compliance.

I. Record Documents:
   1. Elementary schematics:
      a. Furnish as-built elementary schematics indicating final:
         1) Wire numbers.
         2) Interfaces with other equipment.
      b. Provide one custom schematic diagram for each compartment:
         1) Include all remote devices.
         2) Show wire numbers on the schematics.
      c. Layout drawings: Provide complete dimensioned component and unit layout drawings.
   2. Programs and address tables.
   3. The Record Documents shall reflect all modifications made during the submittal review process and during construction.

J. Calculations:
   1. Detailed calculations or details of the actual physical testing performed on the motor control center to prove the motor control center is suitable for the seismic requirements at the Project Site.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. All portions of the motor control center, vertical bays, and components shall be UL listed and labeled.
   1. Where indicated as service entrance equipment, the motor control center shall be UL labeled and listed “Suitable for Service Entrance”.

1.07 DELIVERY, STORAGE AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Ship the motor control center and associated equipment to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize onsite off-loading equipment.

C. Furnish temporary equipment heaters within the motor control center to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

A. Conduct the initial fault current study as specified in Section 16305 - Electrical System Studies and submit results for Engineer’s review.

B. After successful review of the initial fault current study, as specified in Section 16305 - Electrical System Studies, submit complete equipment submittal.

C. Conduct Programming and Data Exchange Coordination Meeting.

D. Conduct factory acceptance test.

E. Submit Manufacturer's Certificate of Installation and Functionality Compliance.

F. Ship equipment to the Project Site after successful completion of factory acceptance test.

G. Assemble equipment in the field.

H. Conduct field acceptance test and submit results for Engineer's review.

I. Submit manufacturer's certification that the equipment has been properly installed and is fully functional for Engineer's review.

J. Conduct Owner's training sessions.

K. Commissioning and process start-up as specified in Section 01756 - Commissioning.

1.10 SCHEDULING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTION (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Eaton, no equal or substitutions.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. General:
   1. Furnish motor control centers as specified in the Contract Documents and indicated on the Drawings.

2. Arrange the equipped sections to form continuous motor control center lineups as indicated on the Drawings:
    a. Identify any deviations from the Drawings in writing and submit for approval.
3. Provide wire markers at each end of every wire as specified in Section 16075 - Identification for Electrical Systems.
4. Provide complete and functional motor control centers.
5. Provide devices or accessories not specified in this Section but necessary for the proper installation and operation of the equipment.

B. Design and construct motor control center to operate at the voltage level and configuration indicated on the Drawings.

C. Bus system:
1. Material:
    a. Tin-plated copper.
    b. Short-circuit rating:
        1) As indicated on the Drawings.
    c. Bus bar supports:
        1) High impact strength, non-tracking glass-polyester material that is impervious to moisture and gases.
2. Horizontal power bus:
    a. Current-carrying capacity as indicated on the Drawings.
    b. Mounting:
        1) Mount horizontal bus bars edgewise, one above the other, and fully isolated from all wireways and units.
    c. Temperature rise:
        1) In accordance with UL 845.
        2) De-rate the temperature rating of the bus for the specified conditions of ambient temperature and altitude as specified in Section 16050 - Common Work Results for Electrical.
3. Vertical power bus:
    a. Current-carrying capacity of not less than 600 amps.
    b. Mounting:
        1) Enclose the vertical bus in a polyester-glass cover with small openings to permit unit stabs to mate with the bus:
            a) Provide a shutter mechanism to cover the stab openings when plug-in units are removed.
        2) Provide top and bottom bus covers for insulation and isolation of the ends of the bus.
    c. Isolated from the unit compartments by a full height barrier.
4. Neutral bus:
    a. Provided in 4-wire motor control centers as indicated on the Drawings.
    b. Current carrying capacity of 100 percent of horizontal power bus.
    c. Mounting:
        1) Bus shall extend the full width of the motor control center.
    d. Pre-drilled and furnished with lugs for attachment of neutral conductors:
        1) Furnish a minimum of 50 percent spare lugs in each vertical section of motor control center.

5. Ground bus:
    a. Horizontal ground bus:
        1) Current-carrying capacity:
            a) 300 amps when the horizontal bus is 2,000 amps or less.
            b) 600 amps when the horizontal bus is greater than 2,000 amps.
        2) Mounting:
            a) Full-width, firmly secured to each vertical section structure:
                (1) Located in the top or bottom wireway.
            b) Pre-drilled and furnished with lugs for connection to equipment ground wires:
                (1) Furnish a minimum of 10 lugs per vertical section of MCC.
    b. Vertical ground bus.
        1) Mounting:
            a) Furnish in each vertical section.
            b) Bolted to the horizontal ground bus.
            c) Install parallel to the vertical power bus.
            d) Mount vertical ground bus such that plug-in units engage the ground bus before any connection to the power bus is made. Upon removal of plug-in units, ground stabs are disconnected from the ground bus after the power stabs have been disconnected.
6. Bus splice bars:
    a. Provided to join the bus at the splits.
    b. Connected to each horizontal bus bar with a minimum of two bolts.
    c. Employ conical or spring washers at connections, designed to maintain constant pressure against the splice joint.
    d. Same ampacity rating as the horizontal bus.

D. Enclosures:
1. Each motor control center shall consist of 1 or more vertical sections bolted together:
    a. Freestanding.
    b. Totally enclosed.
    c. Dead-front assembly.
    d. Designed for modification and/or addition of future vertical sections.
    e. Form each vertical section of heavy gauge steel.
2. Enclosure rating:
    a. Indoor:
        1) NEMA Type 1 gasketed.
3. Standard section dimensions:
    a. Nominal height: 90 inches.
    b. Nominal depth: 20 inches.
    c. Vertical section width as indicated on the Drawings.
4. Wireways:
    a. Provide each vertical section with a horizontal wireway at the top and bottom of the section:
        1) Arranged to provide a full-width metal enclosed wiring trough across the entire motor control center assembly.
    b. Provide each vertical section with a full-height vertical wireway.
    c. Completely isolated from the vertical and horizontal bus bars.
    d. Provide a removable, hinged door.

5. Shipping splits:
    a. No more than 3 vertical sections and not more than 60 inches in width.
    b. Solid bussing between vertical sections in a shipping split is not acceptable.
6. Lifting angles:
    a. Furnish each vertical section and/or shipping split with a removable lifting angle mounted to the top of the enclosure:
        1) Extending the entire width of the shipping split.
7. Mounting channels:
    a. Mount each vertical section and/or shipping split on an external 1.5-inch by 3-inch mounting channel.

E. Units:
1. A plug-in unit consists of:
    a. Unit assembly.
    b. Unit support pan.
    c. Unit door assembly.
2. Completely enclosed and isolated from adjacent units, buses, and wireways, except for conductor entries into the unit, by a metal enclosure.
3. Constructed so that any fault will be contained in the unit compartment.
4. Supported and guided by a removable unit support pan:
    a. Re-arrangement of units and the removal of a unit so that a new and possibly larger unit can be added without the removal of an in-service unit to gain access to the unit support pan.
5. Held in place by screws or other positive locking means after insertion.
6. Provide a test position with the unit supported in the structure but disengaged from the bus.
7. Integral plug-in ground stab.
8. Stabs:
    a. Free floating.
    b. Self-aligning.
    c. Backed by spring steel clips to ensure high pressure contacts.
    d. Electrolytically tin-plated copper.
9. Handle:
    a. Provide a flange mounted handle mechanism to operate each disconnect switch or circuit breaker.
    b. Door mounted operators or operator handles are not acceptable.
    c. Engaged with the disconnect device at all times as an integral part of the unit independent of the door position.
    d. Lockable in the “OFF” position with up to 3 padlocks.
    e. Mechanically interlocked so that the door cannot be opened with the handle in the “ON” position.
        1) Provide a means for qualified personnel to defeat this interlock.
    f. Interlocked so the unit cannot be inserted or withdrawn with the handle in the “ON” position.
    g. Lockable in the “ON” position:
        1) This shall not prevent the circuit breaker from operating and opening the contacts in the event of a fault condition.
    h. Color-coded to indicate position.
    i. Located so the center of the grip when it is in its highest position is not more than 6 feet 7 inches above the finished floor, including the height of the housekeeping pad and mounting channels.

10. Where indicated on the Drawings, provide units for spaces and future equipment:
    a. Equip these units to accept a future plug-in unit without modification to the vertical sections.

F. Motor control center networks:
1. General:
    a. Furnish each MCC with a factory installed network:
        1) Ethernet/IP.
    b. The network shall include a complete and tested cabling system compliant with applicable standards.
2. Ethernet networks:
    a. Ethernet switches:
        1) Provide managed Ethernet switches.
            a) Provide one switch in each MCC shipping split.
        2) Provide the number of switches required to connect each smart device in the MCC and one port for a customer connection.
        3) Provide an empty port for each space, spare and/or future device.
        4) Provide an Electronic Circuit Protector for Ethernet switches requiring a Class 2 power source.
        5) Manufacturers or equal:
            a) Hirschmann BRS-30.
            b) Cisco IE 4000.
            c) Rockwell Stratix 5700.
    b. Network architecture:
        1) Connect each device directly to an Ethernet switch.
            a) Ring or daisy-chained networks between the MCC devices are not allowed.
            b) Disconnecting or removing multiple devices shall not affect communications with the remaining devices.
    c. Power source:
        1) Accept Ethernet network power at voltage 24 VDC from nearby PCM-5.
        2) Provide each switch with a primary power disconnect.
    d. Ethernet cable:
        1) Shielding:
            a) Overall foil shield with foiled twisted pairs.
        2) Voltage rating:
            a) 600 VAC.
        3) Conductors:
            a) #23 AWG solid bare annealed copper.
            b) 4 Bonded pairs.
        4) Type:
            a) Cat 6.

2.06 COMPONENTS

A. Provide components contained within the motor control center as specified in:
1. Section 16075 - Identification for Electrical Systems.
2. Section 16123 - 600-Volt or Less Wires and Cables.
3. Section 16150 - Low Voltage Wire Connections.
4. Section 16290 - Electrical Power Monitoring.

5. Section 16272 - Dry-Type Transformers.
6. Section 16285 - Surge Protective Devices.
7. Section 16412 - Low Voltage Molded Case Circuit Breakers.
8. Section 16422 - Motor Starters.
9. Section 16445 - Panelboards.
10. Section 16494 - Low Voltage Fuses.

2.07 ACCESSORIES

A. Wiring:
   1. Wire the motor control center in accordance with the following NEMA Class and Type as defined by NEMA ICS 18-2001:
      a. NEMA Class II-S:
         1) Furnish wiring diagrams for individual units consisting of drawings that identify electrical devices, electrical connections, and indicate terminal numbering designations.
         2) Furnish individual unit diagrams with each unit and include inter-wiring between units, i.e., electrical interlocking, etc., as specifically specified in the Contract Documents.
         3) Provide custom drawings with unique terminal numbering designations in lieu of standard manufacturer drawings.
      b. NEMA Type B wiring:
         1) Control wiring:
            a) Type B-T pull-apart terminal blocks.
         2) Power wiring:
            a) Type B-T for Size 1 starters.
            b) Type B-T or B-D for Size 2 and 3 starters.
            c) Type B for Size 4 and larger starters and feeder units.

B. Lugs and terminals:
   1. For all external connections of No. 6 AWG wire or larger:
      a. UL listed for copper or aluminum conductors.
   2. Compression type, requiring a hydraulic press and die for installation.
   3. Provide 20 percent spare control block terminals.

C. Nameplates:
   1. Provide nameplates as specified in Section 16075 - Identification for Electrical Systems:
      a. Identifying the motor control center designation as indicated on the Drawings.
   2. Identifying each vertical section:
      a. Mounted and centered on the top horizontal wireway of the vertical section.
   3. Furnish individual nameplates for each unit indicated on the Drawings:
      a. 1 nameplate to identify the unit designation.
      b. 1 nameplate to identify the load served.
      c. Furnish space units with blank nameplates.
   4. Manufacturer’s labels:
      a. Furnish each vertical section with a label identifying:
         1) Serial number.
         2) Bus rating.
         3) Vertical section reference number.

4) Date of manufacture.
5) Catalog number of section.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finish metal surfaces and structural parts with phosphatizing, or equal, treatment before painting.

B. Finish interior surfaces including bus support angles, control unit back plates, and top and bottom barrier plates with baked white enamel.

C. Finish exterior of enclosure with manufacturer's standard gray.
   1. Finish NEMA Type 3R exterior cabinets with ultraviolet resistant enamel paint that is UL recognized for outdoor use.

2.11 SOURCE QUALITY CONTROL

A. Perform manufacturer's standard factory test on all motor control centers prior to shipment.

B. Programming and Data Exchange Coordination Meeting:
   1. Supplier shall on at least one occasion conduct a programming and data exchange coordination meeting at the Owner's facility.
   2. Coordination meeting shall include, but not be limited to, the following topics:
      a. Review of control descriptions.
      b. Power loss and restoration response.
      c. System networking and communication approach and data exchange include any specific requirements relating to Gateway supply and configuration.
      d. Ethernet switch configuration, IP Addressing and IP addressing scheme.
      e. Data exchange approach including data mapping criteria and formatting requirements.
      f. Factory acceptance testing procedures and expectations.
      g. Field services, support and testing procedures and expectations.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:
   1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories necessary to completely install the motor control center for the line, load, and control connections.
   2. Assemble and install the motor control center in the locations and with the layouts as indicated on the Drawings.
   3. Make bus splice connections.
   4. Perform work in accordance with manufacturer's instruction and shop drawings.
   5. Furnish all components, and equipment necessary to complete the installation.
   6. Replace hardware, lost or damaged during installation or handling, in order to provide a complete installation.
   7. Install the MCC on a raised concrete housekeeping pad:
      a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
         1) Remove the manufacturer's supplied mounting channels as required by the manufacturer's installation instructions.
      b. Weld and/or bolt the motor control center frame to leveling channels.

D. Provide openings in the top or bottom of the motor control center for conduit only.
   1. No additional openings will be accepted:
      a. Miscut holes will require that the entire vertical section or removable panel be replaced.
      b. No hole closers or patches will be accepted.

E. Bundle circuits together and terminate in each unit:
   1. Tie with nylon wire ties as specified in Section 16123 - 600-Volt or Less Wires and Cables.
   2. Label all wires at each end with wire markers as specified in Section 16075 - Identification for Electrical Systems as shown on the approved elementary schematics.

F. Programming and configuration:
   1. Manufacturer/supplier may contract with the project Programmer for portions of the tasks below.
   2. Provide all gateway communications between the MCC to the Owner's control system as required.
   3. Provide all configuration settings specific to each device.
   4. Provide all overload logic as indicated in the control descriptions.
   5. Configure all MCC mounted Ethernet switches, including performance and security settings, IP addresses and any other addressing tables required to provide a fully functioning system.
   6. Coordinate all IP addresses for all switches with the Owner.
   7. Coordinate data exchange approach for efficient communications to the Owner's control and maintenance systems. This effort will include a coordination meeting to discuss the data exchange approach including formatting and mapping. ICSC/Programmer shall attend witnessed testing.
   8. Provide source testing to prove out all Overload control logic as well as interaction with Owner's control and maintenance systems at the supplier's facility.

3.04 ERECTION, INSTALLATION, APPLICATION CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Source testing (Factory Acceptance Tests):
   1. Test the complete motor control center at the manufacturer’s establishment. Completely assemble, wire and test the motor control center:
      a. Detailed inspections before and after assembly to ensure correctness of design and workmanship.
   2. Provide groups of wires leaving the shipping-assembled equipment with terminal blocks with suitable numbering strips.
   3. Programming acceptance test:
      a. Programming acceptance test shall include the ICSC or Owner’s programmer.
      b. Test all gateway communications between the MCC to the Owner's control system as required.
      c. Test the functionality of all overload logic in accordance with the control descriptions.
      d. Test control response upon loss and restoration of power for every starter.
      e. Test configuration of all MCC mounted Ethernet switches, including performance and security settings, IP addresses and any other addressing tables required to provide a fully functioning system.
      f. Test and confirm all IP addresses for all switches and equipment in accordance with Owner’s IP addressing scheme.
      g. Test data exchange between each device to the Owner's control and maintenance systems. Confirm formatting and mapping criteria were followed.
         1) Data exchange approach and formatting and mapping criterial shall coordinate with the decisions made during the data exchange coordination meeting.
      h. Test each MCC network to ensure proper communications.

C. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Provide the services of a manufacturer’s representative to:
   1. Inspect, verify, and certify that the motor control center installation meets the manufacturer’s requirements.
   2. Test each MCC network to ensure proper communications.
   3. Test all gateway communications between the MCC to the Owner's control system as required.
   4. Test configuration of all MCC mounted Ethernet switches, including performance and security settings, IP addresses and any other addressing tables required to provide a fully functioning system.

5. Test and confirm all IP addresses for all switches and equipment in accordance with Owner’s IP addressing scheme.
6. Test data exchange between each device to the Owner's control and maintenance systems.
7. Load and test all configuration settings in accordance with actual motor and field equipment.
8. Test the functionality of all overload logic as well as interaction with Owner’s control and maintenance systems in accordance with the control descriptions.
9. Test control response upon loss and restoration of power for every starter.

3.09 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16445

PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Panelboards serving feeder circuits and branch circuits.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Underwriter's Laboratories, Inc. (UL):
   1. 67 - Standard for Panelboards.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Circuit breaker panelboards as indicated in the panelboard schedules, one-lines, and where indicated on the Drawings:
   1. Service voltage and configuration as indicated on the panel schedules.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Manufacturer of panelboard.
   2. Bill of material.
   3. Assembly ratings including:
      a. Voltage.
      b. Phase.
      c. Continuous current.
      d. Short circuit interrupting rating.
   4. NEMA enclosure type.
   5. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.
   6. Furnish circuit breaker submittals as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
   7. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050 - Common Work Results for Electrical:

a. Manufacturer’s statement of seismic qualification with substantiating test data.
b. Manufacturer’s special seismic certification with substantiating test data.

C. Shop drawings:
1. Drawings to contain:
a. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
1) Height.
2) Length.
3) Width.
b. Weight.
c. Anchoring locations.
d. Breaker layout drawing with dimensions:
1) Location of the main, branches, solid neutral, and ground.
e. Conduit entry/exit locations:
1) Identify all conduit entry/exit locations and restrictions.
f. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for every panelboard.

D. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.

E. Operations and maintenance manual:
1. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:
a. Including but not limited to:
1) Instruction narratives and bulletins.
2) Renewal parts lists.
3) Time-current curves for all devices.

F. Calculations:
1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic requirements at the Project Site.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Panelboards shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Eaton.
   2. GE by ABB.
   3. Schneider Electric.

B. Circuit breakers:
   1. Same manufacturer as the panelboard.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Provide panelboards with:
   1. Molded-case circuit breakers with trip ratings as shown on the panel schedules.
   2. Spares and spaces for future circuit breakers in panels as shown on the panel schedules.

B. Short circuit rating:
   1. Provide panelboards with short-circuit ratings as indicated on the Drawings:
   2. Testing method in accordance with UL 67.
   3. Mark each panelboard with its maximum short circuit rating at the supply voltage.
   4. Panelboards shall be fully rated.

2.06 COMPONENTS

A. Enclosure:

1. NEMA enclosure type as indicated on the Drawings.
    a. Where not indicated on the Drawings, as specified in Section 16050 - Common Work Results for Electrical for the installed location.
2. Minimum width: 20 inches.
3. Gutter space in accordance with the NEC:
    a. Minimum of 4 inches of gutter space.
4. Dead-front, no live parts when the panelboard is in service.
5. Enclose entire panelboard bus assembly in a corrosion resistant galvanized steel cabinet.
6. 4-piece front to provide ease of wiring access.
7. Lockable, hinged door over the protective devices with a flush, cylinder tumbler-type lock with catch and door pull:
    a. Minimum 2 keys per panelboard.
    b. Key all panelboard locks alike:
        1) Match locks on existing panelboards to the extent possible.
8. Circuit directory frame and card on the inside of the door.
9. Door-in-door construction consists of a one-piece front with 2 doors:
    a. The smaller door provides access to all device handles and rating labels and shall be lockable.
    b. The larger door provides access to all conductors and wiring terminals.
10. Interior design such that replacement of circuit breakers does not require disturbing adjacent units or removal of the main bus connectors.

B. Bus:

1. General:
    a. Tin-plated copper.
2. Phase bus:
    a. Full size and height without reduction.
    b. Dimensions and temperature rise in accordance with UL 67:
        1) Limit current density to less than 1,000 amps per square inch.
    c. Insulate all current carrying parts from ground and phase-to-phase with a high dielectric strength insulator.
3. Ground bus:
    a. Copper, solidly bonded.
4. Neutral bus:
    a. Provide where indicated on the Drawings.
    b. 100 percent rated.
    c. Provide lugs for each outgoing feeder requiring a neutral connection.
5. Provide insulation barriers over the vertical bus behind the dead front shield to provide increased safety during field service.

C. Lugs:

1. UL listed for copper and aluminum wire:
    a. Provide lugs rated for 75-degree Celsius terminations.
    b. Provide bolted or compression main lug terminations as required for the incoming cable size.

D. Circuit breakers: As specified in Section 16412 - Low Voltage Molded Case Circuit Breakers and as indicated on the Drawings:
    1. Provide all circuit breakers with bolt-on connections:
        a. Plug-in circuit breakers are not allowed.

2.07 ACCESSORIES

A. Surge protective devices:
    1. Furnish panelboards with surge protective devices as indicated on the Drawings.
    2. As specified in Section 16285 - Surge Protective Devices.

B. Nameplates:
    1. As specified in Section 16075 - Identification for Electrical Systems.
    2. Install on outside of door.
    3. Indicating:
        a. Panel designation.
        b. Voltage.
        c. Number of phases and configuration.

C. Circuit identification labels:
    1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.
    2. Type all information on the cards using designations in the panel schedules.
    3. Laminated on both sides.

D. Pad locking mechanism:
    1. Provide a pad locking attachment to allow circuit breakers to be locked in the off position.
    2. At a minimum, provide 1 mechanism per panelboard:
        a. Provide multiple mechanisms if required to accommodate all circuit breaker frame sizes in the panelboard.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finish stand-alone panelboards with a primer, rust-resistant phosphate undercoat, and 2 coats of oven-baked enamel with manufacturer’s standard gray.

B. Finish panelboards mounted in motor control centers to match the motor control center finish and color.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:
   1. MCC mounted as indicated on the Drawings.
   2. Perform work in accordance with the manufacturer's instructions and shop drawings.
   3. Mount panelboard so that top operating handle is not more than 6 feet-7 inches above the operating floor.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Factory testing:
   1. Perform standard factory tests on the panelboards:
   2. Test in accordance with the latest version of NEMA and UL standards.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES

A. Circuiting within the panelboard shall match the panel schedules as indicated on the Drawings.

B. Provide typewritten schedule in each panelboard.

END OF SECTION

SECTION 16494

LOW VOLTAGE FUSES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Fuses: 600 volt class and lower.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Fuses for overcurrent protection and/or current limiting applications as indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Catalog cut sheets.
   2. Complete fuse schedule.
   3. Manufacturer original 11-inch by 17-inch, time current curves for all fuses furnished.

C. Shop drawings:
   1. Include drawings of spare fuse cabinets.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. All low voltage fuses shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Spare parts:
   1. Provide 3 spare fuses for each size and type used or supplied under any Section of the Contract Documents.
   2. Provide spare fuse cabinet(s):
      a. Metal cabinet with hinged door and shelves or fuse holders.
      b. Gray enamel finish.
      c. Mount near equipment and label "Spare Fuses" on face of cabinet.
      d. Suitable pocket inside door of each cabinet with typewritten spare fuse inventory in clear plastic protective insert.
      e. Provide as many cabinets as required to hold entire spare fuse inventory.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Ferraz Shawmut.
   2. Littelfuse.
   3. Bussmann.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. Provide durable, readily visible label inside each fuse enclosure, clearly indicating the correct type, size, and ratings of replacement fuse:
      a. Label shall not cover or interfere with equipment manufacturer's instructions.
   2. Affix a label indicating recommended torque for fuse mounting bolts or studs to the inside of fuse access doors.
   3. To ensure selective coordination of protective devices:
      a. Provide fuses for new facilities by the same manufacturer.
      b. Provide fuses for renovations of the same manufacturer as existing fuses.

4. Provide fuses rated for the voltage and available short circuit current at which they are applied.

B. Fuses for feeders:
   1. 600 amperes and less:
      a. Provide UL listed RK1 dual-element, time-delay fuses with ampere ratings as indicated on the Drawings except as may be modified by the Contract Documents.
   2. 601 to 6,000 amperes:
      a. Provide UL listed Class L fuses.

C. Fuses for motor branch circuits:
   1. Ampere ratings shall not exceed motor controller manufacturer's recommended values:
      a. If manufacturer does not have such standards, provide fuses as specified in this Section.
   2. Provide Class RK1 fuses or fuses as indicated on the Drawings and as specified in the Contract Documents, rated in accordance with the fuse manufacturer's recommendations for backup running protection of motor circuits containing overload relays.
   3. Determine fuse ratings for overload protection of motor branch circuits by actual full-load currents of motors provided.
   4. Fuses in motor control centers may be time-delay Class J or Class CC fuses, if MCC manufacturer's standard designs use these fuse types:
      a. Time-delay Class J fuse ratings shall not exceed 150 percent of motor full load current except as permitted.
      b. Follow fuse manufacturer's recommendations for Class CC fuses.
      c. A motor having starting duty or other special characteristics requiring larger fuses than specified above, may have branch circuit fuse ratings increased as necessary to meet motor's requirements, but no larger than maximum permitted by the NEC:
         1) Increased requirements for an individual motor shall not be cause for increasing size of all fuses.
   5. Provide Class L fuses for motor branch circuits requiring fuses over 600 amperes, sized at 150 percent of motor full load current except as permitted below:
      a. A motor having starting duty or other special characteristics requiring larger fuses than specified above, may have branch circuit fuse ratings increased as necessary to meet motor's requirements, but no larger than maximum permitted by the NEC:
         1) Increased requirements for an individual motor shall not be cause for increasing size of all fuses.

D. Fusing of control circuits:
   1. Provide:
      a. Time-delay Class CC fuses installed in UL listed Class CC fuse blocks as specified in the Contract Documents.
   2. Provide minimum protection for control circuits in accordance with the latest revision of UL Standard 508 for Industrial Control.
   3. Fuse both the primary and secondary circuit of control power transformers:
      a. Fuse ratings shall be in accordance with NEC requirements.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. General:
   1. Install fuses properly aligned, electrically and mechanically secure.
   2. Evenly torque mounting bolts and nuts to ASTM recommendations for type and diameter of mounting bolts or studs provided.
   3. Paralleling of fuses is not permitted.
   4. Install fuses so that the fuse nameplate and rating are easily readable in the equipment.

C. Replace fuses, on all phases, for any fuses that opened during start-up and testing.

D. After completion of testing, deliver spare fuses in quantities specified:
   1. Fuses shall be new, in manufacturer's original packaging, and stored in a clean, dry location.

E. Install spare fuse cabinets where instructed by the Owner.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16510

LIGHTING: LED LUMINAIRES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: LED luminaires, drivers, and accessories.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Illuminating Engineering Society of North America (IESNA):
   1. LM-79 - IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.
   2. LM-80 - IES Approved Method: Measuring Lumen Maintenance of LED Light Sources.
   3. TM-21 - Projecting Long Term Lumen Maintenance of LED Light Sources.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.

D. National Electrical Manufacturers Association (NEMA):
   1. 410 - Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts.

E. Underwriters Laboratories (UL):
   1. 1598 - Luminaires.
   2. 8750 - Light Emitting Diode (LED) Equipment For Use In Lighting Products.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions and abbreviations:
   1. CCT: Correlated color temperature - Scientific scale to describe how “warm” or how “cool” the light source is, measured in Kelvin. The lower the Kelvin temperature, the warmer the light feels, or appears.
   2. CRI: Color Rendering Index - A quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source.
   3. Driver - Device that manages power and controls the current flow from AC to DC for an LED lighting product.
   4. Efficacy - Lumen output of a light source per unit of power supplied to that source (lumens per watt).
   5. EMI: Electromagnetic Interference - Electrical interference (noise) generated by electrical and electronic devices.
   6. FC: Foot Candles - Measure of light level on a surface being illuminated.

7. L70 - The extrapolated life in hours of the luminaire when the luminous output depreciates 30 percent from initial values.
8. LED: Light emitting diode - A solid-state semiconductor device that produces light when electrical current flows through it.
9. LED light source - See LED luminaire.
10. LED luminaire - A complete lighting unit consisting of LED-based light emitting elements and a matched driver together with parts to distribute light, to position and protect the light emitting elements, and to connect the unit to a branch circuit.
11. Lumen - The international (SI) unit of luminous flux or quantity of light. The amount of light that is spread over a square foot of surface by one candle power when all parts of the surface are exactly one foot from the light source.
12. Lumen ambient temperature multiplier - LED light source relative lumen output when compared to a standard ambient temperature.
13. Lumen maintenance factor - How well an LED light source is able to retain its intensity when compared to new.
14. Luminaire - Lighting unit.
15. THD: Total harmonic distortion - The combined effect of harmonic Distortion on the AC waveform produced by a driver or other device.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. LED Luminaires:
      a. Catalog literature for each luminaire specified, cross-referenced to the luminaire type on the Luminaire Schedule in the Drawings.
      b. Provide for each luminaire type:
         1) Materials.
         2) Type of diffuser.
         3) Hardware.
         4) Gasketing.
         5) Reflector.
         6) Chassis.
         7) Finish and color.
         8) Driver type and protection.
         9) LED luminaire:
            a) Initial lumen output at 40 degrees Celsius ambient.
            b) Correlated color temperature.
            c) Lumen maintenance factors.
            d) Lumen ambient temperature multipliers.
            e) Drive current.
            f) Efficacy.
         10) Picture of luminaire.
         11) IES optical distributions.
         12) Weight.
         13) Photometric data:
            a) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
            b) Luminaire dirt depreciation factor.

c) Candlepower distribution curves.
d) Average luminaire brightness.
e) Lumen output charts.

14) Furnish support method for interior luminaires weighing more than 30 pounds and all wall-mounted luminaires:
a) Support methods shall be based on seismic requirements at the project site as specified in Section 16050 - Common Work Results for Electrical.

c. Luminaire substitutions:
1) Provide complete literature for each luminaire substitution:
2) Submittals for substituted luminaires shall be sufficient for competent comparison of the proposed luminaire to the originally specified luminaire:
a) Photometric data:
(1) IES file in standard IES format.
(2) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
(3) Candlepower distribution curves.
(4) Average luminaire brightness.
(5) Lumen output charts.
(6) Power requirements in watts and volt-amperes.
b) Calculations:
(1) Provide software generated calculations showing illuminance levels in footcandles and power usage in watts per square foot for each of the areas in which substitutions are proposed:
(a) Use surface reflectance values and luminaire light loss factors approved by the Engineer to perform all calculations.
c) Specification sheets:
(1) If lacking sufficient detail to indicate compliance with contract documents, standard specification sheets will not be accepted. This includes, but is not limited to, luminaire type designation, manufacturer's complete catalog number, voltage, LED type, CCT, CRI, specific driver information, system efficacy, L70 life rating, and any modifications necessary to meet the requirements of the contract documents.
3) Substitutions for specified luminaires will be evaluated upon quality of construction, light distribution, energy use, appearance, and maintenance.
4) Substitutions shall comply with all applicable building and energy codes.

2. Driver: Provide for each driver type:
a. Catalog number.
b. Type of driver.
c. Output wattage.
d. Input voltage.
e. Operating voltage range.
f. Maximum input power.
g. Efficiency.
h. Operating line current.

i. Power factor.
j. Operating temperature range.
k. Current output range in ambient temperatures of 30 to 55 degrees Celsius.
l. Surge suppression data.

3. Photocell:
   a. Provide for each photocell type:
      1) Switching capacity.
      2) Life expectancy when used on LED sources.
      3) The means of adjusting the lighting pickup level.
      4) Enclosure type.
      5) Mounting method.

C. Record documents:
   1. Update the Luminaire Schedule in the Drawings to reflect the acceptable substitutions, after the substitution has been reviewed and accepted by the Engineer.

1.05 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 SEQUENCING (NOT USED)

1.09 SCHEDULING

A. Exterior and outdoor lighting system operation shall be demonstrated during the hours of darkness.

B. Lighting demonstration shall occur within 2 weeks before substantial completion.

1.10 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

B. LED luminaire:
   1. 5 year warranty from the date of installation including material, workmanship, photometrics, driver, and LED modules.

1.11 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 OWNER’S INSTRUCTIONS (NOT USED)

1.13 MAINTENANCE

A. Furnish 1 complete spare LED luminaire, with driver, of each type used.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Luminaires:
   1. The following or equal:
      a. As noted on the Luminaire Schedule.

B. Drivers:
   1. One of the following or equal:
      a. Philips Advance.
      b. Thomas Research.
      c. eldoLED.

C. Substitutions:
   1. The lighting design and luminaire selection has been based upon the photometric data of the identified luminaire. It is the Contractor's responsibility to ensure and prove to the Engineer at time of submittal the substitutions meet the quality and photometric requirements of the original design.

2.02 SYSTEM DESCRIPTION

A. Provide luminaires, and accessories for all lighting systems, complete and operable, in accordance with the requirements of the Contract Documents.

B. Individual luminaire types are indicated on the Drawings and on the Luminaire Schedule.

2.03 EXISTING PRODUCTS (NOT USED)

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

A. LED Luminaires:
   1. General:
      a. Pre-wired with leads of 18-AWG, minimum, for connection to building circuits.
      b. Provide the luminaires furnished per the Luminaire Schedule in the Drawings:
         1) The Specifications noted in this Section are an addition or supplement to the Luminaire Schedule.
      c. Individual LEDs connected such that a catastrophic loss or the failure of 1 LED will not result in the loss of the entire luminaire.
   2. Minimum ambient temperature range of 0 degrees Celsius to 40 degrees Celsius.

3. Minimum rated life:
    a. Office Areas: 70,000 hours when operated at 25 degrees Celsius.
    b. Process Areas: 60,000 hours when operated at 40 degrees Celsius.
    c. Hazardous Areas: 50,000 hours when operated at 40 degrees Celsius.
4. Minimum efficacy of 70 lumens/watt:
    a. Hazardous Areas: Minimum 60 lumens/watt.
5. Minimum Color Rendering Index of 70.
6. Tested according to IESNA LM-79 and LM-80.
7. Lumen maintenance projection in accordance with IESNA TM-21.
8. RoHS compliant.
9. Integral driver.
10. Suitable for dry, damp, or wet locations as indicated on the Drawings or on the Luminaire Schedule:
    a. Wet or damp locations: UL 1598 listed.
11. Designed as a complete LED assembly. Retrofit LED lamps in luminaires not designed specifically for LED light sources shall not be used.
12. Exterior/outdoor luminaires:
    a. Luminaires in combination with their mounting pole and bracket shall be capable of withstanding:
        1) Wind levels at the project site without damage.
        2) Seismic levels at the project site.
    b. Corrosion-resistant hardware and hinged doors or lens retainer.
    c. Luminaires furnished with integral photoelectrical control shall be of the luminaire manufacturer's standard design.
    d. California Energy Code Light Pollution Reduction Compliance:
        1) Provide all exterior luminaires with cutoff photometrics:
            a) Luminaire design shall allow no more than 0.01 horizontal footcandles to escape beyond the site boundary.
        2) Provide exterior luminaires with photocells to automatically control exterior lighting dusk to dawn to turn off or lower the lighting levels during inactive periods. Reference the Drawings for specific luminaires to be controlled.

B. Photo-electric cells:
    1. Photoelectric cell for control of a single luminaire:
        a. Integral to the luminaire.

C. Luminaire control:
    1. Lighting control relays or contactors as specified in Section 16422 - Motor Starters.

D. Drivers:
    1. Dimmable, with dimming signal protocol of 0-10 VDC or DALI.
    2. Input power source:
        a. As indicated on the Drawings.
    3. Drive current:
        a. As indicated in the Luminaire Schedule.
    4. Power factor: greater than 0.90.
    5. Efficiency: greater than 80 percent.
    6. Total harmonic distortion (THD) of the input current less than 20 percent.
    7. Rated life of 60,000 hours in an LED luminaire operated at an ambient temperature of 40 degrees Celsius.

8. Minimum operating temperature of 0 degrees Celsius.
9. Sound rating: Class A+ or quieter.
10. UL listed Class 2 Outdoor in accordance with UL 8750.
11. In accordance with IEEE C62.41 Category A for transient protection.
12. Driver must limit inrush current:
    a. Meet or exceed NEMA 410 driver inrush standard:
        1) 230 Amps per 10 Amp load with a maximum of 106 Amps squared- seconds at 120V.
        2) 430 Amps per 10 Amp load with a maximum of 370 Amps squared- seconds at 277V.

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES (NOT USED)

2.09 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Install luminaires per the manufacturer's guidelines and submitted installation calculations to meet seismic and wind requirements at the project site.

C. Special techniques:
    1. Support luminaires from structural elements capable of carrying the total weight.
    2. Install luminaires plumb and square with building and wall intersections:
        a. Suspend pendant-mounted luminaries that are mounted from sloping ceilings with ball hangers, unless otherwise indicated on the Drawings.
        b. Install luminaires in machinery rooms after machines have been installed, so as to ensure no conflict with machinery, piping, or ductwork.
    3. In all cases, coordinate luminaire locations with work of other trades to prevent obstruction of light from the fixtures:
        a. Locate bottom of luminaire approximately at the bottom of ductwork, unless otherwise specified or indicated on the Drawings.
    4. Support luminaires weighing more than 25 pounds independently of the outlet box and the conduit.
    5. Provide ceiling or pendent mounted luminaires with a safety chain connecting the lens, driver, and other components to the building structure.

6. Provide recessed luminaires with auxiliary safety supports attached directly to the building structure:
    a. The safety supports shall consist of number 12 AWG soft drawn galvanized wires.
7. Install luminaires in accordance with the architectural reflected ceiling Drawings:
    a. Center luminaires on ceiling tiles unless otherwise indicated.
8. Support luminaires installed in suspended grid ceilings, independently of the grid:
    a. Provide seismic restraint clips for all luminaires installed in suspended grid ceilings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING

A. Aim and verify all exterior and outdoor luminaires alignment, during dark evening hours, as directed by Owner or the Engineer.

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Clean all lenses, diffusers, and reflectors.

C. Refinish all luminaires' trim, poles, and support brackets, where finish has been damaged.

D. Clean all LED luminaires (new and old), used during construction for construction lighting, before substantial completion.

E. Clean and re-lamp all existing fluorescent and HID luminaires used during construction for construction lighting, before substantial completion.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES

A. Refer to the Luminaire Schedule in the Drawings.

END OF SECTION

SECTION 16950

FIELD ELECTRICAL ACCEPTANCE TESTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Responsibilities for testing the electrical installation.
   2. Adjusting and calibration.
   3. Acceptance tests.

B. Copyright information:
   1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc. (NETA). See NETA publication ATS for details.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. American National Standards Institute (ANSI).

C. ASTM International (ASTM):
   1. D877 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
   2. D923 - Standard Practices for Sampling Electrical Insulating Liquids.
   3. D924 - Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
   4. D971 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
   5. D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
   6. D1298 - Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
   7. D1500 - Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
   8. D1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field.
   9. D1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
   10. D2285 - Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop Weight Method.
   11. D3612 - Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.

D. Institute of Electrical and Electronics Engineers (IEEE):
   1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
   2. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.

3. C57.13 - IEEE Standard Requirements for Instrument Transformers.
4. C57.13.1 - IEEE Guide for Field Testing of Relaying Current Transformers.
5. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
6. C57.104 - IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.

E. Insulated Cable Engineer's Association (ICEA).

F. InterNational Electrical Testing Association (NETA).
1. ATS- Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.

G. International Electrotechnical Commission (IEC).

H. Manufacturer's testing recommendations and instruction manuals.

I. National Fire Protection Association (NFPA):
1. 70 - National Electrical Code (NEC).
2. 110 - Standard for Emergency and Standby Power Systems.

J. National Institute of Standards and Technology (NIST).

K. Specification sections for the electrical equipment being tested.

L. Shop drawings.

1.03 DEFINITIONS

A. As specified in Sections 01756 - Commissioning and 16050 - Common Work Results for Electrical.

B. Specific definitions:
1. Testing laboratory: The organization performing acceptance tests.

1.04 SYSTEM DESCRIPTION

A. Testing of all electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.

B. Conduct all tests in the presence of the Engineer or the Engineer's representative:
1. Engineer will witness all visual, mechanical, and electrical tests, and inspections.

C. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.

D. Responsibilities:
1. Contractor responsibilities:
a. Ensure that all resources are made available for testing, and that all testing requirements are met.
2. Electrical subcontractor responsibilities:
a. Perform routine tests during installation.

b. Demonstrate operation of electrical equipment.
c. Commission the electrical installation.
d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:
    1) Providing electrical power as required.
    2) Operating of electrical equipment in conjunction with testing of other equipment.
    3) Activating and shutting down electrical circuits.
    4) Making and recording electrical measurements.
    5) Replacing blown fuses.
    6) Installing temporary jumpers.

3. Testing laboratory responsibilities:
    a. Perform all acceptance tests specified in this Section.
    b. Provide all required equipment, materials, labor, and technical support during acceptance tests.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. LAN cable test form:
1. LAN cable test reports:
    a. Submit 3 copies of test reports showing the results of all tests specified in this Section:
        1) Test type.
        2) Test location.
        3) Test date.
        4) Cable number.
        5) Cable length.
        6) Certification that the cable meets or exceeds the specified standard.
    b. Furnish hard copy and electronic copy for all traces.

C. Manufacturers' testing procedures:
1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer prior to beginning testing.

D. Test report:
1. Include the following:
    a. Summary of Project.
    b. Description of equipment tested.
    c. Description of tests performed.
    d. Test results.
    e. Conclusions and recommendations.
    f. Completed test forms.
    g. List of test equipment used and calibration dates.
    h. LAN cable test reports.

E. Test data records:
1. Include the following:
    a. Identification of the testing organization.

b. Equipment identification.
c. Nameplate data.
d. Humidity, temperature and or other conditions that may affect the results of the tests and or calibrations.
e. Dates of inspections, tests, maintenance and or calibrations.
f. Indication of the inspections, tests, maintenance, and or calibrations to be performed and recorded.
g. Expected results when calibrations are to be performed.
h. Indication of as-found and as-left results as applicable.
i. Indication of all test results outside specified tolerances.

F. Testing laboratory qualifications:
1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
1) Corporate history and references.
2) Resume of individual performing test.
3) Equipment list and test calibration data.

G. Division of responsibilities:
1. Submit a list identifying who is responsible for performing each portion of the testing.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Testing laboratory qualifications:
1. The testing laboratory may be qualified testing personnel from the electrical subcontractor’s staff or an independent testing company.
2. NETA certification required.
3. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

1.07 DELIVERY, STORAGE, AND PROTECTION (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

A. At least 30 days before commencement of the acceptance tests, submit the manufacturer’s complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.

B. Perform testing in the following sequence:
1. Perform routine tests as the equipment is installed including:
a. Insulation-resistance tests.

b. Continuity tests.
c. Rotational tests.

2. Adjusting and preliminary calibration.
3. Acceptance tests.
4. Demonstration.
5. Commissioning and plant start-up.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Test instrument calibration:
   1. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy:
      a. The calibrating standard shall be of better accuracy than that of the equipment tested.
   2. The accuracy shall be traceable to the NIST in an unbroken chain.
   3. Calibrate instruments in accordance with the following frequency schedule:
      a. Field instruments: 6 months maximum.
      b. Laboratory instruments: 12 months maximum.
      c. Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
   4. Dated calibration labels shall be visible on all test equipment.
   5. Maintain an up-to-date instrument calibration record for each test instrument:
      a. The records shall show the date and results of each calibration or test.
   6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.

B. Do not begin testing until the following conditions have been met:
   1. All instruments required are available and in proper operating condition.
   2. All required dispensable materials such as solvents, rags, and brushes are available.
   3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.

4. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
5. Data sheets to record all test results are available.

3.03 INSTALLATION

A. Test decal:
   1. The testing laboratory shall affix a test decal on the exterior of equipment or equipment enclosure of protective devices after performing electrical tests.
   2. The test decal shall be color coded to communicate the condition of maintenance of the protective. The color scheme for condition of maintenance of overcurrent protective devices shall be:
      a. White: electrically and mechanically acceptable.
      b. Yellow; minor deficiency not affecting fault detection and operation, but minor electrical or mechanical condition exists.
   3. The decal shall include the following information at a minimum:
      a. Testing organization.
      b. Project identifier.
      c. Test date.
      d. Technician identifier.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Testing and Training Phase: Installation Testing:
   1. Also called "Field Acceptance Testing".
   2. Panelboards:
      a. Cleaning:
         1) Visually inspect panelboard for evidence of discoloration, abnormal dust accumulation, metal shards, or any other indication of overheating, wear, or other abnormal conditions prior to cleaning.
         2) Clean cabinet with a brush, vacuum cleaner, or clean, dry, lint-free rags to remove any accumulation of dust, dirt, or other foreign matter. Do not use liquids, solvents or detergents when cleaning panelboards or components.
         3) Avoid blowing dust into panelboards. Do not use a blower or compressed air.
         4) Clean Supports, terminals, and other major insulating surfaces with clean, dry, lint-free rags or soft bristled brushes.
         5) Remove dust, soot, grease, moisture, and foreign material from surface of circuit breakers.
      b. General:
         1) Compare equipment nameplate data with the Contract Documents.
         2) Check panelboard circuit schedule for accuracy.
         3) Verify appropriate anchorage, required area clearances, and correct alignment.

4) Inspect overall general condition for physical damage. Check for broken studs and loose or damaged wires, connector, terminations, etc. Check all bolts, nuts, washer, and pins for tightness. Tighten or use manufacture's replacement parts as required.
5) Inspect cabinets for signs of rust, corrosion, or deteriorating paint. Inspect cabinets for evidence of localized heat damage to the paint. Investigate sources of heat. Repair painted surfaces.
6) Check that covers are in place and fastened. Plug any open unused knockouts.
7) Inspect panelboard for moisture. Seal off any cracks or openings which have allowed moisture to enter the cabinet. Inspect all component devices. Replace any components that show evidence of damage from moisture.
8) Look for any recent changes in sprinklers or other plumbing that might expose indoor panelboards to a source of liquids. Eliminate sources of water, moisture, or liquids, or provide adequate barriers to protect panelboards from sources of water, moisture, or liquids.
9) Inspect panelboards and internal components for evidence of overheating, arc spatter, sooty deposits, and tracking. Investigate and correct sources of arcing or overheating. Consult the panelboard manufacturer for recommendations.
10) Verify that fuse and/or circuit breaker sizes and types correspond to record drawings, if available, as well as to the circuit breaker's address for microprocessor communications packages, if equipped.
11) Set adjustable circuit breakers in accordance with engineering coordination study supplied by Contractor.

c. Terminations, Connections, and Lugs:
1) Inspect bolted electrical connections for high resistance using one of the following methods:
a) Use of low-resistance ohmmeter:
(1) Compare bolted connection resistance values to values of similar connections:
(a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
(1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
2) Inspect terminations, connection, and lugs for alignment, physical damage, burns, corrosion, discoloration, flaking, heat damage, arcing, pitting, melting, deterioration, carbonization, cracks, chips, breaks, partial discharge, or moisture. Investigate and eliminate sources of any damage.
3) Follow manufacturer recommendations for cleaning, repairing, and replacing damaged parts.
4) Replace overheated connections. Tighten connections to proper to proper torque levels as specified above.

d. Conductors and raceways:
1) Inspect supply conductors and terminations for overheating, discoloration, and oxidation. Investigate and correct any deficiencies.
2) Ensure the conductors are protected within their ampacities.

3) Visually check panelboard, cables, and raceways for proper bonding and grounding. Correct improper bonding and grounding.
4) Inspect conductors for discoloration, arcing, pitting, melting, flaking of insulation and/or metal parts. Repair or replace damaged components in accordance with manufacturer's recommendations.
5) Inspect for frayed or broken wires. Replace or repair damaged components in accordance with manufacturer recommendations.
6) Inspect for frayed or broken wires. Replace or repair conductors as necessary.
7) Inspect conduits for moisture. Seal conduits which are a source of moisture and provide means to drain moisture away from the panelboard.

e. Circuit breakers:
1) Breakers rated less than 100 A:
a) Operate circuit breakers several times in order to exercise the mechanisms and the contacts, and to ensure smooth operation. Do not oil or grease parts of molded case circuit breakers.
b) Visually check circuit breakers for evidence of overheating and thermal damage. Investigate and eliminate sources of overheating.
c) Check circuit breakers for visual defects, chipping, cracks, breaks, burns, and deterioration. Replace damaged circuit breakers.
d) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.
e) Inspect interchangeable trip-unit circuit breakers for tightness of trip units.
f) Check circuit breaker terminals and connections for tightness as specified above.
2) Breakers rated 100 A and higher:
a) Perform visual and mechanical inspection as specified in this Section.
b) Perform electrical tests as specified in this Section.

3. Dry type transformers:
a. Visual and mechanical inspection:
1) Compare equipment nameplate data with the Contract Documents.
2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, and grounding.
4) Verify that resilient mounts are free and that any shipping brackets have been removed.
5) Inspect equipment for cleanliness.
6) Inspect bolted electrical connections for high resistance using one of the following methods:
a) Use of low-resistance ohmmeter.
b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
(1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
7) Verify that as-left tap connections are as specified.

b. Electrical tests:
    1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    2) Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
        a) Apply voltage in accordance with manufacturer's published data:
            (1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    3) Calculate dielectric absorption ration or polarization index.
    4) Verify correct secondary voltage, phase-to-phase and phase-to -neutral after energization and before loading.
c. Test values:
    1) Compare bolted connection resistance values to values of similar connections:
        a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    2) Bolt-torque levels shall be in accordance with manufacturer's published data:
        a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    3) Tap connections are left as found unless otherwise specified.
    4) Minimum insulation-resistance values of transformer insulation shall be in accordance with manufacturer's published data:
        a) Refer to NETA ATS tables in the absence of manufacturer's published data.
        b) Investigate insulation values less than the allowable minimum.
    5) The dielectric absorption ratio or polarization index shall not be less than 1.0.
    6) Turns-ratio results should not deviate more than 1/2 percent from either the adjacent coils or calculated ratio.
    7) Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.

4. Liquid-filled transformers:
    a. Visual and mechanical inspection:
        1) Compare equipment nameplate data with the Contract Documents.
        2) Inspect physical and mechanical condition.
        3) Inspect impact recorder before unloading.
        4) Test dew point of tank gases if applicable.
        5) Inspect anchorage, alignment, grounding and required clearances.
        6) Verify the presence of PCB content labeling.
        7) Verify removal of any shipping bracing after placement.
        8) Verify the bushings are clean.
        9) Verify that alarm, control and trip settings on temperature and level indicators are as specified.
        10) Verify operation of alarm, control, and trip circuits from temperature and level indicators, pressure relief device, gas accumulator, and fault pressure relay, if applicable.
        11) Verify that cooling fans operate correctly and that fan motors have correct overcurrent protection.
        12) Inspect bolted electrical connections for high resistance using one of the following methods:
            a) Use of low-resistance ohmmeter.

b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
(1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
13) Verify correct liquid level in tanks and bushings.
14) Verify valves are in the correct operating position.
15) Verify that positive pressure is maintained on gas-blanketed transformers.
16) Perform inspections and mechanical tests as recommended by the manufacturer.
17) Test load tap-changer in accordance with NETA ATS requirements.
18) Verify presence of transformer surge arresters.
19) Verify de-energized tap-changer position is left as specified.

b. Electrical tests:
1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
2) Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
a) Apply voltage in accordance with manufacturer's published data:
(1) Refer to NETA ATS tables in the absence of manufacturer's published data.
b) Calculate polarization index.
3) Perform turns ratio tests at all tap positions.
4) Perform insulation power-factor or dissipation-factor tests on all windings in accordance with test equipment manufacturer's published data.
5) Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap:
a) In the absence of a power-factor/capacitance tap perform hot -collar tests.
b) Perform tests in accordance with test equipment manufacturer's published data.
6) Perform excitation-current tests in accordance with test equipment manufacturer's published data.
7) Perform sweep frequency response analysis tests.
8) Measure the resistance of each primary winding in each no-load tap changer position. Measure the resistance of each secondary winding in each no-load tap changer position.
9) Remove a sample of insulating liquid in accordance with ASTM D923 and test per the following standards:
a) Dielectric breakdown voltage: ASTM D877 or ASTM D1816.
b) Acid neutralization number: ASTM D974.
c) Interfacial tension: ASTM D971.
d) Color: ASTM D1500.
e) Visual condition: ASTM D1524.
f) Water in insulating fluids: ASTM D1533.
10) Remove a sample of insulating liquid in accordance with ASTM D924. Sample shall be tested for the following:
a) Dissolved-gas analysis: IEEE C57.104 or ASTM D3612.
11) Test instrument transformers as specified in this Section:
12) Test surge arresters as specified in this Section if applicable.
13) Test transformer neutral grounding impedance device if applicable.

14) Verify operation of cubicle or air terminal compartment space heaters.

c. Test values:
   1) Alarm control, and trip circuits from temperature and level indicators as well as pressure relief device and fault pressure relay shall operate within manufacturer's recommendations for their specified settings.
   2) Cooling fans and pumps shall operate.
   3) Compare bolted connection resistance values to values of similar connections:
      a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   4) Bolt-torque levels shall be in accordance with manufacturer's published data:
      a) Refer to NETA ATS tables in the absence of manufacturer's published data.
   5) Liquid levels in the transformer tanks and bushings shall be within indicated tolerances.
   6) Positive pressure shall be indicated on pressure gauge for gas-blanketed transformers.
   7) Minimum insulation-resistance values of transformer insulation shall be in accordance with manufacturer's published data:
      a) Refer to NETA ATS tables in the absence of manufacturer's published data.
      b) Investigate insulation values less than the allowable minimum.
   8) The polarization index shall be greater than 1.0:
      a) Compare to any previous values.
   9) Turns-ratio test result shall not deviate by more than 1/2-percent from either the adjacent coils or the calculated ratio.
   10) Maximum winding insulation power-factor/dissipation-factor values shall be in accordance with the manufacturer's published data:
      a) Refer to NETA ATS tables in the absence of manufacturer's published data.
   11) Investigate bushing power-factor values that vary from nameplate values by more than 150 percent. Investigate bushing capacitance values that vary from nameplate values by more than 5 percent. Investigate bushing hot-collar test values that exceed 0.1 Watts.
   12) Typical excitation-current test data pattern for a 3-legged core transformer is 2 similar current readings and 1 lower current reading.
   13) Sweep frequency response analysis test results shall be comparable to previously obtained results.
   14) Consult the manufacturer if winding-resistance test values vary by more than 2 percent from factory test values or between adjacent phases.
   15) Investigate leakage reactance per phase test results that deviate from the average of the 3 readings by more than 3 percent. The 3 phase equivalent test results serve as a benchmark for future tests.
   16) Core insulation values shall be comparable to previously obtained results but not be less than 1.0 megohm at 500 VDC.
   17) Investigate the presence of oxygen in the nitrogen gas blanket.
   18) Insulating liquid values shall be in accordance with NETA ATS tables.

19) Evaluate results of dissolved-gas analysis in accordance with IEEE C57.104.
20) Results of electrical tests on instrument transformers shall be as specified in this Section.
21) Results of surge arrester tests shall be as specified in this Section.
22) Compare grounding impedance device results to the manufacturer's published data.
23) Heaters shall be operational.

5. Low voltage cables, 600 volt maximum:
   a. Visual and mechanical inspection:
      1) Compare cable data with the Drawings and Specifications.
      2) Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.
      3) Inspect bolted electrical connections for high resistance by one of the following methods:
         a) Use of low-resistance ohmmeter.
         b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
      4) Inspect compression applied connectors for correct cable match and indentation.
      5) Inspect for correct identification and arrangement.
      6) Inspect cable jacket insulation and condition.
   b. Electrical tests:
      1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      2) Perform insulation resistance test on each conductor sized #8 AWG or larger with respect to ground and adjacent conductors:
         a) Applied potential shall be 500 volts dc for 300 volt rated cable and 1,000 volts dc for 600 volt rated cable.
         b) Test duration shall be 1 minute.
      3) Perform continuity tests on all power and control conductors to insure correct cable connection.
      4) Verify uniform resistance of parallel conductors.
   c. Test values:
      1) Compare bolted connection resistance values to values of similar connections:
         a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
      2) Insulation-resistance values shall be in accordance with manufacturer's published data:
         a) Refer to NETA ATS tables in the absence of manufacturer's published data.
         b) Investigate values of insulation-resistance less than the allowable minimum.
      3) Cable shall exhibit continuity.
      4) Deviations in resistance between parallel conductors shall be investigated.
6. Medium voltage cables:
   a. Visual and mechanical inspection:
      1) Compare cable data with the Contract Documents.

2) Inspect exposed sections of cables for physical damage.
3) Inspect bolted electrical connections for high resistance using one of the following methods:
    a) Use of low-resistance ohmmeter.
    b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
4) Inspect compression-applied connectors for correct cable match and indentation.
5) Inspect shield grounding, cable support, and terminations.
6) Verify the visible bends meet or exceed ICEA and manufacturer's published minimum allowable bending radius.
7) If cables are terminated through window-type current transformers, inspect to verify that neutral and ground conductors are correctly placed and that shields are correctly terminated for operation of protective devices.
8) Inspect for correct identification and arrangements.
9) Inspect jacket insulation and condition.

b. Electrical tests:
1) Perform resistance measurements through bolted connections with low-resistance ohmmeter.
2) Perform an insulation-resistance test individually on each conductor with all other conductors and shields grounded:
    a) Apply voltage in accordance with manufacturer's published data:
        (1) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) Perform shield-continuity test on each power cable.
4) Perform cable and time domain reflectometer (TDR) measurements on each conductor.
5) In accordance with ICEA, IEC, IEEE, and other power cable consensus standards, testing can be performed by means of direct current, power frequency alternating current, very low frequency alternating current, or damped alternating current. These sources may be used to perform insulation-resistance tests, and baseline diagnostic tests such as partial discharge analysis, and power factor or power dissipation factor. The selection shall be made after an evaluation of the available test methods and a review of the installed cable system. Some of available test methods are as follows:
    a) Dielectric withstand:
        (1) Direct current dielectric withstand voltage.
        (2) Very low frequency dielectric withstand voltage.
        (3) Power frequency dielectric withstand voltage.
        (4) Damped alternating current voltage.
    b) Baseline diagnostic tests:
        (1) Power factor/dissipation factor (tan delta):
            (a) Power frequency.
            (b) Very low frequency.
        (2) Direct current insulation-resistance.
        (3) Partial discharge:
            (a) Online (50/60 hertz).
            (b) Offline:

(c) Power frequency.
(d) Very low frequency.

c. Test values:
1) Compare bolted connection resistance values to values of similar connections:
a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Bolt-torque levels shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) The minimum bend radius to which insulated cables may be bent for permanent training shall be in accordance with NETA ATS tables.
4) Insulation-resistance values shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
b) Investigate values of insulation-resistance less than the allowable minimum.
5) Shielding shall exhibit continuity:
a) Investigate resistance values in excess of 10 ohms per 1,000 feet of cable.
6) If no evidence of distress of insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
7) Based on the test methodology chosen, refer to the applicable standards or manufacturer's literature for acceptable values.

7. Low voltage molded case and insulated case circuit breakers:
a. Visual and mechanical inspection:
1) Compare equipment nameplate data with the Contract Documents.
2) Inspect physical and mechanical condition.
3) Inspect anchorage and alignment.
4) Verify the unit is clean.
5) Operate the circuit breaker to ensure smooth operation.
6) Inspect bolted electrical connections for high resistance by one of the following methods:
a) Use of low-resistance ohmmeter.
b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
(1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
7) Perform adjustments for final protective device settings in accordance with the coordination study.
b. Electrical tests:
1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
2) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
a) Apply voltage in accordance with manufacturer's published data.
b) Refer to NETA ATS tables in the absence of manufacturer's published data.

3) Perform a contact/pole-resistance test.
4) Determine long-time pickup and delay by primary current injection.
5) Determine short-time pickup and delay by primary current injection.
6) Determine ground-fault pickup and delay by primary current injection.
7) Determine instantaneous pickup value by primary current injection.
8) Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
9) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function and trip unit battery condition:
   a) Reset all trip logs and indicators.
10) Verify operation of charging mechanism.

c. Test values:
1) Compare bolted connection resistance values to values of similar connections:
   a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Bolt-torque levels shall be in accordance with manufacturer's published data:
   a) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) Insulation-resistance values shall be in accordance with manufacturer's published data:
   a) Refer to NETA ATS tables in the absence of manufacturer's published data.
   b) Investigate values of insulation-resistance less than the allowable minimum.
4) Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
   a) If manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
5) Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band including adjustment factors:
   a) If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
6) Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
7) Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
8) Instantaneous pickup values shall be as specified and within manufacturer's published tolerances:
   a) Refer to NETA ATS tables in the absence of manufacturer's published data.
9) Pickup values and trip characteristics shall be within manufacturer's published tolerances.
10) Determine energy reducing maintenance switch pickup value by primary current injection.

11) Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.
12) The charging mechanism shall operate in accordance with manufacturer's published data.

8. Instrument transformers - current transformers:
   a. Visual and mechanical inspection:
      1) Compare equipment nameplate data with the Contract Documents.
      2) Inspect physical and mechanical condition.
      3) Verify correct connection of transformers with system requirements.
      4) Verify that adequate clearances exist between primary and secondary circuit wiring.
      5) Verify the unit is clean.
      6) Inspect bolted electrical connections for high resistance using one of the following methods:
         a) Use of low-resistance ohmmeter.
         b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
            (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
      7) Verify that all required grounding and shorting connections provide contact.
      8) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
   b. Electrical tests:
      1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      2) Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1,000 VDC for 1 minute:
         a) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
      3) Perform a polarity test of each current transformer in accordance with IEEE C57.13.1.
      4) Perform a ratio verification test using the voltage or current method in accordance with IEEE C57.13.1.
      5) Perform an excitation test on current transformers used for relaying applications in with accordance with IEEE C57.13.1.
      6) Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1.
      7) When applicable perform insulation-resistance tests on the primary winding with the secondary grounded:
         a) Test voltages shall be in accordance with NETA ATS tables.
      8) Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.
      9) Verify that current transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
         a) That grounding point should be located as specified by the Engineer in the Contract Documents.
   c. Test values:
      1) Compare bolted connection resistance values to values of similar connections:
         a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    a) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) Insulation-resistance values of instrument transformers shall be in accordance with manufacturer's published data:
    a) Refer to NETA ATS tables in the absence of manufacturer's published data.
4) Polarity results shall agree with transformer markings.
5) Ratio errors shall be in accordance with IEEE C57.13.
6) Excitation results for current transformers shall match the curve supplied by the manufacturer or be in accordance with IEEE C57.13.1.
7) Measured burdens shall be compared to instrument transformer ratings.
8) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
9) Power-factor or dissipation-factor values shall be compared to manufacturer's published data:
    a) In the absence manufacturer's published data, use the test equipment manufacturer's published data.
10) Test results shall indicate that the circuits have only 1 grounding point.

9. Instrument transformers - voltage transformers:
    a. Visual and mechanical inspection:
        1) Compare equipment nameplate data with the Contract Documents.
        2) Inspect physical and mechanical condition.
        3) Verify correct connection of transformers with system requirements.
        4) Verify that adequate clearances exist between primary and secondary circuit wiring.
        5) Verify the unit is clean.
        6) Inspect bolted electrical connections for high resistance using one of the following methods:
            a) Use of low-resistance ohmmeter.
            b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
                (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
        7) Verify that all required grounding and connections provide contact.
        8) Verify correct primary and secondary fuse sizes for voltage transformers.
        9) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
        10) Perform as-left tests.
    b. Electrical tests - voltage transformers:
        1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
        2) Perform insulation-resistance tests winding-to-winding and winding-to-ground:
            a) Test voltage shall be applied for 1 minute in accordance with NETA ATS requirements.

b) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

3) Perform a polarity test on each voltage transformer to verify the polarity marks on H_1- X_1 relationship as applicable.
4) Perform a turns ratio test on all tap positions.
5) Measure voltage circuit burdens at transformer terminals.
6) Perform a dielectric withstand test on the primary windings with the secondary windings grounded:
   a) The dielectric voltage shall be in accordance with NETA ATS tables.
   b) Apply the test voltage for 1 minute.
7) Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturers published data.
8) Verify that voltage transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
   a) That grounding point should be located as specified by the Engineer in the Contract Documents.

c. Test values:
1) Compare bolted connection resistance values to values of similar connections:
   a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Bolt-torque levels shall be in accordance with manufacturer's published data:
   a) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) Insulation-resistance values of instrument transformers shall be in accordance with manufacturer's published data:
   a) Refer to NETA ATS tables in the absence of manufacturer's published data.
4) Polarity results shall agree with transformer markings.
5) Ratio errors shall be in accordance with IEEE C57.13.
6) Measured burdens shall be compared to instrument transformer ratings.
7) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
8) Power-factor or dissipation-factor values shall be compared to manufacturer's published data:
   a) In the absence manufacturer's published data, use the test equipment manufacturer's published data.
9) Test results shall indicate that the circuits have only 1 grounding point.

10. Metering devices solid state:
a. Visual and mechanical inspection:
1) Compare equipment nameplate data with the Contract Documents.
2) Inspect physical and mechanical condition.
3) Inspect bolted electrical connections for high resistance using one of the following methods:
   a) Use of low-resistance ohmmeter.
   b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:

(1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

4) Record model number, serial number, firmware revision, software revision, and rated control voltage.
5) Verify operation of display and indicating devices.
6) Record passwords.
7) Verify unit is grounded in accordance with manufacturer's instructions.
8) Set all required parameters including instrument transformer ratios, system type, frequency, power demand methods/intervals, and communications requirements.
9) Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts as applicable.
10) Verify the unit is clean.

b. Electrical tests:
1) Apply voltage or current as appropriate to each analog input and verify correct measurement and indication.
2) Confirm correct operation and setting of each auxiliary input/output feature including mechanical relay, digital, and analog.
3) After initial system energization, confirm measurements and indications are consistent with loads present.
4) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
5) Verify accuracy of meter at all cardinal points.
6) Calibrate meters in accordance with manufacturer's published data.
7) Verify that current transformer, and voltage transformer secondary circuits are intact.

c. Test values:
1) Compare bolted connection resistance values to values of similar connections:
a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Bolt-torque levels shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) Meter accuracy shall be in accordance with manufacturer's published data.
4) Calibration results shall be within manufacturer's published tolerances.
5) Instrument multipliers shall be in accordance with system design specifications.
6) Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

11. Grounding systems:
a. Visual and mechanical inspection:
1) Inspect ground system for compliance with the Contract Documents, and the NEC.
2) Inspect physical and mechanical condition.
3) Inspect bolted electrical connections for high resistance using one of the following methods:
a) Use of low-resistance ohmmeter.

b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
(1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

4) Inspect anchorage.

b. Electrical tests:
1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
2) Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.
3) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points.

c. Test values:
1) Grounding system electrical and mechanical connections shall be free of corrosion.
2) Compare bolted connection resistance values to values of similar connections:
a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
3) Bolt-torque levels shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
4) The resistance between the main grounding electrode and ground shall be as specified in Section 16060 - Grounding and Bonding.
5) Investigate point-to-point resistance values that exceed 0.5 ohm.

12. Motor starters, low voltage:
a. Visual and mechanical inspection:
1) Compare equipment nameplate information with the Contract Documents.
2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, and grounding.
4) Verify the unit is clean.
5) Inspect contactors:
a) Verify mechanical operation.
b) Verify contact gap, wipe, alignment, and pressure is in accordance with manufacturer's published data.
6) Motor-running protection:
a) Verify overload element rating/motor protection settings are correct for its application.
b) If motor running protection is provided by fuses, verify correct fuse rating.
7) Inspect bolted electrical connections for high resistance using one of the following methods:
a) Use of low-resistance ohmmeter.
b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
(1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

8) Lubrication requirements:
    a) Verify appropriate lubrication on moving current-carrying parts.
    b) Verify appropriate lubrication on moving and sliding surfaces.

b. Electrical tests:
    1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    2) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase to ground with the starter closed, and across each open pole for 1 minute:
        a) Test voltage shall be in accordance with manufacturer's published data.
        b) Refer to NETA ATS tables in the absence of manufacturer's published data.
    3) Test motor protection devices in accordance with manufacturer's published data.
    4) Test circuit breakers as specified in this Section.
    5) Perform operational tests by initiating control devices.

c. Test values:
    1) Compare bolted connection resistance values to values of similar connections:
        a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    2) Bolt-torque levels shall be in accordance with manufacturer's published data:
        a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    3) Insulation-resistance values shall be in accordance with manufacturer's published data:
        a) Refer to NETA ATS tables in the absence of manufacturer's published data.
        b) Investigate values of insulation-resistance less than the allowable minimum.
    4) Motor protection parameters shall be in accordance with manufacturer's published data.
    5) Circuit breaker test results shall as specified in this Section.
    6) Control devices shall perform in accordance with system design requirements.

13. Motor control centers, low voltage:
    a. Visual and mechanical inspection:
        1) Compare equipment nameplate data with the Contract Documents.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, grounding and required clearances.
        4) Verify the unit is clean and all shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
        5) Verify that circuit breaker/fuse sizes and types correspond to the approved submittals and the coordination study.
        6) Verify that current and voltage transformer ratios correspond to those indicated on the Drawings.
        7) Verify that wiring connections are tight and that wiring is secure to prevent damage during routine operation of moving parts.

8) Inspect bolted electrical connections for high resistance using one of the following methods:
    a) Use of low-resistance ohmmeter.
    b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
9) Verify operation and sequencing of interlocking systems:
    a) Attempt closure on locked-open devices.
    b) Attempt to open locked-closed devices.
    c) Make/attempt key-exchanges in all positions.
10) Lubrication requirements:
    a) Verify appropriate lubrication on moving current-carrying parts.
    b) Verify appropriate lubrication on moving and sliding surfaces.
11) Inspect insulators for evidence of physical damage or contaminated surfaces.
12) Verify correct barrier and shutter installation and operation.
13) Exercise all active components.
14) Inspect all indicating devices for correct operation.
15) Verify that filters are in place and/or vents are clear.
16) Perform visual and mechanical inspection of instrument transformers as specified in this Section.
17) Perform visual and mechanical inspection of surge arresters as specified in this Section.
18) Inspect control power transformers:
    a) Inspect for physical damage, cracked insulation, broken leads, and tightness of connections, defective wiring, and overall general condition.
    b) Verify that primary and secondary fuse/circuit breaker ratings match the submittal drawings.
    c) Verify correction functioning of grounding contacts.
19) Perform visual and mechanical inspection of all motor control center components as specified in this Section.

b. Electrical tests:
1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
2) Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute:
    a) Perform test in accordance with NETA ATS tables.
3) Perform a dielectric withstand test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data or NETA ATS tables. Apply the test voltage for 1 minute.
4) Perform ground-resistance tests:
    a) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral and derived neutral points.
5) Control power transformers:
    a) Perform insulation-resistance tests, winding-to-winding and winding-to-ground:
        (1) Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.

b) Perform secondary wiring integrity test:
(1) Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:
(a) Verify correct potential at all devices.
c) Verify correct secondary voltage by energizing primary winding with system voltage:
(1) Measure secondary voltage with the secondary wiring disconnected.
6) Verify operation of space heaters.
7) Perform electrical tests of all motor control center components as specified in this Section.

c. Test values:
1) Compare bolted connection resistance values to values of similar connections:
a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Bolt-torque levels shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) Insulation-resistance values for bus and control power transformers shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
b) Investigate insulation values less than the allowable minimum.
c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
4) Bus insulation shall withstand the over potential test voltage applied.
5) Instrument transformer test values shall be as specified in this Section.
6) Investigate grounding system point-to-point resistance values that exceed 0.5 ohm.
7) Meter accuracy shall be in accordance with manufacturer's published data.
8) Control power transformers:
a) Insulation-resistance values of control power transformers shall be in accordance with manufacturer's published data:
(1) Refer to NETA ATS tables in the absence of manufacturer's published data.
(2) Investigate insulation values less than the allowable minimum.
(3) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
b) Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.
c) Secondary voltage shall be as indicated on the Drawings.
9) Heaters shall be operational.
10) Test values for motor control center components shall be as specified in this Section.

14. Variable frequency drive systems:
a. Visual and mechanical inspection:
1) Compare equipment nameplate data with the Contract Documents.

2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, and grounding.
4) Verify the unit is clean.
5) Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
6) Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
7) Motor running protection:
    a) Verify drive overcurrent setpoints are correct for their application.
    b) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
    c) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.
8) Inspect bolted electrical connections for high resistance using one of the following methods:
    a) Use of low-resistance ohmmeter.
    b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
9) Verify correct fuse sizing in accordance with manufacturer's published data.
10) Perform visual and mechanical inspection of input circuit breaker as specified in this Section.

b. Electrical tests:
1) Perform resistance measurements through bolted connections with low resistance ohmmeter.
2) Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
3) Test for the following parameters in accordance with relay calibration procedures specified in NETA ATS or as recommended by the manufacturer:
    a) Input phase loss protection.
    b) Input overvoltage protection.
    c) Output phase rotation.
    d) Overtemperature protection.
    e) Direct current overvoltage protection.
    f) Overfrequency protection.
    g) Drive overload protection.
    h) Fault alarm outputs.
4) Perform continuity tests on bonding conductors as specified in accordance with NETA ATS.
5) Perform start-up of drive in accordance with manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.
6) Perform operational tests by initiating control devices:
    a) Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
    b) Verify operation of drive from remote start/stop and speed control signals.

7) Perform electrical tests of input circuit breaker as specified in this Section.
8) Measure fuse resistance.

c. Test values:
1) Compare bolted connection resistance values to values of similar connections:
a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Bolt-torque levels shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) Overload test trip times at 300 percent of overload element rating shall be in accordance with manufacturer's published time-current curve.
4) Test values for input circuit breaker shall be as specified in this Section.
5) Relay calibration results shall be as specified in this Section.
6) Continuity of bonding conductors shall be in accordance with NETA ATS.
7) Control devices shall perform in accordance with system requirements.
8) Operational tests shall conform to system design requirements.
9) Investigate fuse resistance values that deviate from each other by more than 15 percent.

15. Surge arresters, low-voltage:
a. Visual and mechanical inspection:
1) Compare equipment nameplate data with the Contract Documents.
2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, grounding, and clearances.
4) Verify the arresters are clean.
5) Inspect bolted electrical connections for high resistance using one of the following methods:
a) Use of low-resistance ohmmeter.
b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
(1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
6) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
7) Verify that stroke counter is correctly mounted and electrically connected, if applicable.
8) Record stroke counter reading.

b. Electrical tests:
1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
2) Perform an insulation-resistance test on each arrester, phase terminal- to- ground:
a) Apply voltage in accordance with manufacturers published data.
b) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) Test grounding connection as specified in this Section.

c. Test values:
    1) Compare bolted connection resistance values to values of similar connections:
        a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    2) Bolt-torque levels shall be in accordance with manufacturer's published data:
        a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    3) Insulation-resistance values shall be in accordance with manufacturer's published data:
        a) Refer to NETA ATS tables in the absence of manufacturer's published data.
        b) Investigate insulation values less than the allowable minimum.
    4) Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.

16. Fiber-optic cables:
    a. Visual and mechanical inspection:
        1) Compare cable, connector, and splice data with the Contract Documents.
        2) Inspect cable and connections for physical and mechanical damage.
        3) Verify that all connectors and splices are correctly installed.
    b. Optical tests:
        1) Perform cable length measurement, fiber fracture inspection, and construction defect inspection using an optical time domain reflectometer (OTDR):
            a) OTDR test performed on fiber cables less than 100 meters shall be performed with the aid of a launch cable.
            b) Adjust OTDR pulse width settings to a maximum setting of 1/1,000th of the cable length or 10 nanoseconds.
        2) Perform connector and splice integrity test using an optical time domain reflectometer.
        3) Perform cable attenuation loss measurement with an optical power loss test set:
            a) Perform attenuation tests with an Optical Loss Test Set capable and calibrated to show anomalies of 0.1 dB as a minimum.
            b) Test multimode fibers at 850 nanometer and 1,300 nanometer.
            c) Test single mode fibers at 1,310 nanometer and 1,550 nanometer.
        4) Perform connector and splice attenuation loss measurement from both ends of the optical cable with an optical power loss test set:
            a) At the conclusion of all outdoor splices at 1 location, and before they are enclosed and sealed, all splices shall be tested with OTDR at the optimal wavelengths (850 and 1,300 for multimode, 1,310 and 1,550 for single mode), in both directions. The splices shall be tested for integrity as well as attenuation.
        5) Perform fiber links integrity and attenuation tests using each link shall be an OTDR and an Optical Loss Test Set:
            a) OTDR traces shall be from both directions on each fiber at the 2 optimal wavelengths, 850 nanometer, and 1,300 nanometer for multimode fibers.

b) Optical loss testing shall be done with handheld test sets in 1 direction at the 2 optimal wavelengths for the appropriate fiber type. Test equipment shall equal or exceed the accuracy and resolution of Agilent/HP 8147 high performance OTDR.

c. Test values:
   1) Cable and connections shall not have been subjected to physical or mechanical damage.
   2) Connectors and splices shall be installed in accordance with industry standards.
   3) The optical time domain reflectometer signal should be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.
   4) Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer's recommendations when no local site specifications are available.
   5) Individual fusion splice losses shall not exceed 0.1 dB. Measurement results shall be recorded, validated by trace, and filed with the records of the respective cable runs.

17. LAN cable testing:
   a. Visual and mechanical inspections:
      1) Compare cable type and connections with that indicated on the Drawings and specified in the Specifications.
      2) Inspect cable and connectors for physical and mechanical damage.
      3) Verify that all connectors are correctly installed.
   b. Pre-testing:
      1) Test individual cables before installation:
         a) Before physical placement of the cable, test each cable while on the spool with a LAN certification test device.
         b) Before the cable is installed, verify that the cable conforms to the manufacturer's attenuation specification and that no damage has been done to the cable during shipping or handling.
         c) The test shall be fully documented and the results submitted to the Engineer, including a hard copy of all traces, before placement of the cable.
         d) The Engineer shall be notified if a cable fails to meet specification and the cable shall not be installed unless otherwise directed by the Engineer.
   c. Electrical tests:
      1) Perform cable end-to-end testing on all installed cables after installation of connectors from both ends of the cable.
      2) Test shall include cable system performance tests and confirm the absence of wiring errors.
   d. Test results:
      1) Cables shall meet or exceed TIA standards for a Category 6 installation.
   e. Test equipment:
      1) LAN certification equipment used for the testing shall be capable of testing Category 6 cable installation to TIA proposed Level III accuracy. Tests performed shall include:
         a) Near end cross talk.
         b) Attenuation.
         c) Equal level far end cross talk.

d) Return loss.
e) Ambient noise.
f) Effective cable length.
g) Propagation delay.
h) Continuity/loop resistance.

2) LAN certification test equipment shall be able to store and produce plots of the test results.
3) Manufacturers: The following or equal:
   a) Agilent Technologies, WireScope 350.

3.08 FIELD QUALITY CONTROL (NOT USED)

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

B. After the acceptance tests have been completed, dispose of all testing expendables, vacuum all cabinets, and sweep clean all surrounding areas.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16990

CONDUIT SCHEDULE

PART 1 GENERAL

1.01 SUMMARY

A. Specific definitions:

1. Conduits:

a.	ARM:	Armored cable.
b.	GRC:	Galvanized rigid conduit.
c.	PCS:	PVC jacketed rigid steel conduit.
d.	PVC:	Polyvinyl chloride rigid plastic conduit.
e.	SLT:	Sealtight - liquidtight flexible conduit.

2. Cables:

a.	RS-485	RS-485 cable.
b.	CAT5e:	Category 5 enhanced Ethernet cable.
c.	CAT6:	Category 6 Ethernet cable.
d.	DH+:	Data Highway Plus cable.
e.	RIO:	Remote I/O cable.
f.	DF1:	Serial cable.
g.	MODB:	Modbus cable.
h.	MODB+:	Modbus Plus cable.
i.	*/FO:	Fiber optic cable (* indicates number of fibers).
j.	2/C#16S:	2 conductor, 16 gauge, twisted shielded pair. (*/2/C#16S * indicates number of pairs).
k.	3/C#16S:	3 conductor, 16 gauge, twisted shielded triplet. (*/3/C#16S * indicates number of triplets).
l.	*/C#Y:	Multiconductor cable (* indicates number of conductors, Y indicates conductor size and insulation).
m.	MFR:	Manufacturer or vendor furnished cable.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 CONDUIT SCHEDULE

A. Conduit Schedule is presented on the following pages.

PLEASE CONTACT THE ELECTRICAL OR I&C ENGINEER

FOR LOCATION OF UPDATED "CONDUIT SCHEDULE" EXCEL FILE.

SECTION 16990

CONDUIT SCHEDULE
AREA ALL

PART 1 GENERAL

1.01 SUMMARY

A. Conduit requirements:
   1. As defined in Section 16050 and Section 16130.

B. Cable requirements and definitions:
   1. As defined in Section 16050 and Section 16123.
   2. 2/CS#16: 2 conductor, 16 gauge, twisted shielded pair.
   3. */FO: Fiber optic (* indicates strand count).
   4. CAT6: Category 6 Ethernet cable.
   5. MFR: Manufacturer or vendor furnished cable.
   6. PULL: Pull Rope.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 CONDUIT SCHEDULE

A. Conduit Schedule is presented on the following pages.

CONDUIT SCHEDULE AREA 07

WCWD - VFD AND MCC ELECTRICAL REPLACEMENT PROJECT

ALL AREAS

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CONDUIT			CONDUCTORS			GROUND							
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE			DESCRIPTION		CONNECTING SEGMENTS
C-00-501	00E03	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR:		CONDUIT TEE		P-00-501
	00E04		2	#14	XHHW-2				TO:		VFD-00-P01		
										2 #12	>> PUMP NO. 1 MWH		
										2 #14	>> PUMP NO. 1 TSH		
C-00-502	00E03	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR:		CONDUIT TEE		P-00-502
	00E04		2	#14	XHHW-2				TO:		VFD-00-P02		
										2 #12	>> PUMP NO. 2 MWH		
										2 #14	>> PUMP NO. 2 TSH		
C-00-503	00E03	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR:		CONDUIT TEE		P-00-503
	00E04		2	#14	XHHW-2				TO:		VFD-00-P03		
										2 #12	>> PUMP NO. 3 MWH		
										2 #14	>> PUMP NO. 3 TSH		
N-00-501	00E03	0.75"	1		CAT6	1	#14	XHHW-2	FR:		VFD-00-P03		N-00-503
									TO:		CONDUIT TEE		
										1 CAT6	>> VFD NO. 3 NETWORK		
N-00-502	00E03	0.75"	1		CAT6	1	#14	XHHW-2	FR:		VFD-00-P04		N-00-503
									TO:		CONDUIT TEE		
										1 CAT6	>> VFD NO. 4 NETWORK		
N-00-503	00E03	1"	2		CAT6	1	#14	XHHW-2	FR:		CONDUIT TEE		N-00-505
									TO:		CONDUIT TEE		
										1 CAT6	>> VFD NO. 3 NETWORK		N-00-501
										1 CAT6	>> VFD NO. 4 NETWORK		N-00-502
N-00-504	00E03	0.75"	1		CAT6	1	#14	XHHW-2	FR:		VFD-00-P02		N-00-505
									TO:		CONDUIT TEE		
										1 CAT6	>> VFD NO. 2 NETWORK		
N-00-505	00E03	1"	3		CAT6	1	#14	XHHW-2	FR:		CONDUIT TEE		N-00-507
									TO:		CONDUIT TEE		
										1 CAT6	>> VFD NO. 3 NETWORK		N-00-503
										1 CAT6	>> VFD NO. 4 NETWORK		N-00-503
										1 CAT6	>> VFD NO. 2 NETWORK		N-00-504
N-00-506	00E03	0.75"	1		CAT6	1	#14	XHHW-2	FR:		VFD-00-P01		N-00-507
									TO:		CONDUIT TEE		
										1 CAT6	>> VFD NO. 1 NETWORK		
N-00-507	00E03	1.5"	4		CAT6	1	#14	XHHW-2	FR:		CONDUIT TEE		
									TO:		PLC-1		
										1 CAT6	>> VFD NO. 3 NETWORK		N-00-505
										1 CAT6	>> VFD NO. 4 NETWORK		N-00-505
										1 CAT6	>> VFD NO. 2 NETWORK		N-00-505
										1 CAT6	>> VFD NO. 1 NETWORK		N-00-506
P-00-101	00E03	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR:		EXISTING AREA LIGHT POLE		
									TO:		MCC-A		
EXIST.										2 #12	>> EXISTING AREA LIGHTS		
P-00-200	00E03	2.5"	3	250	XHHW-2	1	#2	XHHW-2	FR:		PHOTOVOLTAIC DISCONNECT		
									TO:		MCC-A		
EXIST.										3 250	>> PHOTOVOLTAIC SYSTEM POWER		
P-00-202	00E03	2.5"	3	250	XHHW-2	1	#2	XHHW-2	FR:		PHOTOVOLTAIC DISCONNECT		
									TO:		MCC-A		
EXIST.										3 250	>> PHOTOVOLTAIC SYSTEM POWER		
P-00-501	00E03	1.5"	3	#1	XHHW-2	1	#6	XHHW-2	FR:		00-P01		
	00E04		2	#12	XHHW-2				TO:		CONDUIT TEE		
			2	#14	XHHW-2					3 #1	>> PUMP NO. 1 POWER		P-00-511
										2 #12	>> PUMP NO. 1 MWH		C-00-501
										2 #14	>> PUMP NO. 1 TSH		C-00-501
P-00-502	00E03	2"	3	#2/0	XHHW-2	1	#6	XHHW-2	FR:		00-P02		
	00E04		2	#12	XHHW-2				TO:		CONDUIT TEE		
			2	#14	XHHW-2					3 #2/0	>> PUMP NO. 2 POWER		P-00-512
										2 #12	>> PUMP NO. 2 MWH		C-00-502
										2 #14	>> PUMP NO. 2 TSH		C-00-502
P-00-503	00E03	2"	3	#2/0	XHHW-2	1	#6	XHHW-2	FR:		00-P03		
	00E04		2	#12	XHHW-2				TO:		CONDUIT TEE		
			2	#14	XHHW-2					3 #2/0	>> PUMP NO. 3 POWER		P-00-513
										2 #12	>> PUMP NO. 3 MWH		C-00-503
										2 #14	>> PUMP NO. 3 TSH		C-00-503
P-00-511	00E03	1.5"	3	#1	XHHW-2	1	#6	XHHW-2	FR:		CONDUIT TEE		P-00-501
	00E04								TO:		VFD-00-P01		
										3 #1	>> PUMP NO. 1 POWER		

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CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-00-512	00E03 00E04	2"	3	#2/0	XHHW-2	1	#6	XHHW-2	FR: CONDUIT TEE TO: VFD-00-P02 3 #2/0 >> PUMP NO. 2 POWER	P-00-502
P-00-513	00E03 00E04	2"	3	#2/0	XHHW-2	1	#6	XHHW-2	FR: CONDUIT TEE TO: VFD-00-P03 3 #2/0 >> PUMP NO. 3 POWER	P-00-503
P-00-514	00E03 00E04	1.5"	3 2 2	#1 #12 #14	XHHW-2 XHHW-2 XHHW-2	1	#6	XHHW-2	FR: 00-P04 TO: VFD-00-P04 3 #1 >> PUMP NO. 4 POWER 2 #12 >> PUMP NO. 4 MWH 2 #14 >> PUMP NO. 4 TSH	
P-00-521	00E03	2.5"	3	250	XHHW-2	1	#4	XHHW-2	FR: VFD-00-P01 TO: MCC-A 3 250 >> VFD NO. 1 POWER	
P-00-522	00E03	2.5"	3	250	XHHW-2	1	#4	XHHW-2	FR: VFD-00-P02 TO: MCC-A 3 250 >> VFD NO. 2 POWER	
P-00-523	00E03	2.5"	3	250	XHHW-2	1	#4	XHHW-2	FR: VFD-00-P03 TO: MCC-A 3 250 >> VFD NO. 3 POWER	
P-00-524	00E03	1.5"	3	#1/0	XHHW-2	1	#6	XHHW-2	FR: VFD-00-P04 TO: MCC-A 3 #1/0 >> VFD NO. 4 POWER	
C-06-301 EXIST.	07E11	1"	12	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-06.450 TO: CONDUIT TEE 10 #14 >> DRAIN PUMP NO. 1 CONTROL 2 #14 >> SPARE CONTROL	C-06-303
C-06-302	07E11	0.75"	2 2	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: P-06.450 TO: CONDUIT TEE 2 #12 >> DRAIN PUMP NO. 1 MWH 2 #14 >> DRAIN PUMP NO. 1 TSH	C-06-303
C-06-303 PART EXIST.	07E11	1"	2 14	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 10 #14 >> DRAIN PUMP NO. 1 CONTROL 2 #14 >> SPARE CONTROL 2 #12 >> DRAIN PUMP NO. 1 MWH 2 #14 >> DRAIN PUMP NO. 1 TSH	C-06-307 C-06-301 C-06-301 C-06-302 C-06-302
C-06-304	07E11	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSH-PMP1 TO: CONDUIT TEE 2 #14 >> IMPURE PUMP NO. 1 PSH	C-06-306
C-06-305	07E11	0.75"	2 2	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: IMP-PMP1 TO: CONDUIT TEE 2 #12 >> IMPURE PUMP NO. 1 MWH 2 #14 >> IMPURE PUMP NO. 1 TSH	C-06-306
C-06-306	07E11	0.75"	2 4	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #14 >> IMPURE PUMP NO. 1 PSH 2 #12 >> IMPURE PUMP NO. 1 MWH 2 #14 >> IMPURE PUMP NO. 1 TSH	C-06-307 C-06-304 C-06-305 C-06-305
C-06-307	07E11	1.5"	4 18	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 10 #14 >> DRAIN PUMP NO. 1 CONTROL 2 #14 >> SPARE CONTROL 2 #12 >> DRAIN PUMP NO. 1 MWH 2 #14 >> DRAIN PUMP NO. 1 TSH 2 #14 >> IMPURE PUMP NO. 1 PSH 2 #12 >> IMPURE PUMP NO. 1 MWH 2 #14 >> IMPURE PUMP NO. 1 TSH	C-06-309 C-06-303 C-06-303 C-06-303 C-06-303 C-06-306 C-06-306 C-06-306
C-06-308	07E11	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-PMP1 TO: CONDUIT TEE 4 #14 >> IMPURE PUMP NO. 1 CONTROL 2 #14 >> SPARE CONTROL	C-06-309

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CONDUIT			CONDUCTORS			GROUND						
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE		DESCRIPTION		CONNECTING SEGMENTS
C-06-309	07E11	1.5"	4	#12	XHHW-2	1	#12	XHHW-2	FR:		CONDUIT TEE	C-06-315
			24	#14	XHHW-2				TO:		CONDUIT TEE	
										10 #14	>> DRAIN PUMP NO. 1 CONTROL	C-06-307
										2 #14	>> SPARE CONTROL	C-06-307
										2 #12	>> DRAIN PUMP NO. 1 MWH	C-06-307
										2 #14	>> DRAIN PUMP NO. 1 TSH	C-06-307
										2 #14	>> IMPURE PUMP NO. 1 PSH	C-06-307
										2 #12	>> IMPURE PUMP NO. 1 MWH	C-06-307
										2 #14	>> IMPURE PUMP NO. 1 TSH	C-06-307
										4 #14	>> IMPURE PUMP NO. 1 CONTROL	C-06-308
										2 #14	>> SPARE CONTROL	C-06-308
C-06-310	07E11	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR:		PSH-PMP2	C-06-312
									TO:		CONDUIT TEE	
										2 #14	>> IMPURE PUMP NO. 2 PSH	
C-06-311	07E11	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR:		IMP-PMP2	C-06-312
			2	#14	XHHW-2				TO:		CONDUIT TEE	
										2 #12	>> IMPURE PUMP NO. 2 MWH	
										2 #14	>> IMPURE PUMP NO. 2 TSH	
C-06-312	07E11	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR:		CONDUIT TEE	C-06-314
			4	#14	XHHW-2				TO:		CONDUIT TEE	
										2 #14	>> IMPURE PUMP NO. 2 PSH	C-06-310
										2 #12	>> IMPURE PUMP NO. 2 MWH	C-06-311
										2 #14	>> IMPURE PUMP NO. 2 TSH	C-06-311
C-06-313	07E11	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR:		LCP-PMP2	C-06-314
									TO:		CONDUIT TEE	
										4 #14	>> IMPURE PUMP NO. 2 CONTROL	
										2 #14	>> SPARE CONTROL	
C-06-314	07E11	1"	2	#12	XHHW-2	1	#12	XHHW-2	FR:		CONDUIT TEE	C-06-315
			10	#14	XHHW-2				TO:		CONDUIT TEE	
										2 #14	>> IMPURE PUMP NO. 2 PSH	C-06-312
										2 #12	>> IMPURE PUMP NO. 2 MWH	C-06-312
										2 #14	>> IMPURE PUMP NO. 2 TSH	C-06-312
										4 #14	>> IMPURE PUMP NO. 2 CONTROL	C-06-313
										2 #14	>> SPARE CONTROL	C-06-313
C-06-315	07E11	1.5"	6	#12	XHHW-2	1	#12	XHHW-2	FR:		CONDUIT TEE	C-06-317
			34	#14	XHHW-2				TO:		CONDUIT TEE	
										10 #14	>> DRAIN PUMP NO. 1 CONTROL	C-06-309
										2 #14	>> SPARE CONTROL	C-06-309
										2 #12	>> DRAIN PUMP NO. 1 MWH	C-06-309
										2 #14	>> DRAIN PUMP NO. 1 TSH	C-06-309
										2 #14	>> IMPURE PUMP NO. 1 PSH	C-06-309
										2 #12	>> IMPURE PUMP NO. 1 MWH	C-06-309
										2 #14	>> IMPURE PUMP NO. 1 TSH	C-06-309
										4 #14	>> IMPURE PUMP NO. 1 CONTROL	C-06-309
										2 #14	>> SPARE CONTROL	C-06-309
										2 #14	>> IMPURE PUMP NO. 2 PSH	C-06-314
										2 #12	>> IMPURE PUMP NO. 2 MWH	C-06-314
										2 #14	>> IMPURE PUMP NO. 2 TSH	C-06-314
										4 #14	>> IMPURE PUMP NO. 2 CONTROL	C-06-314
										2 #14	>> SPARE CONTROL	C-06-314
C-06-316	07E11	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR:		PSH-PMP3	C-06-317
									TO:		CONDUIT TEE	
										2 #14	>> IMPURE PUMP NO. 3 PSH	
C-06-317	07E11	1.5"	6	#12	XHHW-2	1	#12	XHHW-2	FR:		CONDUIT TEE	C-06-321
			36	#14	XHHW-2				TO:		CONDUIT TEE	
										10 #14	>> DRAIN PUMP NO. 1 CONTROL	C-06-315
										2 #14	>> SPARE CONTROL	C-06-315
										2 #12	>> DRAIN PUMP NO. 1 MWH	C-06-315
										2 #14	>> DRAIN PUMP NO. 1 TSH	C-06-315
										2 #14	>> IMPURE PUMP NO. 1 PSH	C-06-315
										2 #12	>> IMPURE PUMP NO. 1 MWH	C-06-315
										2 #14	>> IMPURE PUMP NO. 1 TSH	C-06-315
										4 #14	>> IMPURE PUMP NO. 1 CONTROL	C-06-315
										2 #14	>> SPARE CONTROL	C-06-315
										2 #14	>> IMPURE PUMP NO. 2 PSH	C-06-315
										2 #12	>> IMPURE PUMP NO. 2 MWH	C-06-315
										2 #14	>> IMPURE PUMP NO. 2 TSH	C-06-315
										4 #14	>> IMPURE PUMP NO. 2 CONTROL	C-06-315
										2 #14	>> SPARE CONTROL	C-06-315
										2 #14	>> IMPURE PUMP NO. 3 PSH	C-06-316
C-06-318	07E11	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR:		IMP-PMP3	C-06-320
			2	#14	XHHW-2				TO:		CONDUIT TEE	
										2 #12	>> IMPURE PUMP NO. 3 MWH	
										2 #14	>> IMPURE PUMP NO. 3 TSH	

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CONDUIT			CONDUCTORS			GROUND							
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE			DESCRIPTION		CONNECTING SEGMENTS
C-06-319	07E11	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR:		LCP-PMP3		C-06-320
									TO:		CONDUIT TEE		
										4 #14	>> IMPURE PUMP NO. 3 CONTROL		
										2 #14	>> SPARE CONTROL		
C-06-320	07E11	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR:		CONDUIT TEE		C-06-321
			8	#14	XHHW-2				TO:		CONDUIT TEE		
										2 #12	>> IMPURE PUMP NO. 3 MWH		C-06-318
										2 #14	>> IMPURE PUMP NO. 3 TSH		C-06-318
										4 #14	>> IMPURE PUMP NO. 3 CONTROL		C-06-319
										2 #14	>> SPARE CONTROL		C-06-319
C-06-321	07E03	2"	8	#12	XHHW-2	1	#12	XHHW-2	FR:		CONDUIT TEE		
	07E09		44	#14	XHHW-2				TO:		MCC-EPS		
	07E11									10 #14	>> DRAIN PUMP NO. 1 CONTROL		C-06-317
										2 #14	>> SPARE CONTROL		C-06-317
										2 #12	>> DRAIN PUMP NO. 1 MWH		C-06-317
										2 #14	>> DRAIN PUMP NO. 1 TSH		C-06-317
										2 #14	>> IMPURE PUMP NO. 1 PSH		C-06-317
										2 #12	>> IMPURE PUMP NO. 1 MWH		C-06-317
										2 #14	>> IMPURE PUMP NO. 1 TSH		C-06-317
										4 #14	>> IMPURE PUMP NO. 1 CONTROL		C-06-317
										2 #14	>> SPARE CONTROL		C-06-317
										2 #14	>> IMPURE PUMP NO. 2 PSH		C-06-317
										2 #12	>> IMPURE PUMP NO. 2 MWH		C-06-317
										2 #14	>> IMPURE PUMP NO. 2 TSH		C-06-317
										4 #14	>> IMPURE PUMP NO. 2 CONTROL		C-06-317
										2 #14	>> SPARE CONTROL		C-06-317
										2 #14	>> IMPURE PUMP NO. 3 PSH		C-06-317
										2 #12	>> IMPURE PUMP NO. 3 MWH		C-06-320
										2 #14	>> IMPURE PUMP NO. 3 TSH		C-06-320
										4 #14	>> IMPURE PUMP NO. 3 CONTROL		C-06-320
										2 #14	>> SPARE CONTROL		C-06-320
C-06-322	07E11	1"	12	#14	XHHW-2	1	#14	XHHW-2	FR:		LCP-06.440		P-06-307
									TO:		JUNCTION BOX		
										10 #14	>> DRAIN PUMP NO. 2 CONTROL		
EXIST.										2 #14	>> SPARE CONTROL		
P-06-301	07E03	2"	3	#10	XHHW-2	1	#10	XHHW-2	FR:		P-06.450		
	07E09								TO:		MCC-EPS		
PART EXIST.	07E11									3 #10	>> DRAIN PUMP NO. 1 POWER		
P-06-302	07E03	2"	3	#3	XHHW-2	1	#6	XHHW-2	FR:		IMP-PMP1		
	07E09								TO:		MCC-EPS		
	07E11									3 #3	>> IMPURE PUMP NO. 1 POWER		
P-06-303	07E03	2"	3	#3	XHHW-2	1	#6	XHHW-2	FR:		IMP-PMP2		
	07E09								TO:		MCC-EPS		
	07E11									3 #3	>> IMPURE PUMP NO. 2 POWER		
P-06-304	07E03	2"	3	#12	XHHW-2	1	#12	XHHW-2	FR:		SAMPLE PUMP		
	07E09		4	#14	XHHW-2				TO:		MCC-EPS		
	07E11									3 #12	>> SAMPLE PUMP POWER		
PART EXIST.										4 #14	>> SPARE CONTROL		
P-06-305	07E03	2"	3	#3	XHHW-2	1	#6	XHHW-2	FR:		IMP-PMP3		
	07E09								TO:		MCC-EPS		
	07E11									3 #3	>> IMPURE PUMP NO. 3 POWER		
P-06-306	07E11	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR:		P-06.440		P-06-307
									TO:		JUNCTION BOX		
EXIST.										3 #10	>> DRAIN PUMP NO. 2 POWER		
P-06-307	07E03	2"	3	#10	XHHW-2	1	#10	XHHW-2	FR:		JUNCTION BOX		
	07E09		12	#14	XHHW-2				TO:		MCC-EPS		
	07E11									3 #10	>> DRAIN PUMP NO. 2 POWER		P-06-306
										10 #14	>> DRAIN PUMP NO. 2 CONTROL		C-06-322
PART EXIST.										2 #14	>> SPARE CONTROL		C-06-322
S-06-301	07E01	2"	1	2/CS-#16		1	#14	XHHW-2	FR:		FIT-IMPS		
	07E03								TO:		PCM-5		
	07E09									1 2/CS-#16	>> FLOW METER SIGNAL		
X-06-301	07E03	2"	1	PULL	ROPE				FR:		NORTHEAST CORNER OF CCB		
	07E09								TO:		EPS ELECTRICAL BUILDING		
	07E11									1 PULL	>> SPARE		
X-06-302	07E01	2"	1	PULL	ROPE				FR:		EAST SIDE OF CCB		
	07E03								TO:		EPS ELECTRICAL BUILDING		
	07E09									1 PULL	>> SPARE		

CONDUIT SCHEDULE AREA 07

WCWD - VFD AND MCC ELECTRICAL REPLACEMENT PROJECT

ALL AREAS

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REVISION	**0**
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CONDUIT			CONDUCTORS			GROUND				
NUMBER	**DWG**	**SIZE**	**#**	**SIZE**	**TYPE**	**#**	**SIZE**	**TYPE**	**DESCRIPTION**	**CONNECTING SEGMENTS**
X-06-303	07E03 07E09	2"	1	PULL	ROPE				FR: MH-10 TO: EPS ELECTRICAL BUILDING 1 PULL >> SPARE	
X-06-304	07E03 07E09	2"	1	PULL	ROPE				FR: MH-10 TO: MCC-EPS 1 PULL >> SPARE	
C-07-201	07E07	1"	14	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-101-01 TO: CONDUIT TEE 12 #14 >> EFFLUENT PUMP NO. 1 CONTROL 2 #14 >> SPARE CONTROL	C-07-203
C-07-202	07E07	0.75"	2 2	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: PMP-101-01 TO: CONDUIT TEE 2 #14 >> EFFLUENT PUMP NO. 1 TSH 2 #12 >> EFFLUENT PUMP NO. 1 MWH	C-07-203
C-07-203	07E07	1"	2 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 12 #14 >> EFFLUENT PUMP NO. 1 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 1 TSH 2 #12 >> EFFLUENT PUMP NO. 1 MWH	C-07-205 C-07-201 C-07-201 C-07-202 C-07-202
C-07-204	07E07	0.75"	3	#14	XHHW-2	1	#14	XHHW-2	FR: FSL-104-01 TO: CONDUIT TEE 3 #14 >> EFFLUENT PUMP NO. 1 FSL	C-07-205
C-07-205	07E07	1.5"	2 19	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 12 #14 >> EFFLUENT PUMP NO. 1 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 1 TSH 2 #12 >> EFFLUENT PUMP NO. 1 MWH 3 #14 >> EFFLUENT PUMP NO. 1 FSL	C-07-211 C-07-203 C-07-203 C-07-203 C-07-203 C-07-204
C-07-206	07E07	1"	14	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-101-02 TO: CONDUIT TEE 12 #14 >> EFFLUENT PUMP NO. 2 CONTROL 2 #14 >> SPARE CONTROL	C-07-208
C-07-207	07E07	0.75"	2 2	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: PMP-101-02 TO: CONDUIT TEE 2 #14 >> EFFLUENT PUMP NO. 2 TSH 2 #12 >> EFFLUENT PUMP NO. 2 MWH	C-07-208
C-07-208	07E07	1"	2 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 12 #14 >> EFFLUENT PUMP NO. 2 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 2 TSH 2 #12 >> EFFLUENT PUMP NO. 2 MWH	C-07-210 C-07-206 C-07-206 C-07-207 C-07-207
C-07-209	07E07	0.75"	3	#14	XHHW-2	1	#14	XHHW-2	FR: FSL-104-02 TO: CONDUIT TEE 3 #14 >> EFFLUENT PUMP NO. 2 FSL	C-07-210
C-07-210	07E07	1.5"	2 19	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 12 #14 >> EFFLUENT PUMP NO. 2 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 2 TSH 2 #12 >> EFFLUENT PUMP NO. 2 MWH 3 #14 >> EFFLUENT PUMP NO. 2 FSL	C-07-211 C-07-208 C-07-208 C-07-208 C-07-208 C-07-209
C-07-211	07E07	1.5"	4 38	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 12 #14 >> EFFLUENT PUMP NO. 1 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 1 TSH 2 #12 >> EFFLUENT PUMP NO. 1 MWH 3 #14 >> EFFLUENT PUMP NO. 1 FSL 12 #14 >> EFFLUENT PUMP NO. 2 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 2 TSH 2 #12 >> EFFLUENT PUMP NO. 2 MWH 3 #14 >> EFFLUENT PUMP NO. 2 FSL	C-07-217 C-07-205 C-07-205 C-07-205 C-07-205 C-07-205 C-07-210 C-07-210 C-07-210 C-07-210 C-07-210
C-07-212	07E07	1"	14	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-101-03 TO: CONDUIT TEE 12 #14 >> EFFLUENT PUMP NO. 3 CONTROL 2 #14 >> SPARE CONTROL	C-07-214

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CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-07-213	07E07	0.75"	2 2	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: PMP-101-03 TO: CONDUIT TEE 2 #14 >> EFFLUENT PUMP NO. 3 TSH 2 #12 >> EFFLUENT PUMP NO. 3 MWH	C-07-214
C-07-214	07E07	1"	2 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 12 #14 >> EFFLUENT PUMP NO. 3 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 3 TSH 2 #12 >> EFFLUENT PUMP NO. 3 MWH	C-07-216 C-07-212 C-07-212 C-07-213 C-07-213
C-07-215	07E07	0.75"	3	#14	XHHW-2	1	#14	XHHW-2	FR: FSL-104-03 TO: CONDUIT TEE 3 #14 >> EFFLUENT PUMP NO. 3 FSL	C-07-216
C-07-216	07E07	1.5"	2 19	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 12 #14 >> EFFLUENT PUMP NO. 3 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 3 TSH 2 #12 >> EFFLUENT PUMP NO. 3 MWH 3 #14 >> EFFLUENT PUMP NO. 3 FSL	C-07-217 C-07-214 C-07-214 C-07-214 C-07-214 C-07-215
C-07-217	07E07	2"	6 57	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 12 #14 >> EFFLUENT PUMP NO. 1 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 1 TSH 2 #12 >> EFFLUENT PUMP NO. 1 MWH 3 #14 >> EFFLUENT PUMP NO. 1 FSL 12 #14 >> EFFLUENT PUMP NO. 2 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 2 TSH 2 #12 >> EFFLUENT PUMP NO. 2 MWH 3 #14 >> EFFLUENT PUMP NO. 2 FSL 12 #14 >> EFFLUENT PUMP NO. 3 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 3 TSH 2 #12 >> EFFLUENT PUMP NO. 3 MWH 3 #14 >> EFFLUENT PUMP NO. 3 FSL	C-07-223 C-07-211 C-07-211 C-07-211 C-07-211 C-07-211 C-07-211 C-07-211 C-07-211 C-07-211 C-07-211 C-07-216 C-07-216 C-07-216 C-07-216 C-07-216
C-07-218	07E07	1"	14	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-101-04 TO: CONDUIT TEE 12 #14 >> EFFLUENT PUMP NO. 4 CONTROL 2 #14 >> SPARE CONTROL	C-07-220
C-07-219	07E07	0.75"	2 2	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: PMP-101-04 TO: CONDUIT TEE 2 #14 >> EFFLUENT PUMP NO. 4 TSH 2 #12 >> EFFLUENT PUMP NO. 4 MWH	C-07-220
C-07-220	07E07	1"	2 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 12 #14 >> EFFLUENT PUMP NO. 4 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 4 TSH 2 #12 >> EFFLUENT PUMP NO. 4 MWH	C-07-222 C-07-218 C-07-218 C-07-219 C-07-219
C-07-221	07E07	0.75"	3	#14	XHHW-2	1	#14	XHHW-2	FR: FSL-104-04 TO: CONDUIT TEE 3 #14 >> EFFLUENT PUMP NO. 4 FSL	C-07-222
C-07-222	07E07	1.5"	2 19	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 12 #14 >> EFFLUENT PUMP NO. 4 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 4 TSH 2 #12 >> EFFLUENT PUMP NO. 4 MWH 3 #14 >> EFFLUENT PUMP NO. 4 FSL	C-07-223 C-07-220 C-07-220 C-07-220 C-07-220 C-07-221

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CONDUIT			CONDUCTORS			GROUND							
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE			DESCRIPTION		CONNECTING SEGMENTS
C-07-223	07E07	2.5"	8	#12	XHHW-2	1	#12	XHHW-2	FR:		CONDUIT TEE		C-07-229
			76	#14	XHHW-2				TO:		CONDUIT TEE		
										12 #14	>> EFFLUENT PUMP NO. 1 CONTROL		C-07-217
										2 #14	>> SPARE CONTROL		C-07-217
										2 #14	>> EFFLUENT PUMP NO. 1 TSH		C-07-217
										2 #12	>> EFFLUENT PUMP NO. 1 MWH		C-07-217
										3 #14	>> EFFLUENT PUMP NO. 1 FSL		C-07-217
										12 #14	>> EFFLUENT PUMP NO. 2 CONTROL		C-07-217
										2 #14	>> SPARE CONTROL		C-07-217
										2 #14	>> EFFLUENT PUMP NO. 2 TSH		C-07-217
										2 #12	>> EFFLUENT PUMP NO. 2 MWH		C-07-217
										3 #14	>> EFFLUENT PUMP NO. 2 FSL		C-07-217
										12 #14	>> EFFLUENT PUMP NO. 3 CONTROL		C-07-217
										2 #14	>> SPARE CONTROL		C-07-217
										2 #14	>> EFFLUENT PUMP NO. 3 TSH		C-07-217
										2 #12	>> EFFLUENT PUMP NO. 3 MWH		C-07-217
										3 #14	>> EFFLUENT PUMP NO. 3 FSL		C-07-217
										12 #14	>> EFFLUENT PUMP NO. 4 CONTROL		C-07-222
										2 #14	>> SPARE CONTROL		C-07-222
										2 #14	>> EFFLUENT PUMP NO. 4 TSH		C-07-222
										2 #12	>> EFFLUENT PUMP NO. 4 MWH		C-07-222
										3 #14	>> EFFLUENT PUMP NO. 4 FSL		C-07-222
C-07-224	07E07	1"	14	#14	XHHW-2	1	#14	XHHW-2	FR:		LCP-101-05		C-07-226
									TO:		CONDUIT TEE		
										12 #14	>> EFFLUENT PUMP NO. 5 CONTROL		
										2 #14	>> SPARE CONTROL		
C-07-225	07E07	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR:		PMP-101-05		C-07-226
			2	#14	XHHW-2				TO:		CONDUIT TEE		
										2 #14	>> EFFLUENT PUMP NO. 5 TSH		
										2 #12	>> EFFLUENT PUMP NO. 5 MWH		
C-07-226	07E07	1"	2	#12	XHHW-2	1	#12	XHHW-2	FR:		CONDUIT TEE		C-07-228
			16	#14	XHHW-2				TO:		CONDUIT TEE		
										12 #14	>> EFFLUENT PUMP NO. 5 CONTROL		C-07-224
										2 #14	>> SPARE CONTROL		C-07-224
										2 #14	>> EFFLUENT PUMP NO. 5 TSH		C-07-225
										2 #12	>> EFFLUENT PUMP NO. 5 MWH		C-07-225
C-07-227	07E07	0.75"	3	#14	XHHW-2	1	#14	XHHW-2	FR:		FSL-104-05		C-07-228
									TO:		CONDUIT TEE		
										3 #14	>> EFFLUENT PUMP NO. 5 FSL		
C-07-228	07E07	1.5"	2	#12	XHHW-2	1	#12	XHHW-2	FR:		CONDUIT TEE		C-07-229
			19	#14	XHHW-2				TO:		CONDUIT TEE		
										12 #14	>> EFFLUENT PUMP NO. 5 CONTROL		C-07-226
										2 #14	>> SPARE CONTROL		C-07-226
										2 #14	>> EFFLUENT PUMP NO. 5 TSH		C-07-226
										2 #12	>> EFFLUENT PUMP NO. 5 MWH		C-07-226
										3 #14	>> EFFLUENT PUMP NO. 5 FSL		C-07-227
C-07-229	07E03	3"	10	#12	XHHW-2	1	#12	XHHW-2	FR:		CONDUIT TEE		
	07E07		95	#14	XHHW-2				TO:		MH-13		
										12 #14	>> EFFLUENT PUMP NO. 1 CONTROL		C-07-223
										2 #14	>> SPARE CONTROL		C-07-223
										2 #14	>> EFFLUENT PUMP NO. 1 TSH		C-07-223
										2 #12	>> EFFLUENT PUMP NO. 1 MWH		C-07-223
										3 #14	>> EFFLUENT PUMP NO. 1 FSL		C-07-223
										12 #14	>> EFFLUENT PUMP NO. 2 CONTROL		C-07-223
										2 #14	>> SPARE CONTROL		C-07-223
										2 #14	>> EFFLUENT PUMP NO. 2 TSH		C-07-223
										2 #12	>> EFFLUENT PUMP NO. 2 MWH		C-07-223
										3 #14	>> EFFLUENT PUMP NO. 2 FSL		C-07-223
										12 #14	>> EFFLUENT PUMP NO. 3 CONTROL		C-07-223
										2 #14	>> SPARE CONTROL		C-07-223
										2 #14	>> EFFLUENT PUMP NO. 3 TSH		C-07-223
										2 #12	>> EFFLUENT PUMP NO. 3 MWH		C-07-223
										3 #14	>> EFFLUENT PUMP NO. 3 FSL		C-07-223
										12 #14	>> EFFLUENT PUMP NO. 4 CONTROL		C-07-223
										2 #14	>> SPARE CONTROL		C-07-223
										2 #14	>> EFFLUENT PUMP NO. 4 TSH		C-07-223
										2 #12	>> EFFLUENT PUMP NO. 4 MWH		C-07-223
										3 #14	>> EFFLUENT PUMP NO. 4 FSL		C-07-223
										12 #14	>> EFFLUENT PUMP NO. 5 CONTROL		C-07-228
										2 #14	>> SPARE CONTROL		C-07-228
										2 #14	>> EFFLUENT PUMP NO. 5 TSH		C-07-228
										2 #12	>> EFFLUENT PUMP NO. 5 MWH		C-07-228
										3 #14	>> EFFLUENT PUMP NO. 5 FSL		C-07-228

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CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-07-231	07E03 07E07	2"	2 19	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: MH-13 TO: VFD-101-01 12 #14 >> EFFLUENT PUMP NO. 1 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 1 TSH 2 #12 >> EFFLUENT PUMP NO. 1 MWH 3 #14 >> EFFLUENT PUMP NO. 1 FSL	
C-07-232	07E03 07E07	2"	2 19	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: MH-13 TO: VFD-101-02 12 #14 >> EFFLUENT PUMP NO. 2 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 2 TSH 2 #12 >> EFFLUENT PUMP NO. 2 MWH 3 #14 >> EFFLUENT PUMP NO. 2 FSL	
C-07-233	07E03 07E07	2"	2 19	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: MH-13 TO: VFD-101-03 12 #14 >> EFFLUENT PUMP NO. 3 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 3 TSH 2 #12 >> EFFLUENT PUMP NO. 3 MWH 3 #14 >> EFFLUENT PUMP NO. 3 FSL	
C-07-234	07E03 07E07	2"	2 19	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: MH-13 TO: VFD-101-04 12 #14 >> EFFLUENT PUMP NO. 4 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 4 TSH 2 #12 >> EFFLUENT PUMP NO. 4 MWH 3 #14 >> EFFLUENT PUMP NO. 4 FSL	
C-07-235	07E03 07E07	2"	2 19	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: MH-13 TO: VFD-101-05 12 #14 >> EFFLUENT PUMP NO. 5 CONTROL 2 #14 >> SPARE CONTROL 2 #14 >> EFFLUENT PUMP NO. 5 TSH 2 #12 >> EFFLUENT PUMP NO. 5 MWH 3 #14 >> EFFLUENT PUMP NO. 5 FSL	
C-07-240	07E07	1"	2 2	#14 2/CS-#16	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> ULTRASONIC SIGNAL 1 2/CS-#16 >> FLOW METER SIGNAL 2 #14 >> LEVEL SWITCH STATUS	C-07-242 S-07-204 S-07-204 C-07-241
C-07-241	07E07	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: LSHH-107-02 TO: CONDUIT TEE 2 #14 >> LEVEL SWITCH STATUS	C-07-240
C-07-242	07E03 07E07	2"	2 3	#14 2/CS-#16	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-5 1 2/CS-#16 >> TIT-07-101 SIGNAL 1 2/CS-#16 >> ULTRASONIC SIGNAL 1 2/CS-#16 >> FLOW METER SIGNAL 2 #14 >> LEVEL SWITCH STATUS	 S-07-293 C-07-240 C-07-240 C-07-240
C-07-401	07E09	1"	2	#14	XHHW-2	1	#14	XHHW-2	FR: MCC-EPS TO: PCM-5 2 #14 >> ETHERNET SWITCH 24 VDC POWER	
F-07-401	07E01 07E03 07E04 07E09	2"	1		12/FO	1	#14	XHHW-2	FR: PLC-3 TO: PCM-5 INNERDUCT 1 12/FO >> PLC-5 COMMUNICATION	
L-07-201	07E03 07E07 07E09	2"	10	#10	XHHW-2	1	#10	XHHW-2	FR: LIGHTING PANEL LOADS PULL BOX TO: MCC-EPS 10 #10 >> PANELBOARD CIRCUIT LOADS	
L-07-202	07E03 07E07 07E09	2"	10	#10	XHHW-2	1	#10	XHHW-2	FR: LIGHTING PANEL LOADS PULL BOX TO: MCC-EPS 10 #10 >> PANELBOARD CIRCUIT LOADS	
L-07-203	07E03 07E07 07E09	2"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: PCM-5 2 #12 >> FIT-103-1 POWER 2 #12 >> TIT-07-101 POWER	 L-07-204 L-07-205
L-07-204	07E07	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FIT-103-01 TO: CONDUIT TEE 2 #12 >> FIT-103-1 POWER	L-07-203

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CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
L-07-205	07E07	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: TIT-07-101 TO: CONDUIT TEE 2 #12 >> TIT-07-101 POWER	L-07-203
L-07-401	07E09	1"	6	#12	XHHW-2	1	#12	XHHW-2	FR: PCM-5 TO: MCC-EPS 2 #12 >> PCM-5 2 #12 >> PCM-5 AUXILIARY 2 #12 >> MCC-EPS 24VDC POWER SUPPLY	
M-07-001	07E03	4"	3	#2:15KV	15KV-EPR	1	#6	XHHW-2	FR: XFMR-1 TO: MH-EPS-3 3 #2:15KV >> XFMR-1 POWER	
N-07-201	07E09	1"	1		CAT6	1	#14	XHHW-2	FR: VFD-101-01 TO: PCM-5 1 CAT6 >> VFD-101-01 NETWORK	
N-07-202	07E09	1"	1		CAT6	1	#14	XHHW-2	FR: VFD-101-02 TO: PCM-5 1 CAT6 >> VFD-101-02 NETWORK	
N-07-203	07E09	1"	1		CAT6	1	#14	XHHW-2	FR: VFD-101-03 TO: PCM-5 1 CAT6 >> VFD-101-03 NETWORK	
N-07-204	07E09	1"	1		CAT6	1	#14	XHHW-2	FR: VFD-101-04 TO: PCM-5 1 CAT6 >> VFD-101-04 NETWORK	
N-07-205	07E09	1"	1		CAT6	1	#14	XHHW-2	FR: VFD-101-05 TO: PCM-5 1 CAT6 >> VFD-101-05 NETWORK	
N-07-405	07E09	1.5"	4		CAT6	1	#14	XHHW-2	FR: MCC-EPS TO: PCM-5 2 CAT6 >> MCC-EPS NETWORK 1 CAT6 >> POWER MONITOR 1 CAT6 >> SPARE NETWORK	
P-07-101	07E03 07E09	4"	4	500	XHHW-2	1	#3/0	XHHW-2	FR: MCC-EPS TO: XFMR-1 3 500 >> MCC-EPS POWER 1 500 >> MCC-EPS NEUTRAL	
P-07-102	07E03 07E09	4"	4	500	XHHW-2	1	#3/0	XHHW-2	FR: MCC-EPS TO: XFMR-1 3 500 >> MCC-EPS POWER 1 500 >> MCC-EPS NEUTRAL	
P-07-103	07E03 07E09	4"	4	500	XHHW-2	1	#3/0	XHHW-2	FR: MCC-EPS TO: XFMR-1 3 500 >> MCC-EPS POWER 1 500 >> MCC-EPS NEUTRAL	
P-07-104	07E03 07E09	4"	4	500	XHHW-2	1	#3/0	XHHW-2	FR: MCC-EPS TO: XFMR-1 3 500 >> MCC-EPS POWER 1 500 >> MCC-EPS NEUTRAL	
P-07-201	07E03 07E07 07E09	2"	3	#2/0	XHHW-2	1	#6	XHHW-2	FR: PMP-101-01 TO: VFD-101-01 3 #2/0 >> EFFLUENT PUMP NO. 1 POWER	
P-07-202	07E03 07E07 07E09	2"	3	#2/0	XHHW-2	1	#6	XHHW-2	FR: PMP-101-02 TO: VFD-101-02 3 #2/0 >> EFFLUENT PUMP NO. 2 POWER	
P-07-203	07E03 07E07 07E09	2"	3	#2/0	XHHW-2	1	#6	XHHW-2	FR: PMP-101-03 TO: VFD-101-03 3 #2/0 >> EFFLUENT PUMP NO. 3 POWER	
P-07-204	07E03 07E07 07E09	2"	3	#2/0	XHHW-2	1	#6	XHHW-2	FR: PMP-101-04 TO: VFD-101-04 3 #2/0 >> EFFLUENT PUMP NO. 4 POWER	
P-07-205	07E03 07E07 07E09	2"	3	#2/0	XHHW-2	1	#4	XHHW-2	FR: PMP-101-05 TO: VFD-101-05 3 #2/0 >> EFFLUENT PUMP NO. 5 POWER	
P-07-206	07E07	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: EF-07-91 DISCONNECT TO: CONDUIT TEE 3 #12 >> EF-07-91 POWER	P-07-208

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WCWD - VFD AND MCC ELECTRICAL REPLACEMENT PROJECT

ALL AREAS

ENGINEER	EB
REVISION	0
DATE	2/25/21

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-07-207	07E07	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: EF-07-92 DISCONNECT TO: CONDUIT TEE 3 #12 >> EF-07-92 POWER	P-07-208
P-07-208	07E07	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #12 >> EF-07-91 POWER 3 #12 >> EF-07-92 POWER	P-07-216 P-07-206 P-07-207
P-07-209	07E07	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: EHF-1 TO: DISC-EHF-1 3 #12 >> EHF-1 POWER	
P-07-210	07E07	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISC-EHF-1 TO: CONDUIT TEE 3 #12 >> EHF-1 POWER	P-07-216
P-07-211	07E09	2"	3	#3/0	XHHW-2	1	#6	XHHW-2	FR: VFD-101-01 TO: MCC-EPS 3 #3/0 >> EFFLUENT PUMP NO. 1 POWER	
P-07-212	07E09	2"	3	#3/0	XHHW-2	1	#6	XHHW-2	FR: VFD-101-02 TO: MCC-EPS 3 #3/0 >> EFFLUENT PUMP NO. 2 POWER	
P-07-213	07E09	2"	3	#3/0	XHHW-2	1	#6	XHHW-2	FR: VFD-101-03 TO: MCC-EPS 3 #3/0 >> EFFLUENT PUMP NO. 3 POWER	
P-07-214	07E09	2"	3	#3/0	XHHW-2	1	#6	XHHW-2	FR: VFD-101-04 TO: MCC-EPS 3 #3/0 >> EFFLUENT PUMP NO. 4 POWER	
P-07-215	07E09	2"	3	#3/0	XHHW-2	1	#6	XHHW-2	FR: VFD-101-05 TO: MCC-EPS 3 #3/0 >> EFFLUENT PUMP NO. 5 POWER	
P-07-216	07E03 07E07 07E09	2"	9	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: MCC-EPS 3 #12 >> EF-07-91 POWER 3 #12 >> EF-07-92 POWER 3 #12 >> EHF-1 POWER	 P-07-208 P-07-208 P-07-210
P-07-217	07E03 07E07 07E09	2"	4	#1/0	XHHW-2	1	#6	XHHW-2	FR: PHOTOVOLTAIC DISCONNECT NO. 1 TO: MCC-EPS 3 #1/0 >> SOLAR SYSTEM POWER 1 #1/0 >> SOLAR SYSTEM NEUTRAL	
P-07-401	07E09	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: AHU-101 VIA DISCONNECT TO: MCC-EPS 3 #10 >> HVAC POWER	
S-07-201	07E07	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: LE-107-01 TO: LIT-107-01 1 MFR >> ULTRASONIC SIGNAL	
S-07-202	07E07	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-107-01 TO: CONDUIT TEE 1 2/CS-#16 >> ULTRASONIC SIGNAL	S-07-204
S-07-203	07E07	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: FIT-103-01 TO: CONDUIT TEE 1 2/CS-#16 >> FLOW METER SIGNAL	S-07-204
S-07-204	07E07	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> ULTRASONIC SIGNAL 1 2/CS-#16 >> FLOW METER SIGNAL	C-07-240 S-07-202 S-07-203
S-07-293	07E07	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: TIT-07-101 TO: CONDUIT TEE 1 2/CS-#16 >> TIT-07-101 SIGNAL	C-07-242
X-07-001	07E03	4"	1	PULL	ROPE				FR: MH-EPS-3 TO: XFMR-1 1 PULL >> SPARE	
X-07-105	07E03 07E09	4"	1	PULL	ROPE				FR: MCC-EPS TO: XFMR-1 1 PULL >> SPARE	

CONDUIT SCHEDULE AREA 07

WCWD - VFD AND MCC ELECTRICAL REPLACEMENT PROJECT

ALL AREAS

ENGINEER	**EB**
REVISION	**0**
DATE	2/25/21

CONDUIT			CONDUCTORS			GROUND				
NUMBER	**DWG**	**SIZE**	**#**	**SIZE**	**TYPE**	**#**	**SIZE**	**TYPE**	**DESCRIPTION**	**CONNECTING SEGMENTS**
X-07-106	07E03 07E09	4"	1	PULL	ROPE				FR: MCC-EPS TO: XFMR-1 1 PULL >> SPARE	
X-07-201	07E03 07E07 07E09	2"	1	PULL	ROPE				FR: EPS BUILDING TO: MCC-EPS 1 PULL >> SPARE	
X-07-202	07E03 07E07 07E09	2"	1	PULL	ROPE				FR: EPS BUILDING TO: EPS ELECTRICAL BUILDING 1 PULL >> SPARE	
X-07-203	07E03 07E07 07E09	2"	1	PULL	ROPE				FR: EPS BUILDING TO: MH-213 1 PULL >> SPARE	
X-07-401	07E01 07E03 07E04 07E09	2"	1	PULL	ROPE				FR: C&D BUILDING TO: PCM-5 1 PULL >> SPARE	
X-07-402	07E01 07E04 07E09	2"	1	PULL	ROPE				FR: C&D BUILDING TO: MH-10 1 PULL >> SPARE	
L-25-201	25E01	3"	4	250	XHHW-2	1	#2	XHHW-2	FR: MAINTENANCE BUILDING LIGHTING PANEL TO: MAINTENANCE BUILDING TRANSFORMER 3 250 >> LIGHTING PANEL POWER 1 250 >> NEUTRAL	
P-25-201	25E01	1.5"	3	#1/0	XHHW-2	1	#6	XHHW-2	FR: MAINTENANCE BUILDING TRANSFORMER TO: MAINTENANCE BUILDING POWER PANEL 3 #1/0 >> TRANSFORMER POWER	

END OF CONDUIT SCHEDULE

END OF SECTION

SECTION 17050

COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 GENERAL

1.02 SUMMARY

A. Section includes:
   1. General requirements applicable to all Process Control and Instrumentation Work.
   2. General requirements for process control and instrumentation submittals.
   3. The ICSC including all programming shall be the following, no equal:
      a. Cascade Integration and Development Inc, (CID).

B. Interfaces to equipment, instruments, and other components:
   1. Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers, which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
   2. Provide all material and labor needed to install the actual equipment furnished, include all costs to add any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., which may be necessary to make a complete, functional installation based on the actual equipment furnished:
      a. Make all changes necessary to meet the manufacturer's wiring requirements.
   3. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation, control systems, and related services are provided. Include any items indicated on the Drawings or in Specifications from other disciplines in the scope of Work.
   4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation and control systems are completely accounted for. Include any items indicated on the Drawings or in Specifications from another discipline in the scope of Work:
      a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
   5. Loop drawings:
      a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and for all pre-purchased equipment.
      b. The form, minimum level of detail, and format for the loop drawings must match that of the sample loop drawings included in the Contract Documents.
      c. The Owner and Engineer are not responsible for providing detailed loop diagrams for Contractor furnished equipment.

C. All instrumentation, and control equipment and systems for the entire project to comply with the requirements specified in the Instrumentation and Control Specifications, whether referenced in the individual Equipment Specifications or not:
   1. The requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in other Specifications, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
   2. Inform all vendors supplying instrumentation, control systems, panels, and/or equipment of the requirements of the Instrumentation and Control Specifications.
   3. Contractor shall be responsible for informing all subcontractor's and/or suppliers of all applicable requirements as specified in Section 15936 - Instrumentation and Control Devices for HVAC, including but not limited to programming, configuration, interface, and other requirements described in this Section:
      a. Owner shall not be responsible for any additional costs due to the failure of Contractor to notify all subcontractors and/or suppliers of Section 15936 - Instrumentation and Control Devices for HVAC requirements.

D. Contract Documents:
   1. General:
      a. The drawings and specifications are complementary and are to be used together in order to fully describe the Work.
   2. Specifications:
      a. Documents 01005- General Conditions and 01007 - Supplementary Project Conditions of the Contract Documents govern the Work.
      b. These requirements are in addition to all General Requirements.
   3. Contract drawings:
      a. The Instrumentation and Control Drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the Instrumentation Work. Follow the drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the best possible installation, use the entire drawing set for construction purposes.
      b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only, exercise professional judgment in executing the Work to ensure the best possible installation:
         1) The equipment locations and dimensions indicated on the Drawings and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all instrumentation and control equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
         2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual Specifications; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.

c. Installation details:
    1) The Contract Drawings include installation details showing means and methods for installing instrumentation and control equipment. For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary for completing the Work, and submit these details for review by the Engineer.
d. Schematic diagrams:
    1) All controls are shown de-energized.
    2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
    3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
    4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
    5) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences indicated on the Drawings or in the Specifications. Combine all information and furnish a coordinated and fully functional control system.

E. Alternates/Alternatives:
    1. Substitute item provisions as specified in Document 01005 - General Conditions.

F. Changes and change orders:
    1. As specified in Document 01005 - General Conditions.

1.03 REFERENCES

A. Code compliance:
    1. As specified in Section 01410 - Regulatory Requirements:
        a. The publications are referred to in the text by basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of Bid governs.
    2. The following codes and standards are hereby incorporated into this Section:
        a. American National Standards Institute (ANSI).
        b. American Petroleum Institute (API):
            1) RP 550 - Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5 - Oxygen Analyzers.
            2) RP 551 - Process Measurement Instrumentation.
        c. International Organization for Standardization (ISO):
            1) 9001 - Quality Management Systems - Requirements.
        d. International Society of Automation (ISA):
            1) 5.1 - Instrumentation Symbols and Identification.
            2) 5.4 - Instrument Loop Diagrams.
            3) 20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.

e. National Electrical Manufacturers Association (NEMA):
   1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
f. National Fire Protection Association (NFPA).
g. National Institute of Standards and Technology (NIST).
h. Underwriters Laboratories, Inc. (UL):
   1) 508 - Standard of Safety for Industrial Control Equipment.
   2) 508A - Standard of Safety for Industrial Control Panels.

B. Compliance with Laws and Regulations:
   1. As specified in Document 01005 - General Conditions.

1.04 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations in accordance with:
   1. Factory Mutual (FM).
   2. International Electrotechnical Commission (IEC).
   3. Institute of Electrical and Electronics Engineers (IEEE).
   4. International Society of Automation (ISA).
   5. International Organization for Standardization (ISO).
   6. National Electrical Code (NEC).
   7. National Electrical Manufacturers Association (NEMA).
   8. InterNational Electrical Testing Association (NETA).
   9. National Fire Protection Association (NFPA).
   10. National Institute of Standards and Technology (NIST).
   11. Underwriters Laboratories (UL).

B. Specific definitions:
   1. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
   2. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems.
   3. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
   4. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.
   5. Digital bus: A communication network, such as PROFIBUS, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.
   6. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, 2-wire transmitter refers to a transmitter that provides a signal such as 4 to 20 mA 24 VDC regulation of a signal in a series circuit with an external 24 VDC driving potential:
      a. Fieldbus communications signal or both.

7. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 mA 24 VDC signal, a digital bus communications signal, or both.
8. Modifications: Changing, extending, interfacing to, removing, or altering an existing circuit.

C. NEMA:
1. Type 1 enclosure in accordance with NEMA 250.
2. Type 2 enclosure in accordance with NEMA 250.
3. Type 3 enclosure in accordance with NEMA 250.
4. Type 3R enclosure in accordance with NEMA 250.
5. Type 3S enclosure in accordance with NEMA 250.
6. Type 3X enclosure in accordance with NEMA 250.
7. Type 3RX enclosure in accordance with NEMA 250.
8. Type 3SX enclosure in accordance with NEMA 250.
9. Type 4 enclosure in accordance with NEMA 250.
10. Type 4X enclosure in accordance with NEMA 250.
11. Type 5 enclosure in accordance with NEMA 250.
12. Type 6 enclosure in accordance with NEMA 250.
13. Type 6P enclosure in accordance with NEMA 250.
14. Type 7 enclosure in accordance with NEMA 250.
15. Type 12 enclosure in accordance with NEMA 250.
16. Type 12K enclosure in accordance with NEMA 250.
17. Type 13 enclosure in accordance with NEMA 250.

D. Acronym definitions:
1. ACB: Automatic current balance.
2. ATS: Automatic Transfer Switch.
3. CCS: The PCS central computer system (CCS) consisting of computers and software. The personal computer-based hardware and software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software and functions.
4. DPDT: Double-pole, double-throw.
5. ES: Enterprise system: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
6. FAT: Factory acceptance test also known as Source Test.
7. HART: Highway addressable remote transducer.
8. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
9. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically information is displayed in a graphical format.

10. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
11. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
12. I/O: Input/Output.
13. IP: Internet protocol or ingress protection.
14. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
15. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
16. LOI: Local Operator Interface is an operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The LOI is typically a flat panel type of display mounted on the front of an enclosure with either a touch screen or tactile button interface.
17. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the HOA. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
18. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO, etc.
19. P&ID: Process and instrumentation diagram.
20. PC: Personal computer.
21. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings. This includes all the PCS and instruments and networking components as well as the various servers, workstations, thin clients, etc.
22. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
23. PCS: Process Control System: A general name for the computerized system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOs, LOIs, HMIs, both LCPs, VCPs and all data management systems accessible to staff.
24. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.
25. PLC: Programmable logic controller.
26. PS: Power supply.
27. RIO: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.
28. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.

29. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment located outside of the facility, such as wells, lift stations, metering stations, etc.
30. SPDT: Single-pole, double-throw.
31. SPST: Single-pole, single-throw.
32. UPS: Uninterruptible power supply.
33. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, LOI, HMI, etc.
34. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330 - Submittal Procedures and this Section.

B. General:
   1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
   2. Furnish the submittals required by each section in the Instrumentation Specifications.
   3. Adhere to the wiring numbering scheme specified in Section 16075 - Identification for Electrical Systems throughout the Project:
      a. Uniquely number each wire.
      b. Wire numbers must appear on all Equipment Drawings.
   4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

C. Submittal preparation:
   1. During the period of preparation of submittals, the Contractor shall authorize direct, informal liaison between the ICSC and the Engineer for exchange of technical information. As a result of this liaison, certain minor refinements and revisions may be authorized informally by the Engineer, which do not alter the scope of Work or cause increase or decrease in the Contract price or times. During this informal exchange, no oral statement by the Engineer shall be construed to give formal approval of any component or method, nor shall any statement be construed to grant exception to, or variation from, these Contract Documents.
   2. In these Contract Documents, some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
      a. Employ the nomenclature and numbers designated in this Section and indicated on the Drawings exclusively throughout shop drawings, data sheets, and similar submittals.
      b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, suppliers, or subcontractor's standard methods with those identified in this Section and indicated on the Drawings.

D. Specific submittal requirements:
    1. Shop drawings:
        a. Required for materials and equipment listed in this and other sections.
        b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
        c. Shop drawings requirements:
            1) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
            2) Locations of conduit entrances and access plates.
            3) Component layout and identification.
            4) Schematic and wiring diagrams with wire numbers and terminal identification.
            5) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
            6) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
            7) Weight.
            8) Finish.
            9) Nameplates:
                a) As specified in Section 16075 - Identification for Electrical Systems or as indicated on the Drawings.
            10) Temperature limitations, as applicable.
        d. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
        e. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
            1) Uniquely number each wire per the Specifications.
        f. Wire numbers must appear on all equipment drawings.
        g. Organize the shop drawing submittals for inclusion in the Operation and Maintenance Manuals:
            1) Furnish the initial shop drawing submittal bound in one or more standard size, 3-ring, D-ring, loose-leaf, vinyl plastic, hard-cover binders suitable for bookshelf storage.
            2) Binder ring size: 2 inches.
        h. Include the letterhead and/or title block of the firm responsible for the preparation of all shop drawings. Include the following information in the title block, as a minimum:
            1) The firm's registered business name.
            2) Firm's physical address, email address, and phone number.
            3) Owner's name.
            4) Project name and location.
            5) Drawing name.
            6) Revision level.
            7) Personnel responsible for the content of the drawing.
            8) Date.
        i. The work includes modifications to existing circuits:
            1) Clearly show all modifications to existing circuits.
            2) In addition, show all existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.

2. Product data:
    a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
    b. Include:
        1) Catalog cuts.
        2) Bulletins.
        3) Brochures.
        4) Quality photocopies of applicable pages from these documents.
        5) Identify on the data sheets the Project name, applicable specification section, and paragraph.
        6) Identify model number and options for the actual equipment being furnished.
        7) Neatly cross out options that do not apply or equipment not intended to be supplied.
    c. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
    d. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
        1) Uniquely number each wire per the Specifications.
    e. Wire numbers must appear on all equipment drawings.
3. Detailed sequence of operation for all equipment or systems.
4. Operation and maintenance manuals:
    a. As specified in Section 01782 - Operation and Maintenance Manuals.
    b. Operational Manual:
        1) Prepare and provide a simplified version of the standard manufacturer's HMI software and system operations manual that includes basic instructions in the application of the system as required for operators in day-to-day operations.
    c. Control System Software Record Documents:
        1) Include complete documentation of all the software programs provided for the entire control and PCS system, including:
            a) Listings of all application software on both hard copy and DVD, DVD-ROM, and CD-ROM.
            b) Database, both hard copy and DVD, DVD-ROM, and CD-ROM.
            c) Communication protocols.
            d) All documentation necessary to maintain, troubleshoot, modify, or update the software system.
    d. Organize the operation and maintenance manuals for each process in the following manner:
        1) Section A - Process and Instrumentation Diagrams.
        2) Section B - Control Descriptions.
        3) Section C - Loop Drawings.
        4) Section D - Instrument Summary.
        5) Section E - Instrument Data Sheets and Brochures.
        6) Section F - Sizing Calculations.
        7) Section G - Instrumentation Installation Details.
        8) Section H - Test Results.
        9) Section I - Operational Manual.
        10) Section J - Spare Parts List.
        11) Section K - Control System Software.

5. Material and equipment schedules:
    a. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
        1) Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
6. Itemized instrument summary:
    a. Submit a hard copy of the instrument summary.
    b. List all of the key attributes of each instrument including:
        1) Tag number.
        2) Manufacturer.
        3) Model number.
        4) Service.
        5) Area location.
        6) Calibrated range.
        7) Loop drawing number.
    c. Associated LCP, VCP, PCM, or PLC.
7. Instrument data sheets and cutsheets:
    a. Furnish fully completed data sheets, both electronically in Microsoft Word or Excel and in hard copy, for each instrument and component according to ISA-20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves. The data sheets provided with the instrument specifications are preliminary and are not complete. They are provided to assist with the completion of final instrument data sheets. Additional data sheets may be required. Include the following information on the data sheet:
        1) Component functional description specified in this Section and indicated on the Drawings.
        2) Manufacturers model number or other product designation.
        3) Tag number specified in this Section and indicated on the Drawings.
        4) System or loop of which the component is a part.
        5) Location or assembly at which the component is to be installed.
        6) Input and output characteristics, including digital bus communication.
        7) Scale range with units and multiplier.
        8) Requirements for electric supply.
        9) Requirements for air supply.
        10) Power consumption.
        11) Response timing.
        12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
        13) Special requirements or features, such as specifications for ambient operating conditions.
        14) Features and options that are furnished.
    b. Provide a technical brochure or bulletin (“cutsheet”) for each instrument on the project. Submit with the corresponding data sheets:
        1) Where the same make and model of instrument is used in 2 or more applications on the project, and the process applications are nearly identical, and the materials, features and options are identical submit one brochure or bulletin for the set of identical instruments.
        2) Include a list of tag numbers for which it applies with each brochure or bulletin.

3) Furnish technical product brochures that are complete enough to verify conformance with all Contract Document requirements, and to reflect only those features supplied with the device.
4) Cross out models, features, options, or accessories that are not being provided.
5) Clearly mark and identify special options and features.

c. Organization: Index the data sheets and brochures in the submittal by systems or loops.

8. Control panel hardware submittal:
   a. Submit the following in 1 submittal package.
   b. Complete and detailed bills of materials:
      1) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
      2) Include all items within an enclosure.
   c. Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and Control System equipment.
   d. Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium-voltage power cables.
   e. UPS and battery load calculations to show that the backup capacity and time meet the specified requirements.
   f. Provide a data sheet for each control system component together with a technical product brochure or bulletin, which include:
      1) The manufacturer's model number or other identifying product designation.
      2) Tag and loop number.
      3) System to which it belongs.
      4) Site to which it applies.
      5) Input and output characteristics.
      6) Requirements for electric power.
      7) Device ambient operating requirements.
      8) Materials of construction.
9. Schedule of values:
   a. In addition to completing all items referred to in the schedule of values, Section 01292 - Schedule of Values, submit per unit instrument and labor costs used in developing the final bid for the PCS system, for the express purpose of pricing and cost justification for any proposed change orders. It is the responsibility of the ICSC subcontractor to prove to the Engineer’s satisfaction that said per unit costs were used in the development of the final Bid amount.
10. Installation recommendations:
    a. Submit the manufacturer’s printed recommendations for installation of instrumentation equipment.
11. Training submittals:
    a. Develop and submit for review a general training plan for approval by Owner within 14 calendar days from Notice to Proceed. Include complete descriptions of all planned training classes, a preliminary training schedule, a list of all proposed instructors along with resumes, examples of proposed training manuals, and a description of any special training tools to be used (simulators, self-paced modules, personal computer-based training, etc.).

b. The Engineer will review the general training plan. Special emphasis will be placed on review of the qualifications of the proposed instructors and the timing of the individual courses to maximize their effectiveness. If, in the opinion of the Engineer, the proposed instructors are not sufficiently qualified to conduct the specified training courses, or lack experience, where required, on the specific configuration of the system, provide more qualified instructors.
c. The general training plan and schedule shall be updated by the Contractor at the beginning of each Phase and approved by the Owner a minimum of 30 days prior to commencement of training.
d. Training course plan submittals:
    1) For each training course or other training activity, submit a detailed, complete outline and agenda for each lesson as specified in Section 01756 - Commissioning.
    2) Describe any student pre-requisites for the course or training activity.
    3) Provide an updated schedule for all sessions of the course, including dates, times, durations, and locations.
    4) Submit training materials.
e. Incorporate all submittal review comments into the course.
f. Do not conduct training courses before review and acceptance of the Course Plan submittal for the course.

12. Project Record documents:
    a. Furnish as specified in Section 01770 - Closeout Procedures.
    b. Record Drawing requirements:
        1) Provide Project Record Drawing of all Instrumentation Drawings.
        2) Update Record Drawings weekly.
        3) Record Drawings must be fully updated as a condition of the monthly progress payments.
        4) Clearly and neatly show all changes including the following:
            a) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
13. Loop Drawings:
    a. Submit loop drawings for every analog, discrete, and fieldbus signal and control circuit:
        1) Provide a loop drawing submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop on this Project.
        2) This requirement applies to all signal and control circuits associated with equipment on this Project including vendor supplied equipment packages and control panels.
        3) Provide loop drawings in the format indicated in the contract drawings. Provide all tagging in accordance with the Owner's standard.
    b. Show every instrument and I/O point on at least one loop diagram.
    c. Provide a complete index in the front of each bound volume:
        1) Index the loop drawings by systems or process areas.
    d. Provide drawings showing definitive diagrams for every instrumentation loop system:
        1) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
        2) Furnish a separate drawing sheet for each system or loop diagram.

e. In addition to the ISA-5.4 requirements, show the following details:
    1) Functional name of each loop.
    2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
    3) Show all terminal numbers, regardless of the entity providing the equipment.
    4) MCC panel, circuit, and breaker numbers for all power feeds to the loops and instrumentation.
    5) Designation of and, if appropriate, terminal assignments associated with, every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
    6) Show vendor control panel, instrument panel, conduit, junction box, equipment and PCS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
    7) If a circuit is continued on another drawing, show the name and number of the continuation drawing on the loop drawing. Provide complete references to all continuation drawings whether vendor control panels, other loop drawings, existing drawings provided by the Owner, or other drawings.
f. In addition to the above requirements, provide loop diagrams in accordance with the example loop diagram as indicated on the Drawings.

14. Instrument Installation Drawings:
    a. Submit, instrument installation, mounting, and anchoring details for all components and assemblies, including access requirements and conduit connection or entry details.
    b. Furnish for each instrument a dedicated 8 1/2-inch by 11-inch installation detail that pertains to the specific instrument by tag number.
    c. For each detail, provide certification and the hard copies, by the instrument manufacturer, that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable.
    d. For each detail, provide, as a minimum, the following contents:
        1) Necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
        2) Ambient temperature and humidity where the instrument is to be installed.
        3) Corrosive qualities of the environment where the instrument is to be installed.
        4) Hazardous rating of the environment where the instrument is to be installed.
        5) Process line pipe or tank size, service and material.
        6) Process tap elevation and location.
        7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
        8) Routing of tubing and identification of supports.
        9) Mounting brackets, stands, anchoring devices, and sun shades.
        10) Conduit entry size, number, location, and delineation between power and signal.
        11) NEMA ratings of enclosures and all components.
        12) Clearances required for instrument servicing.

13) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

15. Control Panel Drawings:
    a. Layout Drawings:
        1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
        2) As a minimum, include the following information:
            a) To scale front, side, and plan views.
            b) Dimensions.
            c) Interior and exterior arrangements.
            d) Mounting information, including conduit entrance location.
            e) Finish data.
            f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
            g) Nameplate legend including text, letter size, materials, and colors.
    b. Wiring and piping diagrams:
        1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.
        2) Include the following information:
            a) Name of panel.
            b) Wiring and piping sizes and types.
            c) Terminal strip numbers.
            d) Wire tags and labels.
            e) Functional name and manufacturer's designation for items to which wiring and piping are connected.
            f) Electrical control schematics in accordance with ANSI standards.
    c. Installation drawings:
        1) Provide site-specific installation drawings for all control equipment panels, including dimensions.
        2) Provide scaled drawings and show the position of the equipment at its intended installation location.
        3) Show the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas.
        4) Show all required access and clearances associated with the equipment with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.
16. Schematic Diagrams:
    a. Submit schematic diagrams for all electrical equipment in ladder diagram format.
    b. Include device and field connection terminal numbers on all schematic diagrams.
    c. Incorporate equipment manufacturer’s shop drawing information into the schematic diagrams in order to document the entire control system.
17. Control System Diagram:
    a. Submit a complete set of control system diagrams including the following information:
        1) All PLCs, workstations, printers, communication devices, and communication links:

a) Show all PLCs with their current I/O allocation, and future I/O allocation, current plus spares provided, and maximum potential I/O based on available slots.
2) All cables required for communication requirements.
3) Show each component fully annotated with conduit size and number associated with the power source.

18. Process Control Software Submittal:
    a. In accordance with Product Data and Shop Drawing general requirements.
    b. Submit a complete description of the standard application software programs, operating system and utility programs, including modifications and explanation of how the specific functional requirements are met:
        1) Provide a cross-reference between the Specification requirements and the software submittal, in order to provide the Engineer the ability to identify how each specified requirement or function is met.
    c. A complete listing of the PCS system point I/O database:
        1) Include for each data point, relevant parameters such as range, contact orientation, limits, incremental limits, I/O card byte, I/O hardware address, and PLC assignment.
        2) Organize on a site-by-site basis, separate by point type.
        3) In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
        4) Upon completion of the Work, update all I/O lists to indicate the final as-built configuration of the systems:
            a) Organize as-built I/O list on a site-by-site basis, separated by equipment and point type.
    d. Detailed descriptions of procedures used to implement and modify control strategies and database construction.
    e. Preliminary overview, screens, station graphic displays, and preliminary reports.
19. Instrumentation and Control System Contractor Statement of Qualifications:
    a. Submit statement of qualifications of the proposed ICSC in accordance with subsequent requirements of this Section.
20. Control Descriptions:
    a. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls as shown on the P&IDs:
        1) Include all functions depicted or described in the Contract Documents.
        2) Include within the Control Description content:
            a) All specific requirements.
            b) All common requirements that pertain in general to all loops.
            c) Listing all ranges, setpoints, timers, values, counter values, etc.
21. Test Procedure Submittals:
    a. Submit the proposed procedures to be followed during tests of the PCS and its components in 2 parts:
        1) Preliminary Submittal: Outline of the specific proposed tests and examples of proposed forms and checklists.

2) Detailed Submittal: After successful review of the Preliminary Submittal, submit the proposed detailed test procedures, forms, and checklists. Include a statement of test objectives with the test procedures.

22. Test reports:
    a. As specified in Section 01330 - Submittal Procedures.
23. Meetings as specified in this Section:
    a. Agenda.
    b. Meeting minutes.

1.06 QUALITY ASSURANCE

A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.

B. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

C. The ICSC must have their own operating UL listed panel fabrication facility. All panels must be fabricated at this facility and meet all UL 508/508A requirements.

D. ICSC:
1. Contractor, through the use of the sole sourced ICSC, CID, is responsible for the implementation of the PCIS and the integration of the system with other required instrumentation, control devices, and software.
2. The ICSC assumes full responsibility, through the Contractor, to perform all work to select, furnish, install, program, test, calibrate, and place into operation all instrumentation, controls, telemetry equipment, control panels, and control system including application software, for a complete, integrated and functional PCIS system.
3. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these Specifications that the ICSC be responsible for the integration of the PCIS with existing devices and devices provided under the Contract Documents with the objective of providing a completely integrated control system.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements.

B. Special instructions:
1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

C. Tagging:
1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.
2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment constituting the PCS.
3. Tag instruments immediately upon receipt in the field.
4. Prominently display identification on the outside of the package.
5. Utilize the Tag and Loop Number identifications shown on the P&IDs.

D. Delivery and inspection:
    1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

1.08 PROJECT OR SITE CONDITIONS

A. Site conditions:
    1. Provide a PCS, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
    2. Seismic classification:
        a. Provide all equipment and construction techniques suitable for the seismic requirements for the site, as specified in Section 01612 - Seismic Design Criteria.
    3. Wind:
        a. Provide all equipment and construction techniques suitable for the site wind loading criteria, as specified in Section 01614 - Wind Design Criteria.
    4. Altitude, temperature and humidity:
        a. As specified in Section 01610 - Project Design Criteria.
        b. Provide all equipment and instrumentation fully rated for continuous operation at this altitude, temperature and humidity conditions with no additional derating factors applied.
        c. Provide additional temperature conditioning equipment to maintain all equipment and instrumentation in non-conditioned spaces or outdoors subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment manufacturer's guidelines:
            1) Provide all power wiring for these devices (e.g., heaters, fans, etc.), whether or not indicated on the Drawings.
    5. Area classifications:
        a. Furnish enclosures that match the area classifications as specified in Section 16050 - Common Work Results for Electrical.
    6. Site security:
        a. Abide by all security and safety rules concerning the Work on the Site.

1.09 SEQUENCING

A. General:
    1. As specified in Section 01312 - Project Meetings and Section 01756 - Commissioning.
    2. Testing requirements are specified in Section 01756 - Commissioning and Section 17950 - Commissioning for Instrumentation and Controls.
    3. General scheduling requirements are specified in Section 01321 - Schedules and Reports.
    4. Work restrictions and other scheduling requirements are specified in Section 01140 - Work Restrictions.
    5. Commissioning requirements as specified in Section 01756 - Commissioning.

B. For every meeting specified in this Section:
    1. Agenda:

a. Submit 7 days in advance of the meeting date.
2. Meeting minutes:
   a. Provide draft minutes for comment by all attendees within 7 days of completion of the meeting.
   b. Incorporate comments from attendees and submit final meeting minutes within 7 days of receipt of comments transmitted by the construction manager.

C. Pre-submittal conferences:
1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire project, equipment, control philosophy, schedules, and submittal requirements.
2. The Contractor, instrumentation and control subcontractor, electrical subcontractor, and all manufacturers furnishing major pieces of equipment must attend, including but not limited to:
   a. Vendor control panels.
   b. Chemical feed systems.
   c. Motor control centers.
   d. Switchgear.
   e. Variable frequency drives.
   f. Lighting.
   g. Engine generators.

D. System configuration meetings:
1. Review the system configuration, the HMI system database, control schemes, displays, report formats, etc. with the Engineer and Owner on at least 1 occasion during development:
   a. Preliminary meeting: Before configuration work is begun. The ICSC must bring to this meeting example of displays, display symbols, reports, etc. to show the capabilities of the system software.
   b. Final review meeting: Held after initial completion of all configuration work. This final meeting may not be held in conjunction with the Source Test. Make final format revisions after this review.
2. Additional requirements as specified in Sections 17101 - Specific Control Strategies and 17720 - Control Systems: Programmable Logic Controllers.

E. Control logic meetings
1. Review the PLC programming with the Programmer, Engineer, and Owner on at least 2 occasions during development. Individuals responsible for programming PLCs and other programmable devices supplied by Contractor shall attend this meeting by telephone conference call:
   a. Preliminary meeting: Meet before configuration work is begun on any PLCs programmed by the Contractor (including those provided through subcontractors and suppliers).

1) Contractor shall provide a list of each PLC and other programmable devices that will interface to the rest of the control system, including make, model, and a description of the interface; provide contact information for each individual responsible for programming each said PLC and device; and provide a listing of the submittals that will contain HMI/LOI interface information with a schedule for when each submittal will be provided.

b. Final review meeting: Held after all HMI/LOI interface submittals have been submitted:
   1) Meet to discuss HMI/LOI interface submittals and requirements.

2. Vendor Equipment Meetings: Facilitate a meeting with each equipment supplier (including HVAC) who is providing equipment with a PLC and/or LOI. Meeting discussion point will include the following at a minimum:
   a. Tag naming conventions.
   b. PLC to PLC global data mapping.
   c. All PLCs to HMI tags mapping.
   d. LOI screen colors and navigation.
   e. Interlock and permissive definitions.
   f. Communication methods.
   g. Standard code blocks for common control functionality.
   h. Alarms: Clearing, formats, colors, and status.
3. Additional requirements as specified in Sections 17720 - Control Systems: Programmable Logic Controllers.

F. Source testing:
1. Before the delivery and installation of the PCS system to the job site, but after the procurement, assembly, and configuration of all components, perform the Source Test.
2. Schedule the Source Test after receiving approval of the Source Test procedures submittal.
3. Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
4. Notify the Engineer of scheduled tests a minimum of 15 days before the date of the test.

G. General Field Start-Up and testing procedures:
1. As specified in Section 01756 - Commissioning.

H. Installation testing:
1. As specified in Section 01756 - Commissioning.
2. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
3. Acceptance of the PCIS Installation testing must be provided in writing by the Owner before the performance testing may begin.

I. Training:
1. As specified in Section 01756 - Commissioning.

J. Functional testing:
   1. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
   2. Loop validation test.
   3. As specified in Section 17950 - Commissioning for Instrumentation and Controls:
      a. Notify the Owner of scheduled tests a minimum of 21 days before the estimated completion date of installation and wiring of the PCIS.
      b. Complete loop validation testing a minimum of 5 days before the pre-commissioning phase of the project.
      c. Loop validation certifications:
         1) After the field device loop tests have been successfully completed as specified in Section 17950 - Commissioning for Instrumentation and Controls for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, Vendor, and the Owner's representative with test data entered, together with a clear and unequivocal statement that all instrumentation, including all control and signal wiring, has been successfully calibrated, inspected, and tested:
            a) Acceptance of the PCIS Installation Testing must be provided in writing by the Engineer before the Process Operational Period may begin.

K. Provide all special tools and spare parts, as specified in the Maintenance paragraph of this Section, before Process Operational Period commences, suitably wrapped, and identified.

L. Process Operational Period:
   1. Upon completion of the Process Operational Period, conduct an Instrumentation and Controls Process Performance Test as a condition for Project final completion.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. Provide additional warranty as specified in the individual Instrumentation and Control Specifications that extends beyond the Correction Period, as specified in Documents 01005 - General Conditions and 01007 - Supplementary Project Conditions.

1.12 SYSTEM PROCESS START-UP

A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
   1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Before Substantial Completion, perform all maintenance activities required by the Contract Documents including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

B. Furnish all spare parts as required by the Contract Documents.

C. Spare parts:
   1. Furnish the spare parts selected by the Engineer from the priced list of spare parts in the hardware submittal.
   2. Furnish a price list of all special tools required to calibrate and maintain all of the instrumentation provided under the Contract Documents. Furnish the special tools selected by the Engineer from the priced list.

D. Provide additional spare parts specified in other sections of the Instrumentation and Control Specifications.

E. Submit all special tools and spare parts, suitably wrapped and identified, before Process Operational Period commences.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide similar items from a single manufacturer throughout the PCIS portion of the Project.

B. Allowable manufacturers are specified in individual instrument and equipment specifications.

2.02 SYSTEM DESCRIPTION

A. General requirements:
   1. The Work includes everything necessary for and incidental to executing and completing the instrumentation and control system work indicated on the Drawings and specified in the Specifications and reasonably inferable there from including but not limited to:
      a. Preparing hardware submittals for field instrumentation.
      b. Design, develop, and draft loop drawings, control panel designs, and all other drawing submittals specified in the Instrumentation and Control Specifications.
      c. Prepare the test plan, the training plan, and the spare parts submittals.
      d. Procure all hardware.
      e. Provide all PCS system hardware.
      f. Provide all PCS system software.
      g. Fabricate panels.
      h. Perform factory tests on panels.
      i. Perform bench calibration and verify calibration after installation.

j. Oversee and certify installation of the PCS system.
k. Oversee, document, and certify loop testing.
l. Oversee, document, and certify system.
m. Installation Testing.
n. Oversee and document Functional Testing.
o. Conduct the Process Operational Period and the Instrumentation and Controls Process Performance Testing.
p. Prepare operation and maintenance manuals.
q. Conduct training classes.
r. Integrate the PCS with instrumentation and control devices provided under other sections.
s. Provide Record Drawings and Loop Drawings associated with Instruments and equipment:
    1) As specified in the Contract Documents.
    2) For Owner furnished items.
    3) For interfaces with existing equipment.
t. Resolve signal, power, or functional incompatibilities between the PCS and interfacing devices.
u. Perform all required corrective and preventative maintenance.

2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of all equipment furnished by others, as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
3. Provide the complete operating PCS to perform the specified monitoring, communications, alarm, control, display, and reporting functions in accordance with the PCS requirements.
4. Coordinate all aspects of the Work between Contractor and all subcontractors before bidding to ensure that all costs associated with a complete installation are included. Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the ICSC, the other subcontractors, or suppliers.
5. Furnish detailed, complete, and thorough operations and maintenance documentation, including but not limited to operations manuals, maintenance manuals, as-built wiring drawings, training manuals, as-built software documentation, and all other documentation required to operate, modify, and maintain all parts of the PCS.
6. Where demolition is indicated on the Drawings, the electrical subcontractor is responsible for disconnecting equipment electrical connections and rendering the equipment safe. The ICSC is responsible for physically removing all instrumentation to be demolished and return it either to the Owner or dispose of it as directed by the Owner's representative. The ICSC shall be responsible for any program modifications needed based on the demolition of the equipment, both for the loops directly and indirectly affected.
7. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
    a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before performing any Work.

b. Provide and document interface with, modifications to, upgrade, or replacement of existing circuits, power systems, controls, and equipment.

8. Revise in a manner as directed by the Engineer all I/O and addressing that the Engineer determines to be unacceptable as a result of a lack of Contractor coordination between Contract Documents and all suppliers.
9. Defective Work:
   a. As specified in Document 01005 - General Conditions.

B. Existing system:
1. This project includes electrical upgrades at the existing WCWD Waste Water Treatment Facility. New VFDs will be installed at the South Headworks facility. The VFDs will be tied into the existing control system over Ethernet/IP. All Electrical and Control equipment will be replaced in the Effluent Pump Station.
2. This project is a control system upgrade that encompasses many automation upgrades. The project will require implementation in several phases as specified in Section 01110 - Summary of Work. Each phase will need to be planned and fully executed as if they were individual projects. This includes submittals, programming development meetings, testing, and training.

C. Operating facility:
1. As specified in Section 01140 - Work Restrictions.
2. Portions of this existing facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
   a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction to meet the requirements of the Owner.
   b. As weather and facility demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
   c. Where portions of the Work are in existing facilities and require interface to existing circuits, power systems, controls and equipment, perform comprehensive and detailed field investigations of existing conditions. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
3. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
4. Where shown or specified, replace existing field instruments with new.
5. Contractor is responsible for the integrity and measurement accuracy of all loops.
6. Any defect found in existing equipment is the responsibility of the Owner. Contractor is not responsible for defects on existing Owner components.
7. The standards of documentation, instrument tagging, cable and conductor termination, terminal identification and labeling that apply to the new installation apply equally to the existing installation.

2.03 EXISTING PRODUCTS (NOT USED)

2.04 MATERIALS

A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these devices and that bear all approvals and labels as required by the Specifications.

B. Provide materials complying with the applicable industrial standard as specified in the Contract Documents.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. Furnish all meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of submittal of the shop drawings unless otherwise specified to match existing equipment.

B. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of within 0.5 percent of full scale and a minimum repeatability of within 0.25 percent of full scale.

C. Signal transmission:
   1. Analog signals:
      a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
      b. Furnish electrical analog signals outside control panels that are 4-to-20 milliamperes 24 VDC, except as indicated.
      c. Electrically or optically isolate all analog signals from other signals.
      d. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
      e. Maintain the total 4-to-20 milliamperes loop impedance to 10 percent below the published value at the loop operating voltage.
      f. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
   2. Pneumatic signals:
      a. All pneumatic signals: 3-to-15 pounds per square inch gauge.
   3. Discrete input signals:
      a. As indicated in the controller hardware specification.
   4. Discrete output signals:
      a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
      b. Provide external terminal block mounted fuse with blown fuse indication for all discrete outputs.
      c. Provide interposing relays for all discrete outputs for voltage and/or current compatibilities.
      d. Provide interposing relays as required for functionality of the control circuit.

5. Signal performance and design criteria:
    a. Stability:
        1) After Controls have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.
    b. Response:
        1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.
    c. Agreement:
        1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
    d. Repeatability:
        1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.
    e. Sensitivity:
        1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.
    f. Performance:
        1) All instruments and control devices shall perform in accordance with the manufacturers' specifications.

D. Discrete circuit configuration:
    1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
    2. Alarm contacts: Fail to the alarm condition.
    3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.

E. Grounding:
    1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
    2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable.
    3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
    4. Terminate the signal cable shield on a dedicated grounding terminal block.
    5. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

F. Instrument air:
    1. Where indicated on the Drawings, provide dry, filtered control air at 30 pounds per square inch gauge nominal pressure piped to all field instruments and instrument panels requiring air:
        a. Provide each field instrument with an integral, non-adjustable filter/regulator assembly to provide regulated air.

b. Provide each instrument panel requiring air with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments.
c. Filter all air to 5-micron maximum particle size.
d. Provide low pressure switch to alarm on insufficient air supply.

2.08 ACCESSORIES

A. Provide flow conditioning devices or other required accessories if necessary to meet the accuracy requirements in the Contract Documents.

B. Nameplates:
1. Provide a nameplate for each controller, instrument transducer, instrument power supply, solenoid, or any other control device located either in the field or within panels.
2. All nameplates shall be of identical style, color, and material throughout the facility.
3. Device nameplates shall include:
a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings:
1) Device tag and loop number ID (e.g., FIT-60.011).
2) PLC ID (e.g., PLC-11).
3) Power information (e.g., PCM-11, 120 VAC).
b. White lettering on a black background, laminated plastic.
4. All instruments shall be equipped with Type 316 stainless steel nameplate with the instrument tag stamped in 3/8-inch letters and connected to the instrument using Type 316 stainless steel wire.

2.09 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL

A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products that bear all approvals and labels as required by the Specifications.

B. Arrange with all manufacturers of the equipment and fabricators of panels and cabinets, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
1. Equipment includes the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices.

C. Source Test is specified in Section 17950 - Commissioning for Instrumentation and Controls.

PART 3 EXECUTION

3.01 EXAMINATION

A. The ICSC is encouraged to visit the site and examine the premises completely before bidding. It is the ICSC's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

B. Review the existing Site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

C. Provide a complete instrumentation and control system:
   1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, and process control and instrumentation system.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Equipment locations indicated on the Drawings may change due to variations in equipment size or minor changes made by others during construction:
   1. Verify all dimensions as indicated on the Drawings:
      a. Actual field conditions govern all final installed locations, distances, and levels.
   2. Review all information indicated on the Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
   3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.

B. Perform all related Electrical Work in accordance with the applicable sections of the Electrical Specifications.

C. The PCIS configurations are diagrammatic:
   1. The locations of equipment are approximate unless dimensioned.
   2. Where Project conditions require, make reasonable changes in locations and arrangements.

D. Field instruments installation:
   1. Install field instruments as specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer’s instructions.
   2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
      a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
      b. Provide sun shields for all field electronic instruments located outdoors.

3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
    a. Type of flexible conduit required for the area classification:
        1) Area classification as specified in Section 16050 - Common Work Results for Electrical.
    b. Maximum length of 18 inches.
4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
    a. Special cable applications shall be in accordance with the NEC.
5. Verify the correctness of each installation:
    a. Polarity of electric power and signal connections.
6. Ensure all process connections are free of leaks.

E. Process sensing lines and air tubing:
1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
2. Provide supports for rigid tubing at intervals of not more than 3 feet.
3. Slope horizontal runs of instrument tubing at a minimum of 1/16-inch per foot to allow for draining of any condensate.
4. Bends:
    a. Make bends for parallel lines symmetrical.
    b. Make bends without deforming or thinning the walls of the tubing.
5. Square-cut and clean all ends of tubing before being inserted in the fittings.
6. Provide bulkhead fittings at all panels requiring pipe and/or tubing entries.
7. Use stainless steel tubing for all piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
    a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.

F. Equipment tie-downs:
1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the Site.
2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.

G. Existing instrumentation:
1. Clean, recondition and re-calibrate each existing instrument to be reused, removed, or reinstalled using an authorized service facility of the instrument manufacturer.
2. Provide certification of this Work before reinstallation of each instrument.

H. Instrument tagging:
1. As specified in Section 16075 - Identification for Electrical Systems.
2. Provide all field-mounted instruments with nameplates:
    a. Nameplates engraved with the instrument’s full tag number as indicated on the Drawings:
        1) Affix tags with stainless steel wire fasteners.

3. Provide all back of panel instruments with nameplates:
    a. Engraved with the instrument's full tag number as indicated on the Drawings.
4. Provide all front of panel instruments with a nameplate:
    a. Engraving to include the following:
        1) Instrument's full tag number.
        2) Service description.
    b. Nameplates:
        1) Secure nameplates to the panel with stainless steel screws.
        2) Use an accepted adhesive if screws would violate the NEMA or other ratings of the enclosure.

I. Cable and conductor termination:
1. Terminate all cables and conductors on terminal blocks.
2. Terminal block enclosures:
    a. Suitable for the area classification as specified in Section 16050 - Common Work Results for Electrical.

J. Surge protection:
1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments and the panel.
2. Individually fuse each 4 to 20 milliamperes direct current loop with a 1/2-ampere fuse between power supplies and receiver surge protectors.
3. Provide voltage surge protection for 4 wire transmitters and analyzers:
    a. Protect both power source and signal loop.

K. Scope and responsibilities:
1. Refer to the following table for procurement and installation scope and responsibilities for the owner, design engineer, contractor, integrator, and programmer.

NO.	TASK	OWNER	CONTRACTOR	ENGINEER
1.00	**I&C Design Update**			
1.01	Owner-furnished equipment procurement.	Lead		Assist
1.02	Equipment and package system procurement.		Lead	
1.03	Equipment and package system submittal preparation.		Lead	
1.04	Equipment and package system submittal review.	Assist		Lead
1.05	Update I&C design to incorporate any changes, if changes approved by Owner during the submittal processes, for equipment and/or package systems.	Assist		Lead

NO.	TASK	OWNER	CONTRACTOR	ENGINEER
2.00	**HMI Application Programming**			
2.01	HMI software application programming.	Assist	Assist	
2.02	Develop PLC/DCS interfaces to Vendor package systems (Vendor package system programmed by Vendor).	Assist	Assist	
2.03	Digital field network interface and network configuration (ownership including calibration and setup).	Assist	Assist	
2.04	HMI graphical user interface.	Assist	Assist	
3.00	**Vendor Package and Auxiliary System Application Programming**			
3.01	Vendor Package PLC software application programming (procured by Contractor).		Assist	
3.02	Configuration of auxiliary systems necessary to provide required functionality and connectivity for monitoring and control of auxiliary systems: HVAC, power monitors, lighting, and fire protection.		Assist	
4.00	**Integration**			
4.01	Instrumentation specifications and procurement.		Assist	
4.02	Vendor-supplied package and auxiliary system coordination with plant PLC/DCS (communications, submittals, software development).		Assist	
4.03	Vendor package systems and auxiliary system interface demonstration at FAT, where required.		Support	
4.04	Control system equipment, Vendor package system, and auxiliary system interface submittal review and preparation for formal Owner review.		Support	

NO.	TASK	OWNER	CONTRACTOR	ENGINEER
4.05	I&C design update to reflect approved Vendor submittals (if required).	Assist	Support	Lead
5.00	**Equipment and Panels**			
5.01	***PLC/DCS Process Control System***			
a5.02	PLC/DCS control panels and associated panel equipment procurement.		Assist	
5.03	PLC/DCS control panels and associated panel equipment fabrication.		Assist	
5.04	PLC/DCS control panels factory testing.	Witness	Assist	Witness
5.05	PLC/DCS installation.	Witness	Assist	
5.06	PLC/DCS field testing OAT, SAT.	Witness	Assist	Witness
5.07	Operator interface stations (both in panel and desktop) related setup and configuration.	Witness	Assist	
5.08	Field PLC/DCS interfaces (HMIs).		Assist	
5.09	***Communications***			
5.10	Fiber patch panel procurement and installation.		Assist	
5.11	Ethernet switch procurement and installation.		Assist	
5.12	Copper patch panel procurement and installation.		Assist	
5.13	Uninterruptible power supply procurement and installation.		Assist	
5.14	***Field Local Control Panels (LCPs)***			
5.15	LCP procurement and fabrication.		Assist	
5.16	LCP installation.		Assist	
5.17	***Local Operator Interfaces (LOIs)***			

NO.	TASK	OWNER	CONTRACTOR	ENGINEER
5.18	LOI procurement and fabrication.		Assist	
5.19	LOI installation.		Assist	
5.20	LOI programming.		Assist	
5.21	***Control Room***			
5.22	Workstation furniture procurement and installation.			Assist
6.00	**Instruments and Control Valves**			
6.01	Submittal and datasheets.		Assist	
6.02	Procurement.		Assist	
6.03	Installation.		Assist	
6.04	Setup and/or calibration.		Assist	
7.00	**Electrical and Mechanical for Process Control System**			
7.01	Building electrical provision and installation - cable/conduit/wire.		Assist	
7.02	Building mechanical provision and installation - including process instruments related tubing.		Lead	
7.03	Building wiring racks and supports (cable and/or conduit) - coordinated with power contractor where applicable.		Lead	
7.04	Building internal fiber-optic backbone conduit installation (from building entrance/duct bank).		Assist	
7.05	Building internal communication wiring - DeviceNet, Modbus, Ethernet, etc. from PLC/DCS and/or patch panel.		Assist	
7.06	Electrical and mechanical installation inspection.	Witness	Lead	Assist
7.07	Vendor package - On/off skid-related electrical controls installation.		Assist	

NO.	TASK	OWNER	CONTRACTOR	ENGINEER
7.08	Vendor package - On/off skid-related mechanical controls installation.		Lead	
7.09	Vendor package electrical and mechanical installation inspection.	Witness	Lead	Assist
7.10	Site fiber-optic backbone cable installation, termination, and certification testing.			
7.11	Network testing.	Witness	Assist	Assist
8.00	**Process Start-Up**			
8.01	Pre-operation and component test.	Witness	Assist	Assist
8.02	Loop checkout.	Witness	Assist	Assist
8.03	System Acceptance Test (SAT).	Witness	Assist	Assist
8.04	Operational testing.	Witness	Assist	Assist
8.05	Commissioning testing.	Lead	Assist	Assist
9.00	**Process Closeout**			
9.01	Redline drawings and/or electronic files submittal to Owner.		Assist	
9.02	As-builts (record set) - Update all drawings.		Assist	
9.03	Operation and maintenance manuals.		Assist	
9.04	Operational testing and commissioning sign-off forms.	Witness	Assist	Witness
9.05	Training.	Witness	Assist	
9.06	Commissioning (process performance testing).	Lead	Assist	Assist
Key: L – Lead, A – Assist, S – Support, W – Witness				

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Owner Training:
   1. Demonstration requirements are specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.08 FIELD QUALITY CONTROL

A. Inspection:
   1. Allow for inspection of PCIS installation as specified in Section 01450 - Quality Control.
   2. Provide any assistance necessary to support inspection activities.
   3. Engineer inspections may include, but are not limited to, the following:
      a. Inspect equipment and materials for physical damage.
      b. Inspect installation for compliance with Drawings and Specifications.
      c. Inspect installation for obstructions and adequate clearances around equipment.
      d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
      e. Inspect equipment nameplate data to verify compliance with design requirements.
      f. Inspect cable terminations.
      g. Inspect/witness instrument calibrations/verifications.
   4. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Commissioning for Instrumentation and Controls.

B. Instrument Installation Inspection:
   1. Provide any assistance necessary to support inspection activities.
   2. Inspections may include, but are not limited to, the following:
      a. Inspect equipment and materials for physical damage.
      b. Inspect the installed arrangement, lay lengths, orientation, piping obstructions, etc., that could affect the instruments accuracy or repeatability.
      c. Inspect installation for compliance with Drawings and Specifications.
      d. Inspect installation for obstructions and adequate clearances around equipment.
      e. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
      f. Inspect equipment nameplate data to verify compliance with design requirements.
      g. Inspect cable terminations.
      h. Inspect/witness instrument calibrations/verifications.
   3. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Commissioning for Instrumentation and Controls.
   4. Field acceptance testing: (Functional Testing) is specified in Section 17950 - Commissioning for Instrumentation and Controls. Additional general requirements are specified in Section 01756 - Commissioning.

C. Installation supervision:
    1. Ensure that the entire PCIS is installed in a proper and satisfactory manner. At a minimum, the ICSC shall provide the following services:
        a. Installation resources:
            1) Coordinate with the Contractor regarding installation requirements of the Contract Documents.
        b. Provide technical assistance to installation personnel by telephone:
            1) Furnish installation personnel with at least 1 copy of the accepted submittals, including all installation details.
        c. Periodic inspections during the construction period.
        d. A complete check of the completed installation to ensure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
        e. Field verify accuracy and calibration of all instruments.

3.09 ADJUSTING

A. Control valves:
    1. Stroke all control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
    2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.

B. Make all revisions necessary to the control system software, as directed by the Engineer.
    1. It is understood that the Contractor knows and agrees that changes will be required in the control system software during the Source Testing, Functional Testing, Process Operational Period, Process Start-Up, and during the Project Correction Period.

3.10 CLEANING

A. As specified in Section 01770 - Closeout Procedures.

B. Vacuum clean all control panels and enclosures before process start-up and again after final completion of the project.

C. Clean all panel surfaces.

D. Return to new condition any scratches and/or defects.

E. Wipe all instrument faces and enclosures clean.

F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
    1. Neatly coil and label all spare wiring lengths.
    2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

G. As specified in other sections of the Contract Documents.

3.11 PROTECTION

A. Protect all Work from damage or degradation until date of Substantial Completion.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101

SPECIFIC CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.
   3. Loop description format: As specified in this Section.

B. Loop number and title:
   1. References:
      a. List P&IDs that are specifically referenced.
   2. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.
      b. Process values, setpoints, and limits, including units and ranges:
         1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.

3. Hardwired control:
    a. Detailed description of the control functions at the local level.
    b. Function of local operator interfaces.
    c. Operation of hardwired field pilot controls:
        1) Pushbuttons.
        2) Selector switches.
        3) Potentiometers.
        4) Pilot lights, indicators, and other displays.
4. Hardwired interlocks:
    a. Explanation of the operation of system interlocks and hardwired permissive conditions.
5. PLC control:
    a. Detailed description of the control functions that are under control of the PLC.
    b. Operator controls and automatic controls.
    c. Setpoints, alarms, etc.:
        1) Include units and ranges for analog values.
        2) Include span and range for analog inputs and outputs.
        3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
    d. Control sequences.
    e. Software interlocks:
        1) Operation of system software interlocks.
6. PCS/LOI/HMI control:
    a. Detailed description of the operator controls.
    b. Setpoints, alarms, etc.
7. Indicators and alarms:
    a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
8. Failure modes:
    a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Raw Sewage Pumps:
   1. References:
      a. 00E06 – Raw Sewage Pumps Control Schematic.
   2. Abstract:
      a. Control and monitoring points to be re-mapped for the existing programming and utilize the existing control strategy. Trending for additional monitoring points now available over the network connection to be provided.
   3. Hardwired control:
      a. Field:
         1) None.
      b. LCP:
         1) None.
      c. MCC/VFD:
         1) HAND-OFF-AUTO (HOA) selector switch.
         2) START pushbutton.
         3) STOP pushbutton.
         4) Failed Light.
         5) High Temperature Light.
   4. Hardwired interlocks:
      a. Motor HIGH TEMPERATURE: Stops the pump.
      b. Discharge HIGH PRESSURE: Stops the pump.
      c. Automatically transfer to bypass starter when the VFD fails. Reference the schematics in the contract drawings for additional features programmed in the VFD.
   5. PLC control:
      a. Match existing.
      b. Provide new option:
         1) Add manual start/stop control from SCADA for each pump.
   6. PCS/LOI/HMI control:
      a. Match existing.
   7. Indicators and alarms:
      a. Match existing.
   8. Failure modes:
      a. Match existing.

B. Loop IMP – Effluent Pumps:
   1. References:
      a. 07N01.
   2. Abstract:
      a. Effluent Pumps No. 1 and No. 2 pump effluent to EBMUD's facilities. They can also pump to the San Francisco Bay outfall if valve FCV-103-01 is opened by EBMUD.
      b. Effluent Pumps No. 3, No. 4, and No. 5 pump effluent to the San Francisco Bay outfall near the City of Richmond's Wastewater Treatment Plant.
      c. During normal operation, pumps 1 and 2 run based on level in the wet well. The lead pump begins discharging treated effluent to the EBMUD's facilities. The lag pump comes on as needed to maintain the level in the wet well. These pumps currently run at a fixed speed when called on by EBMUD.
      d. When the level in the EBMUD equalization tank reaches high level setpoints, EBMUD DCS closes LCV-121-01 and pump 1 discharges through FCV-103-01 to the San Francisco Bay outfall.
      e. When the flow exceeds what Effluent Pumps No. 1 and No. 2 can handle, Pumps No. 3, No. 4, and No. 5 run to maintain the level in the wet well, and the lead pump begins discharging treated effluent to the San Francisco Bay outfall. Lag pumps come on as needed to maintain the level in the wet well.
      f. Coordinate this strategy with WCWD operations staff during the first programming meeting to ensure it meets the needs of the facility at the time of construction.
   3. Hardwired control:
      a. Field:
         1) None.
      b. LCP:
         1) HAND-OFF-AUTO selector switch.
         2) Start pushbutton.
         3) Stop pushbutton.
         4) Failed Light.
         5) High Temperature Light.
      c. MCC/VFD:
         1) Running Light.
   4. Hardwired interlocks:
      a. Motor HIGH TEMPERATURE: Stops the pump.
      b. Discharge LOW FLOW: Stops the pump.
   5. PLC control:
      a. Match existing. Update as needed.
   6. PCS/LOI/HMI control:
      a. Match existing. Update as needed.
   7. Indicators and alarms:
      a. Match existing. Update as needed.
   8. Failure modes:
      a. Match existing. Update as needed.

C. Loop IMP – Impure Water Pumps:
   1. References:
      a. 07N03.

2. Abstract:
    a. The purpose of the No 3 Impure Water Pumps is to supply chlorinated effluent for scum sprays, washdown, pump seal water, polymer mixing, irrigation, and other purposes.
3. Hardwired control:
    a. Field:
        1) None.
    b. LCP:
        1) START pushbutton.
        2) STOP pushbutton.
    c. MCC/VFD:
        1) Failed Light.
        2) High Temperature Light.
4. Hardwired interlocks:
    a. Motor HIGH TEMPERATURE: Stops the pump.
    b. Discharge HIGH PRESSURE: Stops the pump.
5. PLC control:
    a. No SCADA control desired.
6. PCS/LOI/HMI control:
    a. No SCADA control desired.
7. Indicators and alarms:
    a. Match existing.
8. Failure modes:
    a. Match existing.

D. Loop 07-9X - HVAC:
9. References:
    a. 07N04.
10. Abstract:
    a. Fans run based on temperature setpoint for the room.
11. Hardwired control:
    a. Field:
        1) None.
    b. LCP:
        1) None.
    c. MCC/VFD:
        1) HAND-OFF-AUTO selector switch.
        2) Start pushbutton.
        3) Stop pushbutton.
        4) Failed Light.
        5) Running Light.
12. Hardwired interlocks:
    a. None.
13. PLC control:
    a. PCS Manual:
        1) None.
    b. PCS Auto:
        1) Temperature setpoint one turns on lead fan
        2) Temperature setpoint 2 turns on lag fan.
        3) Provide a selector switch to choose the LEAD vs. LAG fan.
14. PCS/LOI/HMI control:
    a. No SCADA control desired.

15. Indicators and alarms:
    a. High Temperature.
    b. Fail Failed.
16. Failure modes:
    a. Match existing.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17201

LEVEL MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Ball float level switch.

B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

D. Manufacture instrument facilities certified to the quality standards of ISO Standard 9001 – Quality Systems – Model for Quality Assurance in Design/Development, Production, Installation and Servicing.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Ball float level switch:
      a. E+H, Liquifloat T FTS20.
      b. Evoqua Water Technologies, 9G-EF.
      c. ITT Flygt, Model ENM-10.
      d. Anchor Scientific Inc., Ecofloat/Solofloat.

2.02 MANUFACTURED UNITS

A. Ball float level switch:
   1. General:
      a. Encapsulated body with a switch to determine position of float.
   2. Outputs:
      a. Power supply.
      b. Relay outputs.
      c. 1 Form C contact.
      d. Rated at 6 amperes at 120 VAC.
      e. Programmable for adjustable hysteresis.
   3. Element:
      a. Mechanical switch encapsulated in waterproof floating ball of nominal diameter, supported by flexible PVC cable and jacket or heavy neoprene.
      b. The length of the PVC cable shall be, at a minimum, equal to sump depth plus 5 feet.

c. Float: Provide Type 316 stainless steel or polypropylene, maximum 5.5 inches in diameter.
d. An operating temperature rating: -4 degrees Fahrenheit to +185 degrees Fahrenheit.
e. Mercury switches are not acceptable.
f. Suspend ball float and adjust for level setpoint as required.
g. Lead wires: Mounted in flexible waterproof PVC cable from switch to junction box terminals without splices.
h. Provide the number of floats per level system as indicated on the Drawings.

4. Switch:
   a. Power supply:
      1) None.
   b. Outputs:
      1) Single pole double throw contacts rated 10 amps resistive at 120 VAC.
   c. Enclosure: NEMA Type 4X.
   d. Approvals: Class I, Div 1 - if wired intrinsically safe.
5. Components:
   a. Floats shall include Type 316 stainless steel clamp and brackets and 1/4-inch cable to allow testing of the float without entering the basin or wet well.
   b. Provide strain relief at both ends of the float cable.
   c. Float anchors:
      1) Furnish 15-pound PVC coated anchor kit with 10 feet of Type 316 stainless steel chain.
      2) Provide stainless steel shackles and float clamps.
      3) Manufacturers: The following or equal:
         a) Conery Mfg. Inc.

2.03 ACCESSORIES

A. Provide sunshades for outdoor installation.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed:
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.06 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be as indicated on the Drawings, as specified in the Specifications or both.

END OF SECTION

Level Switch

SPECIFICATION: 17201

PROJECT INFORMATION

PLANT WATER POLLUTION CONTROL PLANT

PROJECT 11862A10

CUSTOMER WEST COUNTY WASTEWATER DISTRICT

LOCATION RICHMOND, CA

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

Tag:	P&ID				
LSHH-107-02	07N001	**SERVICE:**	LEVEL SWITCH HIGH HIGH		
LE-107-02		**FLUID:**	WATER	**HAZARDOUS APP:**	N/A
		MEASURING PRINCIPLE:	BALL FLOAT	**ELEM. ENC. CLASS:**	NEMA 4X
		SET POINT:	___ FT	**ELEM. MATERIAL:**	MFR. STD.
		MOUNTING:	INTEGRAL	**SWITCH ENCL. CLASS:**	NEMA 4X
		TYPICAL DETAILS:	NL100	**ENCL. MATERIAL:**	MFR. STD.
		SURGE PROTECTION:	NO		

POWER:	[*]
POWER LOCATION:	LOOP
OUTPUT:	RELAY
RELAY FORM:	SPDT
PLC:	PLC-5

SECTION 17206

LEVEL MEASUREMENT: ULTRASONIC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Ultrasonic level instruments.

B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

D. Manufacture instruments facilities certified to the quality standards of ISO Standard 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and Servicing.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Ultrasonic level sensor with 4-wire remote transmitter:
      a. Ametek Drexelbrook: USonic-R Series.
      b. Endress+Hauser: Prosonic S FDU Series Sensor with FMU Series Transmitter.
      c. Magnetrol: Echomaster 384 Series Sensor with Echotel 344 Series Transmitter.
      d. Siemens: Echomax Series sensor with HydroRanger 200 Series Transmitter.

2.02 MANUFACTURED UNITS

A. Ultrasonic level measurement with 4-wire remote transmitter:
   1. General:
      a. Continuous non-contact level measurement device with remote transmitter using ultrasonic echo sensing. The transducer generates an ultrasonic pulse in the range of 12 to 50 kHz and measures the time required for the pulse to travel to the process surface and return. The distance is calculated from the send and receive times. Each 4-wire level transmitter system includes, but is not limited to:
         1) Ultrasonic transducer.
         2) Signal cable.
         3) Transmitter.

2. Performance requirements:
    a. Accuracy:
        1) 0.25 percent of range.
    b. Repeatability:
        1) 0.1 percent of range.
3. Ultrasonic transducer:
    a. Encapsulated in chemical- and corrosion-resistant material as indicated on the Instrument Data Sheet or Instrument Index.
    b. Class I Division 1 for transducer only.
    c. Operating temperature range: -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius).
    d. Operating relative humidity range: 5 to 95 percent.
    e. Functions:
        1) Temperature compensation.
    f. Mounting: As indicated in the Contract Documents.
    g. Sensors shall be rated for NEMA 6P submergence. Sensors shall have mechanical decoupling between sensor membrane and outer housing. Sensors shall be provided with automatic build up compensation to provide self-cleaning when condensation may occur. Sensors shall be provided with internal heating elements and separate power supplies for these elements when freezing condensation may occur.
4. Transmitter:
    a. Level-indicating transmitter:
        1) Indicator: Liquid crystal display with approximately 0.50-inch display scaled to read in engineering units.
        2) Sensitivity: Able to ignore momentary level spikes or momentary loss of echo and indicate loss of echo condition on indicating transmitter unit.
        3) Ability to allow for signal profiles and echo mapping:
            a) Provide manufacturer's software for re-mapping the signal.
    b. Functions:
        1) Level measurement.
        2) Tank volume.
        3) Flow measurement.
    c. Power supply:
        1) 120 VAC.
        2) Power consumption: 36 VA maximum.
    d. Outputs:
        1) Isolated 4 to 20 milliamperes DC.
        2) Relay outputs:
            a) Minimum 6 Form A or Form C contacts.
            b) Rated 5 amps at 250 VAC.
            c) Programmable.
        3) Enclosure: NEMA Type 4X.
        4) Mounting: As indicated in the Contract Documents.
        5) Operating temperature range from -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius); relative humidity of 10 to 100 percent.
        6) Power supply shall be 90-253 VAC, or 10.5-32 VDC.

7) The transmitter shall have automatic volume calculation for horizontal or vertical tanks with 32 point linearization; pre-programmed linearization tables for flumes and weirs; back water detection for submerged flow conditions; sludge detection; synchronization of pulses between two ultrasonic units used in same tank; automatic sensor detection; alternating pump control; rake/screen control.
8) There shall be at least 3 integral totalizers and 3 daily counters with the ability for simultaneous measurement of level and flow in storm water overflow basin with only 1 sensor; EE prom memory backup; temperature compensation; average, difference and sum calculations.

2.03 ACCESSORIES

A. Mounting brackets: As indicated on the Drawings.

B. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to manufacturer's standard at a facility that is traceable to NIST:
   1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed:
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

B. Turn on turbulent surface software feature for all installations measuring surfaces lacking a placid surface. This would include but not be limited to level measurements in mixed media filters and potentially wet wells.

3.06 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be as indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

Engineers...Working Wonders With Water®

Level Transmitter

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PROJECT INFORMATION

PLANT	WATER POLLUTION CONTROL PLANT	**CUSTOMER**	WEST COUNTY WASTEWATER DISTRICT
PROJECT	11862A10	**LOCATION**	RICHMOND, CA

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

SPECIFICATION NUMBER	17206	**MEASURING PRINCIPLE**	ULTRASONIC
DRAWING NUMBER	07N001	**PLC**	PLC-5
SERVICE	ULTRASONIC LEVEL METER	**TYPICAL DETAILS**	NL185

CONNECTION

PROCESS CONNECTION	N/A

FLUID

LEVEL RANGE	0-15 FT	**TEMPERATURE**	N/A

ELEMENT

ELEMENT TAG NO.	LE-107-01	**ENCLOSURE CLASS**	NEMA 4X
ELEMENT HAZ. MATERIALS	N/A	**ELEMENT MATERIAL**	MFR. STD.
SUBMERGENCE DETECTION	NO	**TEMPERATURE COMP.**	NO
HEATED ELEMENT	NO		

TRANSMITTER

TRANSMITTER TAG NO.	LIT-107-01	**HAZARDOUS APPROVALS**	N/A
MOUNTING	REMOTE	**ENCLOSURE CLASS**	NEMA 4X
POWER	120VAC-1P	**OUTPUT**	4-20 MA
AMBIENT TEMPERATURE	[*]	**MEASUREMENT APPL**	LEVEL
SURGE PROTECTION	NO		

NOTES

[*]

SECTION 17301

FLOW MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Thermal dispersion flow switches.

B. Provide all instruments identified in the Contract Drawings.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Thermal dispersion type:
      a. Fluid Components International LLC, FLT93.
      b. Kayden.

2.02 MANUFACTURED UNITS

A. Thermal dispersion type:
   1. General:
      a. Instrument uses a heated probe and a reference probe:
         1) Deviation in the amount of heat measured by the reference probe deviates beyond the setpoint an adjustable relay closes.
         2) Switch:
            a) Micro-processor based with continuous self-diagnostics, “Smart Heater” to prevent sensor failure, no mechanical jumpers or trim pots, and a 3-year warranty.
   2. Performance requirements:
      a. Accuracy: Within 2 degrees Fahrenheit.
      b. Repeatability: Within 1 percent of setpoint range.
      c. Response time: 0.5 to 2.5 seconds.
      d. Adjustable Bypass Delay Timer.
      e. Adjustable range.
   3. Switch characteristics:
      a. Exposed parts: Powder coated aluminum housing.

b. Wetted parts:
    1) Materials as recommended by the manufacturer and approved by the Engineer.
c. Power supply:
    1) 115 VAC.
    2) Power consumption: 13 VA maximum.
d. Operating temperature range: -40 degrees Fahrenheit to 140 degrees Fahrenheit.
e. Enclosure:
    1) NEMA Type 4X.

2.03 ACCESSORIES

A. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST:
    1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed:
    1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.06 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

Engineers...Working Wonders With Water®

Flow Switch

SPECIFICATION: 17301

RESERVOIR

PROJECT INFORMATION

PLANT WATER POLLUTION CONTROL PLANT

CUSTOMER WEST COUNTY WASTEWATER DISTRICT

PROJECT 11862A10

LOCATION RICHMOND, CA

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

Tag:	P&ID				
FSL-104-01	07N001	**SERVICE:** THERMAL FLOW SWITCH			
FE-104-01		**FLUID:** WATER	**HAZARDOUS APP:** N/A	**POWER:**	120VAC-1P
		MEASURING PRINCIPLE: THERMAL	**ELEM. ENC. CLASS:** NEMA 4X	**POWER LOCATION:**	VFD
		SET POINT: ___ GPM	**SWITCH ENCL. CLASS:** NEMA 4X	**OUTPUT:**	RELAY
		PROCESS CONNECTION: MATCH EXISTING	**PRESSURE:** N/A	**RELAY FORM:**	SPDT
		CONNECTION MATERIAL: MATCH EXISTING	**TEMPERATURE:** N/A	**PLC:**	PLC-5
		TYPICAL DETAILS: NF111	**VISCOSITY:** N/A	**SURGE PROTECTION:**	NO
Tag:	**P&ID**				
FSL-104-02	07N001	**SERVICE:** THERMAL FLOW SWITCH			
FE-104-02		**FLUID:** WATER	**HAZARDOUS APP:** N/A	**POWER:**	120VAC-1P
		MEASURING PRINCIPLE: THERMAL	**ELEM. ENC. CLASS:** NEMA 4X	**POWER LOCATION:**	VFD
		SET POINT: ___ GPM	**SWITCH ENCL. CLASS:** NEMA 4X	**OUTPUT:**	RELAY
		PROCESS CONNECTION: MATCH EXISTING	**PRESSURE:** N/A	**RELAY FORM:**	SPDT
		CONNECTION MATERIAL: MATCH EXISTING	**TEMPERATURE:** N/A	**PLC:**	PLC-5
		TYPICAL DETAILS: NF111	**VISCOSITY:** N/A	**SURGE PROTECTION:**	NO
Tag:	**P&ID**				
FSL-104-03	07N001	**SERVICE:** THERMAL FLOW SWITCH			
FE-104-03		**FLUID:** WATER	**HAZARDOUS APP:** N/A	**POWER:**	120VAC-1P
		MEASURING PRINCIPLE: THERMAL	**ELEM. ENC. CLASS:** NEMA 4X	**POWER LOCATION:**	VFD
		SET POINT: ___ GPM	**SWITCH ENCL. CLASS:** NEMA 4X	**OUTPUT:**	RELAY
		PROCESS CONNECTION: MATCH EXISTING	**PRESSURE:** N/A	**RELAY FORM:**	SPDT
		CONNECTION MATERIAL: MATCH EXISTING	**TEMPERATURE:** N/A	**PLC:**	PLC-5
		TYPICAL DETAILS: NF111	**VISCOSITY:** N/A	**SURGE PROTECTION:**	NO
Tag:	**P&ID**				
FSL-104-04	07N001	**SERVICE:** THERMAL FLOW SWITCH			
FE-104-04		**FLUID:** WATER	**HAZARDOUS APP:** N/A	**POWER:**	120VAC-1P
		MEASURING PRINCIPLE: THERMAL	**ELEM. ENC. CLASS:** NEMA 4X	**POWER LOCATION:**	VFD
		SET POINT: ___ GPM	**SWITCH ENCL. CLASS:** NEMA 4X	**OUTPUT:**	RELAY
		PROCESS CONNECTION: MATCH EXISTING	**PRESSURE:** N/A	**RELAY FORM:**	SPDT
		CONNECTION MATERIAL: MATCH EXISTING	**TEMPERATURE:** N/A	**PLC:**	PLC-5
		TYPICAL DETAILS: NF111	**VISCOSITY:** N/A	**SURGE PROTECTION:**	NO

Flow Switch

SPECIFICATION: 17301

PROJECT INFORMATION

PLANT WATER POLLUTION CONTROL PLANT

CUSTOMER WEST COUNTY WASTEWATER DISTRICT

PROJECT 11862A10

LOCATION RICHMOND, CA

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

Tag:	P&ID						
FSL-104-05	07N001	**SERVICE:**	THERMAL FLOW SWITCH				
FE-104-05		**FLUID:**	WATER	**HAZARDOUS APP:**	N/A	**POWER:**	120VAC-1P
		MEASURING PRINCIPLE:	THERMAL	**ELEM. ENC. CLASS:**	NEMA 4X	**POWER LOCATION:**	VFD
		SET POINT:	___ GPM	**SWITCH ENCL. CLASS:**	NEMA 4X	**OUTPUT:**	RELAY
		PROCESS CONNECTION:	MATCH EXISTING	**PRESSURE:**	N/A	**RELAY FORM:**	SPDT
		CONNECTION MATERIAL:	MATCH EXISTING	**TEMPERATURE:**	N/A	**PLC:**	PLC-5
		TYPICAL DETAILS:	NF111	**VISCOSITY:**	N/A	**SURGE PROTECTION:**	NO

SECTION 17401

PRESSURE/VACUUM MEASUREMENT: DIAPHRAGM AND ANNULAR SEALS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Diaphragm seals.

B. Provide all seals identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Additional requirements:
   1. Product data:
      a. Manufacturer’s installation instructions.
      b. Seal type.
      c. Body materials.
      d. Diaphragm material.
      e. Fill fluid type.
      f. Seal size.
      g. Options.
      h. Process connection.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify the compatibility with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.

b. Location within the process.
c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide spare annular seal for every size indicated in the project.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Diaphragm seals:
1. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch gauge: One of the following or equal:
   a. Ashcroft:
      1) Flushing connection: Type 741.
      2) Without flushing connection: Type 740.
   b. Mansfield and Green:
      1) Flushing connection: Type SGT.
      2) Without flushing connection: Type SBT.
   c. Wika, Type L990.40.
2. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures greater than or equal to 15 pounds per square inch gauge: One of the following or equal:
   a. Ashcroft:
      1) Flushing connection: Type 201.
      2) Without flushing connection: Type 200.
      3) Saddle mount: Type 205.

b. Mansfield and Green:
    1) Flushing connection: Type SG.
    2) Without flushing connection: Type SB.
    3) Saddle mount: Type SJ.

2.02 MANUFACTURED UNITS

A. Diaphragm seals:
    1. General:
        a. Diaphragm seal and pressure instrument shall be assembled by pressure instrument manufacturer and shipped as an assembly.
    2. Requirements:
        a. Seal type:
            1) Metallic diaphragm: Welded to upper housing.
            2) Elastomer diaphragm: Bonded to upper housing.
        b. Process connection: 1 inch NPT.
        c. Instrument connection: 1/2 inch NPT.
        d. Material Construction: Type 316 Stainless Steel.
        e. Provide 1/4-inch flushing connection in diaphragm lower housing or provide flushing ring.
        f. Flush port plug: Same material of construction as diaphragm lower housing.
        g. Provide fill/bleed connection.
        h. Mounting: As indicated in the Contract Documents.
        i. Provide Type 316 stainless steel armored capillary for all remote installations.
        j. Nuts and bolts: Type 316 stainless steel.
        k. Materials of construction:
            1) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch:
                a) Diaphragm: Type 316 stainless steel.
                b) Lower housing: Type 316 stainless steel.
                c) Upper housing: Manufacturer’s standard.
                d) Fill fluid: Silicone oil.
            2) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures greater than 15 pounds per square inch:
                a) Diaphragm: Type 316 stainless steel.
                b) Lower housing: Type 316 stainless steel.
                c) Upper housing: Manufacturer’s standard.
                d) Fill fluid: Silicone oil.
            3) Engineer’s approval.

2.03 ACCESSORIES

A. Provide field fill kits.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation System.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

C. Do not use Teflon™ thread seal tape on pressure instruments with silicone oil fill fluid.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING (NOT USED)

3.06 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17404

PRESSURE/VACUUM MEASUREMENT: GAUGES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure/vacuum gauges.

B. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. American Society of Mechanical Engineers (ASME):
   1. B40.100 - Pressure Gauges and Gauge Attachments.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Additional requirements:
   1. Product data:
      a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Ashcroft:
      a. Maximum pressure less than 10 pounds per square inch:
         1) Model 1188.
      b. Maximum pressure greater than or equal to 10 pounds per square inch: Model 1279.
   2. Wika.
   3. Ametek U.S. Gauge.

2.02 MANUFACTURED UNITS

A. General:
   1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.

B. Performance requirements:
   1. Pressure range:
      a. As specified in the Contract Documents.
   2. Accuracy:
      a. Grade 2A, as defined by ASME B40.100.
      b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
      c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.

3. Element:
    a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon® tube.
    b. Socket tips for bellows and Bourdon® tube:
        1) Materials: Type 316 stainless steel.
    c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
    d. Wetted materials: Type 316 stainless steel.
4. Dial gauge:
    a. Dial size: 4-1/2 inches.
    b. Dial case material:
        1) Maximum pressure less than 10 pounds per square inch:
            a) Phenolic.
        2) Maximum pressure greater than or equal to 10 pounds per square inch:
            a) Phenolic.
    c. Provide safety gauge with safety blow out through the back or top of the unit.
    d. Dial face: Gasketed shatterproof glass or polycarbonate.
    e. Provide gauge locks on all pressure gauges directly connected to diaphragm seals.
    f. Provide gauge locks where possible.
    g. Hermetically sealed.
    h. Connection and mounting:
        1) Direct mounted and suitable for outdoor installation.
        2) 1/2-inch NPT.
        3) Connection material: Stainless steel.
    i. Pointer: Externally adjustable.

2.03 ACCESSORIES

A. Pulsation dampeners and snubbers:
    1. Provide pulsation dampener or snubber with each pressure gauge installed on discharge of positive displacement type pump.
    2. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
    3. Materials: Type 316 stainless steel.
    4. Mount pulsation dampener or snubber integrally to the pressure gauge.
    5. Connection: 1/2-inch NPT.

B. Provide diaphragm seals as specified in the Contract Documents and in Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals:
    1. Diaphragm seal and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

C. Provide means for gauge isolation:
    1. Mount valve manifold integrally to the gauge.
    2. Valve manifold and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

D. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

Pressure Gauge

SPECIFICATION: 17404

PROJECT INFORMATION

PLANT WATER POLLUTION CONTROL PLANT
PROJECT 11862A10
CUSTOMER WEST COUNTY WASTEWATER DISTRICT
LOCATION RICHMOND, CA

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

Tag:	P&ID				
PI-102-01	07N002	**SERVICE:** PRESSURE INDICATOR			
		FLUID: WATER	**CONNECTION TYPE:** MATCH EXISTING	**BOTT. HOUSING MAT.:** MFR. STD.	
		TEMPERATURE: [*]	**ISOLATION SEALS:** UTILIZE EXISTING	**INSTRUMENT VALVES:** UTILIZE EXISTING	
		MEASURING PRINCIPLE: DIRECT	**CASE MATERIAL:** PHENOLLIC	**DIAPHRAGM MAT.:** MFR. STD.	
		TYPICAL DETAILS: [*]	**DIAL SIZE:** 4-1/2"	**AMBIENT TEMP:** [*]	
		GAUGE RANGE: __-__ PSI	**OPTIONS:** [*]		
Tag:	**P&ID**				
PI-102-02	07N002	**SERVICE:** PRESSURE INDICATOR			
		FLUID: WATER	**CONNECTION TYPE:** MATCH EXISTING	**BOTT. HOUSING MAT.:** MFR. STD.	
		TEMPERATURE: [*]	**ISOLATION SEALS:** UTILIZE EXISTING	**INSTRUMENT VALVES:** UTILIZE EXISTING	
		MEASURING PRINCIPLE: DIRECT	**CASE MATERIAL:** PHENOLLIC	**DIAPHRAGM MAT.:** MFR. STD.	
		TYPICAL DETAILS: [*]	**DIAL SIZE:** 4-1/2"	**AMBIENT TEMP:** [*]	
		GAUGE RANGE: __-__ PSI	**OPTIONS:** [*]		
Tag:	**P&ID**				
PI-102-03	07N002	**SERVICE:** PRESSURE INDICATOR			
		FLUID: WATER	**CONNECTION TYPE:** MATCH EXISTING	**BOTT. HOUSING MAT.:** MFR. STD.	
		TEMPERATURE: [*]	**ISOLATION SEALS:** UTILIZE EXISTING	**INSTRUMENT VALVES:** UTILIZE EXISTING	
		MEASURING PRINCIPLE: DIRECT	**CASE MATERIAL:** PHENOLLIC	**DIAPHRAGM MAT.:** MFR. STD.	
		TYPICAL DETAILS: [*]	**DIAL SIZE:** 4-1/2"	**AMBIENT TEMP:** [*]	
		GAUGE RANGE: __-__ PSI	**OPTIONS:** [*]		
Tag:	**P&ID**				
PI-102-04	07N002	**SERVICE:** PRESSURE INDICATOR			
		FLUID: WATER	**CONNECTION TYPE:** MATCH EXISTING	**BOTT. HOUSING MAT.:** MFR. STD.	
		TEMPERATURE: [*]	**ISOLATION SEALS:** UTILIZE EXISTING	**INSTRUMENT VALVES:** UTILIZE EXISTING	
		MEASURING PRINCIPLE: DIRECT	**CASE MATERIAL:** PHENOLLIC	**DIAPHRAGM MAT.:** MFR. STD.	
		TYPICAL DETAILS: [*]	**DIAL SIZE:** 4-1/2"	**AMBIENT TEMP:** [*]	
		GAUGE RANGE: __-__ PSI	**OPTIONS:** [*]		

Pressure Gauge

SPECIFICATION: 17404

PROJECT INFORMATION

PLANT WATER POLLUTION CONTROL PLANT
PROJECT 11862A10
CUSTOMER WEST COUNTY WASTEWATER DISTRICT
LOCATION RICHMOND, CA

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

Tag:	P&ID						
PI-102-05	07N002	**SERVICE:**	PRESSURE INDICATOR				
		FLUID:	WATER	**CONNECTION TYPE:**	MATCH EXISTING	**BOTT. HOUSING MAT.:**	MFR. STD.
		TEMPERATURE:	[*]	**ISOLATION SEALS:**	UTILIZE EXISTING	**INSTRUMENT VALVES:**	UTILIZE EXISTING
		MEASURING PRINCIPLE:	DIRECT	**CASE MATERIAL:**	PHENOLLIC	**DIAPHRAGM MAT.:**	MFR. STD.
		TYPICAL DETAILS:	[*]	**DIAL SIZE:**	4-1/2"	**AMBIENT TEMP:**	[*]
		GAUGE RANGE:	__-__ PSI	**OPTIONS:**	[*]		
Tag:	**P&ID**						
PI-PMP1	07N003	**SERVICE:**	PRESSURE INDICATOR				
		FLUID:	[*]	**CONNECTION TYPE:**	[*]	**BOTT. HOUSING MAT.:**	MFR. STD.
		TEMPERATURE:	[*]	**ISOLATION SEALS:**	N/A	**INSTRUMENT VALVES:**	[*]
		MEASURING PRINCIPLE:	DIRECT	**CASE MATERIAL:**	[*]	**DIAPHRAGM MAT.:**	MFR. STD.
		TYPICAL DETAILS:	[*]	**DIAL SIZE:**	[*]	**AMBIENT TEMP:**	[*]
		GAUGE RANGE:	__-__ PSI	**OPTIONS:**	[*]		
Tag:	**P&ID**						
PI-PMP3	07N003	**SERVICE:**	PRESSURE INDICATOR				
		FLUID:	[*]	**CONNECTION TYPE:**	[*]	**BOTT. HOUSING MAT.:**	MFR. STD.
		TEMPERATURE:	[*]	**ISOLATION SEALS:**	N/A	**INSTRUMENT VALVES:**	[*]
		MEASURING PRINCIPLE:	DIRECT	**CASE MATERIAL:**	[*]	**DIAPHRAGM MAT.:**	MFR. STD.
		TYPICAL DETAILS:	[*]	**DIAL SIZE:**	[*]	**AMBIENT TEMP:**	[*]
		GAUGE RANGE:	__-__ PSI	**OPTIONS:**	[*]		

SECTION 17710

CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Design, fabrication and assembly of all instrumentation enclosures, control panels and components provided under this contract, including but not limited to:
      a. Custom built instrumentation and control panels, including all enclosures for hand stations controllers, low voltage power distribution and marshalling panels.
      b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs) and chemical feed panels.
      c. Control components.
      d. Control panel installation.

B. Provide all control panels identified in Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
   2. 802.3af - Standard for Information Technology Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.
   3. 802.3at - Standard for Information Technology -- Local and Metropolitan area networks -- Specific requirements -- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements.

C. International Electrotechnical Commission (IEC):
   1. 61643-11 - Low-Voltage Surge Protective Devices - Part 11: Surge Protective Devices Connected to Low-Voltage Power Systems - Requirements and test methods.
   2. 61643-21 - Low-Voltage Surge Protective Devices - Part 21: Surge Protective Devices Connected to Telecommunications and Signaling Networks - Performance Requirements and Testing Methods.

D. Underwriters Laboratories Inc. (UL):
   1. 248-14 - Low-Voltage Fuses - Part 14: Supplemental Fuses.
   2. 497B - Standard for Protectors for Data Communications and Fire-Alarm Circuits.
   3. 508 - Standard for Industrial Control Equipment.
   4. 508A - Standard for Industrial Control Panel.
   5. 698A - Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations.
   6. 913 - Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations.
   7. 1077 - Standard for Supplementary Protectors for Use in Electrical Equipment.
   8. 1283 - Standard for Electromagnetic Interference Filters.
   9. 1449 - Standard for Surge Protective Devices.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Specific definitions:
   1. The term “panel” in this Section is interchangeable with the term “enclosure.”

1.04 SUBMITTALS

A. Provide submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide a control panel hardware submittal for each control panel and enclosure being provided on this project, including but not limited to:
   1. Product data:
      a. Enclosure construction details and NEMA type.
      b. Manufacturer's literature and specification data sheets for each type of equipment to be installed within or on the panel or enclosure.
   2. Shop drawings:
      a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
         1) Provide draft for review and approval by Engineer. The Engineer has the authority to substantially alter initial panel layouts.
      b. Complete nameplate engraving schedule.
      c. Structural details of fabricated panels.
   3. Calculations:
      a. Provide installation details based on calculated shear and tension forces:
         1) Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.
      b. For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:
         1) Weight including panel internal components.
         2) Seismic forces and overturning moments.
         3) Shear and tension forces in connections.

c. Cooling calculations, including but not limited to:
    1) Highest expected ambient temperature for the enclosure's location.
    2) Internal heat load.
    3) Exposure to direct sunlight.
    4) Dimensions of the enclosure in inches.
    5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

C. Seismic design:
    1. Seismic panel construction:
        a. Seismic anchorage: Provide seismic design calculations and installation details for anchorage of all panels, enclosures, consoles, etc. to meet seismic requirements in Section 01612 - Seismic Design Criteria:
            1) Stamped by a Professional Engineer registered in the state where the project is being constructed.
        b. For floor-mounted freestanding panels weighing 200 pounds or more (assembled, including contents), submit calculations, data sheets, and other information to substantiate that panel, base, and framing meet minimum design strength requirements and seismic requirements as specified in Section 01612 - Seismic Design Criteria. Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
    1. Provide all components and equipment with UL 508 listing.
    2. All control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL 508A labeling.
    3. Provide fuses for all equipment that is not UL or UR listed.
    4. Install all intrinsically safe circuits and equipment in accordance with UL698A.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
    1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation.

1.08 SEQUENCING (NOT USED)

1.09 SCHEDULING (NOT USED)

1.10 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.11 SYSTEM START-UP (NOT USED)

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 COMMISSIONING (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. As listed below in the individual component paragraphs.

B. Provide instruments and other components performing similar functions of the same type, model, or class, and from 1 manufacturer.

2.02 SYSTEM DESCRIPTION

A. Panel dimensions:
   1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer's non-certified information. It is the responsibility of the Contractor or manufacturer to design and size all panels:
      a. Size panels to provide space for all equipment, wiring, terminations, and other items in the panel, including space for future build out.
      b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
      c. Maximum panel depth: 30 inches, unless otherwise indicated.

B. Structural design:
   1. Completed and installed panel work shall safely withstand seismic requirements at the project site as specified in Section 16050 - Common Work Results for Electrical. Enclosures and internal equipment shall be braced to prevent damage from specified forces.

2.03 EXISTING PRODUCTS

A. Provide labor and materials for complete modifications to existing panels as required.

B. Field cut and refinish existing panel faces to original condition to accommodate installation of new instruments, removal of existing instruments, and fitting of blanks to suit new layouts. New instrument supports shall be provided as required for complete installation.

2.04 MATERIALS

A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
   1. Enclosures shall have the following properties:
      a. NEMA Type 1: Steel.
      b. NEMA Type 4: Steel with gasketed door, raintight.
      c. NEMA Type 4X: Type 316 stainless steel (unless Type 304 is indicated on the Drawings).
      d. NEMA Type 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
      e. NEMA Type 12: Steel with gasketed door, dusttight.
      f. NEMA Type 7: Cast aluminum.

B. Bolting material:
   1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts, and washers, with unified coarse (UNC) threads.
   2. Carriage bolts for attaching end plates.
   3. All other bolted joints shall have S.A.E. standard lock washers.

2.05 MANUFACTURED UNITS

A. Panels/enclosures:
   1. Manufacturers: One of the following or equal:
      a. Rittal.
      b. nVent/Hoffman.
      c. Saginaw Control & Engineering.
   2. Panel assembly:
      a. General guidelines for panel fabrication include:
         1) Continuous welds ground smooth.
         2) Exposed surfaces free of burrs and sharp edges.
         3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
      b. Construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	14	14
Up to 57	12	12
57 - 69	12	10
69 - 82	12, except 10 on back	10
82 or more	10	10

         1) Use heavier sheet metal to meet seismic requirements at the project site or when required due to equipment requirements.

c. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.
d. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.
e. Door construction:
    1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
    2) Sufficient width to permit door opening without interference with rear projection of flush-mounted instruments.
    3) Heavy-gauge stainless steel hinges.
    4) For NEMA Type 12, Type 4, and Type 4X, provide oil-resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
    5) Gasket installed to seal against roll lip on the enclosure opening.
f. Latches:
    1) For panels, provide each door with a 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods shall be connected to a common door handle, hold doors securely, and form a compressed seal between door and gasket, at the top, side, and bottom:
        a) Provide padlock for each enclosure with padlock provisions.
    2) Include an oiltight key-locking, 3-point latching mechanism on each door:
        a) Provide 2 keys per panel.
        b) All locks keyed alike.
    3) For large NEMA Type 4 and NEMA Type 4X cabinets not available with 3-point latching hardware, provide multiple clips and padlock hasps.
g. Panel cut-outs:
    1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
    2) Allow a minimum of 3-inch envelope around all displays, controllers, and monitors.
    3) Reinforce around cut-outs with steel angles or flat bars for the following:
        a) Large panel cutouts; for example, openings for local operator interfaces.
        b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.

3. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
    a. All enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
    b. Door hardware: Stainless steel.
    c. Provide factory installed rain canopy and sun shield for all enclosures with operator interface panels.
    d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.

B. Arrangement of components:
   1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
   2. Arrange panel instruments and control devices in a logical configuration, associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
   3. Mount internal control components on an internal back panel. Devices may be mounted on the side panel only by special permission from the Engineer.
   4. All control panel mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.

C. Overcurrent protection:
   1. Main overcurrent device:
      a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange-mounted disconnect handle operating a molded-case circuit breaker and provide a control power transformer for 120-VAC circuits:
         1) Door-mounted disconnect handles are not acceptable.
         2) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
         3) Provide means to defeat the interlock.
         4) Lockable in the off position.
      b. Control panels supplied with 120 VAC:
         1) Provide an internal breaker with the line side terminals covered by a barrier.
         2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
         3) Provide a nameplate prominently positioned on the control panel stating “CAUTION Risk of Electric Shock – UPS equipment outputs remain energized with main disconnect in off position” for any panel containing a UPS.
   2. Provide circuit breakers as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
   3. Selection and ratings of protective devices:
      a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
      b. Voltage rating: Not less than the voltage of the application.
      c. Select current rating and trip characteristics to be suitable for:
         1) Maximum normal operating current.
         2) Inrush characteristics.
         3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
      d. Circuit breakers, fuses, and motor overcurrent protection devices used for branch circuit protection must be UL 508A compliant:
         1) Circuit breakers listed under UL 1077 Standard for Supplementary Protectors that do not comply with UL 508A requirements are not acceptable.

2) Miscellaneous, miniature, and micro fuses listed under UL 248 Part 14 that do not comply with UL 508A requirements are not acceptable.
3) Manual motor controllers provided with an instantaneous-trip overcurrent mechanism listed under UL 508 that do not comply with UL 508A requirements are not acceptable.

4. Provide a separate protective device for each powered electrical device:
   a. An individual circuit breaker for each 120-VAC instrument installed within its respective control panel and clearly identified for function.
   b. An individual fuse for each PLC discrete output. Provide with individual blown fuse indication external of the I/O card:
      1) Size external fuse to open before any I/O-card-mounted fuses.
   c. Individual discrete inputs shall use a 1/2-ampere fuse.
   d. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.
5. Fuses for 4 to 20 milliamperes signals:
   a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
      1) Label shall not cover or interfere with equipment manufacturer's instructions.
   b. An individual 1/2-ampere fuse for each 4-to-20 milliamperes analog loop powered from the control panel.
   c. Provide fuses rated for the voltage and available short-circuit current at which they are applied.
   d. Manufacturers: One of the following or equal:
      1) Ferraz Shawmut.
      2) Littelfuse.
      3) Bussmann.
6. Fuse holders:
   a. Modular type:
      1) DIN rail mounting on 35-millimeter rail.
      2) Touch-safe design: All connection terminals to be protected against accidental touch.
      3) Incorporates blown-fuse indicator.
      4) Plug-in style fuse terminals and fuse plugs are not acceptable.
   b. Provide nameplate identifying each fuse:
      1) As specified in Section 16075 - Identification for Electrical Systems.
   c. Manufacturers: One of the following or equal:
      1) Phoenix Contact, UT4-HESI Series.
      2) Allen-Bradley, 1492-FB Series B.
7. Control circuit breakers:
   a. DIN rail mounting on 35-millimeter rail.
   b. Manual OPEN-CLOSE toggle switch.
   c. Rated for 250 VAC.
   d. Interrupting rating: 10 kiloampere (kA) or available fault current at the line terminal, whichever is higher.
   e. Current ratings: As required for the application.
   f. Provide nameplate identifying each circuit breaker:
      1) As specified in Section 16075 - Identification for Electrical Systems.
   g. Manufacturers: One of the following or equal:
      1) Phoenix Contact, TMC Series.
      2) ABB.

3) Allen-Bradley.
4) Square D.

8. Electronic circuit protectors:
   a. Used where a NEC Class 2 power circuit is required to protect devices with NEC Class 2 power supplies.
   b. DIN rail mounting on 35-millimeter rail.
   c. Rated for 24 VDC.
   d. 4 channels to feed 4 independent power feeds to separate devices.
   e. Output current ratings: As required for the application.
   f. LED input status indication.
   g. LED failure status of each channel indication.
   h. Fail contacts.
   i. Provide nameplate identifying each circuit electronic circuit protector module:
      1) As specified in Section 16075 - Identification for Electrical Systems.
   j. Manufacturers: One of the following or equal:
      1) Rockwell Automation 1692-TD014.
      2) Puls PISA11 series.

D. Conductors and cables:
   1. Power and control wiring:
      a. Materials: Stranded, soft annealed copper.
      b. Insulation: 600 volts type MTW.
      c. Minimum sizes:
         1) Primary power distribution: 12 AWG.
         2) Secondary power distribution: 14 AWG.
         3) Control: 16 AWG.
      d. Color:
         1) AC power (line and load): Black.
         2) AC power (neutral): White.
         3) AC control: Red.
         4) AC control: Orange for foreign voltages.
         5) DC power and control (ungrounded): Blue.
         6) DC power and control (grounded): White with Blue stripe.
         7) Ground: Green.
   2. Signal cables:
      a. Materials: Stranded, soft annealed copper.
      b. Insulation: 600 volts, PVC outer jacket.
      c. Minimum size: 18 AWG paired triad.
      d. Overall aluminum shield (tape).
      e. Copper drain wire.
      f. Color:
         1) 2-Conductor:
            a) Positive (+): Black.
            b) Negative (-): White and red.
         2) 3-Conductor:
            a) Positive (+): Black.
            b) Negative (-): Red.
            c) Signal: White.
      g. Insulate the foil shielding and exposed drain wire for each signal cable with heat-shrink tubing.

E. Conductor identification:
   1. Identify each conductor and cable with unique wire numbers as specified in Section 16075 - Identification for Electrical Systems.
   2. Readily identified without twisting the conductor.

F. General wiring requirements:
   1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
   2. Install all components in accordance with the manufacturer's instructions included in the listing and labeling.
   3. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
   4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
   5. Provide power surge protection for all control panels.
   6. Provide signal surge protection within control panels for each analog I/O, discrete I/O, and data line (Copper Ethernet, Coax, Fieldbus signals) that originates from outdoor devices.
   7. Provide non-metallic ducts for routing and organization of conductors and cables:
      a. Provide wiring separation plan.
      b. Size ducts for ultimate build-out of the panel, or for 20-percent spare, whichever is greater.
      c. Provide separate ducts for signal and low-voltage wiring from power and 120-VAC control wiring:
         1) 120 VAC: Grey colored ducts.
         2) 24 VDC: White colored ducts.
   8. Cables shall be fastened with cable-mounting clamps or with cable ties supported by any of the following methods:
      a. Screw-on cable tie mounts.
      b. Hammer-on cable-tie mounting clips.
      c. Fingers of the nonmetallic duct.
   9. Wire ties:
      a. No wire ties inside wire duct.
      b. Use Panduit Cable tie installation tool, with tension control/cutoff.
      c. Verify cut ends are cut flush filed smooth after installed.
   10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
   11. Support panel conductors where necessary to keep them in place.
   12. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
   13. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
      a. Factory-applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
   14. The control panel shall be the source of power for all 120-VAC devices interconnected with the control panel including, but not limited to:
      a. Solenoid valves.
      b. Instruments both mounted in the control panel and remotely connected to the control panel.

G. Provide power circuits for all Contractor and Vendor-furnished PLC cabinets in accordance with the PLC and Instrument Power wiring diagrams Indicated on the Drawings or as specified.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. Thermal management:
   1. Provide heating, cooling, and dehumidifying devices in order to maintain all instrumentation and control devices to within a range as specified in Section 17050 - Common Work Results for Process Control and Instrumentation.
   2. Air conditioner:
      a. Provide solid-state cabinet coolers or air conditioning units on all outdoor panels containing electronic components such as local operator interfaces, panel instruments, programmable logic controllers, or remote I/O.
      b. Provide filters on intake and exhaust openings.
      c. Increase panel sizes as needed to accommodate cooling units.
      d. Manufacturers: The following or equal:
         1) Kooltronic, Guardian DP Series.
         2) ICEqube, Blade series or IECEx/ATEX for Zone 1 & 2.
   3. Heating:
      a. Provide all panels located in areas that are not climate controlled with thermostatically controlled strip heaters, except where all of the following conditions apply:
         1) The panel is not supplied with 120 VAC power.
         2) There are no electronics or moisture-sensitive devices in the enclosure.
         3) The panel is smaller than 38 inches high.
   4. Heat exchanger:
      a. Closed-loop design ensuring separation of ambient air and clean air inside the cabinet.
      b. Filterless design to facilitate easy cleaning of the core.
      c. Mounting: As indicated on the Drawings.
      d. Manufacturers: The following or equal:
         1) Noren, CC Series.
         2) ICEqube, Blade series.
   5. Enclosure temperature switch:
      a. Provide wall-mounted bimetallic switch transmitter (to measure internal cabinet temperature in all enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
      b. Sensor and electronic enclosure.
      c. Accuracy: Within 2 degrees Fahrenheit.
      d. Single contact:
         1) Manufacturers: One of the following or equal:
            a) nVent/Hoffman ATEMNC.
            b) Pfannenberg FLZ.
      e. Dual contact:
         1) Manufacturers: The following or equal:
            a) nVent/Hoffman ADLTEMP.

6. Status relays and discrete inputs for switches, power supplies, and fieldbus devices (if applicable):
    a. Provide as indicated on the Drawings or as specified.
7. Fan ventilation:
    a. Provide nVent/Hoffman fan speed control:
        1) Provide 2 door/cabinet-mounted vent fans for every 72 inches of cabinet width.
        2) Provide finger-guard kit.
        3) Filter kit with 2 spare filters for each intake fan.
        4) Provide bezel and gasket kit.
        5) Provide fan shroud.
        6) Automatically adjust fan speed depending on remote temperature sensor input.
        7) 120 VAC, 60 hertz.
        8) NEMA Type 5-15R cord connections.

B. Pilot devices:
1. General:
    a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
    b. Size:
        1) 30.5 millimeters.
    c. Heavy duty.
    d. Pushbuttons:
        1) Contacts rated:
            a) NEMA Type A600.
        2) Furnish 1 spare normally open contact and normally closed contact with each switch.
    e. Selector switches:
        1) Contacts rated:
            a) NEMA Type A600.
            b) Knob type.
        2) Furnish 1 spare normally open contact and normally closed contact with each switch.
        3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
    f. Pilot lights:
        1) Type:
            a) LED for interior installations.
        2) Push to test.
        3) Lamp color:
            a) On/Running/Start: Red.
            b) Off/Stop: Green.
            c) Power: White.
            d) Alarm: Amber.
            e) Status or normal condition: White.
            f) Opened: Red.
            g) Closed: Green.
            h) Failure: Red.

2. Indoor and outdoor areas:
    a. NEMA Type 4/13.
    b. Manufacturers: One of the following or equal:
        1) Allen-Bradley, Type 800T.
        2) Schneider Electric, Class 9001, Type K.
        3) General Electric, Type CR104P.
        4) IDEC, TWTD Series.
3. Corrosive areas:
    a. NEMA Type 4X.
    b. Corrosion resistant.
    c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc.
    d. Manufacturers: One of the following or equal:
        1) Cutler Hammer, Type E34.
        2) Schneider Electric, Class 9001, Type SK.
        3) Allen-Bradley Type 800H.
        4) IDEC, TWTD Series.
4. Hazardous (Classified) Areas/Class I Division 2:
    a. NEMA Type 4X.
    b. Corrosion resistant.
    c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc:
        1) All contacts contained within a hermetically sealed chamber:
            a) Pushbuttons.
            b) Selector switches.
            c) Push-to-test contacts on pilot lights.
        2) UL listed and labeled for Class I Division 2 areas.
    d. Manufacturers: One of the following or equal:
        1) Cutler Hammer, Type E34.
        2) Allen-Bradley, Type 800H.

C. Signal isolators and converters:
1. Furnish signal isolators that provide complete isolation of input, output, and power input:
    a. Minimum isolation level: 1.0 kilovolts AC/50 hertz for at least 1 minute.
    b. Adjustable span and zero.
    c. Accuracy: Within 1.0 percent of span.
    d. Ambient temperature range: -4 degrees to 149 degrees Fahrenheit.
2. Manufacturers: One of the following or equal:
    a. Phoenix Contact, Mini Analog Pro.
    b. Acromag, 1500, 600T, 800T, Flat Pack, or ACR Series.
    c. Action Instruments, Q500 Series or Ultra SlimPakII.
    d. AGM Electronics, Model TA-4000.
    e. Moore Industries, MIT 4-Channel.

D. Relays:
1. General:
    a. For all types of 120-VAC relays, provide surge protection across the coil of each relay.
    b. For all types of 24-VDC relays, provide a free-wheeling diode across the coil of each relay.

c. For plug in type relays, provide a relay base from the same manufacturer as the relay manufacturer.

2. General purpose:
   a. Magnetic control relays.
   b. NEMA ratings:
      1) 300 volts.
      2) 10 Amps thermal continuous test current.
      3) 60 Amps make.
      4) 6 Amps break.
   c. Plug-in type.
   d. LED indication for energization status.
   e. Coil voltages: As required for the application.
   f. Minimum poles: DPDT.
   g. Touch-safe design: All connection terminals to be protected against accidental touch.
   h. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
   i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
   j. Relays with screw-type socket terminals.
   k. Provide additional (slave/interposing) relays when the following occurs:
      1) The number or type of contacts shown exceeds the contact capacity of the specified relays.
      2) Higher contact rating is required in order to interface with starter circuits or other equipment.
   l. DIN rail mounting on 35-millimeter rail.
   m. Ice-cube-type relays with retainer clips to secure relay in socket.
   n. Integrated label holder for device labeling.
   o. Manufacturers: One of the following or equal:
      1) Potter and Brumfield: Type KRP or KUP.
      2) IDEC: R* Series (* = H, J, R, S, U).
      3) Allen-Bradley: Type 700 HC.
      4) Square D: Type K.

3. Terminal block relays:
   a. Magnetic control relays.
   b. For use as an interposing relay for PLC based discrete I/O signals.
   c. NEMA ratings:
      1) 250 volts.
      2) 6 Amps continuous.
      3) 1,500 volt-amperes make.
   d. Plug-in type.
   e. LED indication for energization status.
   f. Coil voltages: As required for the application.
   g. Minimum poles: SPDT.
   h. Touch-safe design: All connection terminals to be protected against accidental touch.
   i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
   j. Relays with screw-type socket terminals.
   k. DIN rail mounting on 35-millimeter rail.
   l. Integrated label holder for device labeling.

m. Manufacturer: One of the following or equal:
    1) Phoenix Contact PLC Series.
    2) Eaton XR TBR Series.
    3) IDEC RV8H Series.
    4) Allen-Bradley Type 700 HL TBR Series.

4. Latching:
    a. Magnetic-latching control relays.
    b. NEMA ratings:
        1) 300 volts.
        2) 5 Amps continuous.
        3) 360 volt-amperes make.
        4) 320 volt-amperes break.
    c. Plug-in type.
    d. DIN rail mounting on 35-millimeter rail.
    e. Coil voltage: As required for the application.
    f. Minimum poles: 2 PDT; as required for the application. Plus 1 spare pole.
    g. Touch-safe design: All connection terminals to be protected against accidental touch.
    h. Clear cover for visual inspection.
    i. Provide retainer clip to secure relay in socket.
    j. Manufacturers: One of the following or equal:
        1) Square D, 8501, Type K.
        2) IDEC, RR2KP Series.
5. Time delay:
    a. Provide time-delay relays to control contact transition time.
    b. Contact rating:
        1) 240 volts.
        2) 10 Amps continuous.
        3) 3,600 volt-amperes make.
        4) 360 volt-amperes break.
    c. Coil voltage: As required for the application.
    d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off-delay:
        1) For off-delay, use true power-off time-delay relays. Where the required timing range exceeds capability of the off-delay relay use, signal off-delay where power loss will not cause undesirable operation or pneumatic time-delay relays.
    e. Minimum poles: 2 PDT.
    f. Units include adjustable dial with graduated scale covering the time range in each case.
    g. Minimum timing range: 0.1 seconds to 10 minutes, or as required for the application.
    h. Manufacturers: One of the following or equal:
        1) IDEC, RTE Series.
        2) Tyco Electronics, Agastat 7000 Series (pneumatic).
        3) Allen-Bradley, Type 700-HR.

E. Terminal blocks:
    1. DIN rail mounting on 35-millimeter rail.
    2. Rated for 15 amperes at 600 volts.
    3. Screw terminal type.

4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
5. Finger-safe protection for all terminals for conductors.
6. Construction: Polyamide insulation material capable of withstanding temperature extremes from -40 degrees to 221 degrees Fahrenheit.
7. Terminals: Plainly identified to correspond with markings on the diagrams:
    a. Permanent machine-printed terminal identification.
8. Disconnect-type field signal conductor terminals with socket/screw for testing.
9. Identify terminals suitable for use with more than 1 conductor.
10. Position:
    a. So that the internal and external wiring does not cross.
    b. To provide unobstructed access to the terminals and their conductors.
11. Provide minimum 25-percent spare terminals.
12. Manufacturers: One of the following or equal:
    a. Phoenix Contact, UT4 Series.
    b. Allen-Bradley, 1492 Series.

F. DIN rail grounding:
1. Grounding terminal blocks used exclusively for bonding each DIN rail section to panel grounding busbar shall:
    a. Mount to DIN rail via grounding foot with mounting screw.
    b. Connect to the panel grounding busbar shall be via a green insulated conductor sized in accordance with NEC.
    c. Not be used for grounding signal cable shields.
2. Screw terminal type.
3. DIN rail mounting on 35-millimeter rail.
4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
5. Finger-safe protection for all terminals for conductors.
6. Terminals: Plainly identified to correspond with markings on the diagrams:
    a. Permanent machine-printed terminal identification.
7. Manufacturers: One of the following or equal:
    a. Phoenix Contact, USKLG Series.
    b. Allen-Bradley, 1492-JG Series.

G. Wire duct:
1. Provide flame retardant plastic wiring duct, slotted with dust cover.
2. Type:
    a. Wide slot.
    b. Narrow slot.
    c. Round hole.
3. Manufacturers: The following or equal:
    a. Panduit.
    b. Phoenix Contact.
    c. Thomas & Betts.
    d. Iboco.

H. DIN rail:
1. Perforated steel.
2. 35 mm width.

3. 15 mm deep.
4. Provide 2-inch offset using one of the following:
    a. Offset brackets.
    b. Preformed standoff DIN Rail Channel.

I. Surge protection devices (SPD):
1. 120 VAC control panel power SPD:
    a. Provide SPD for panel 120 VAC power entrances:
        1) Non-faulting and non-interrupting design.
        2) Provide line to neutral and neutral to ground surge protection.
    b. Provide surge protection at secondary of main circuit breaker:
        1) Surge protection is not required for 120 VAC circuits that are only used for panel lights and receptacles.
        2) For panels receiving power at 480 VAC, provide surge protection on the 120 VAC control power transformer secondary.
    c. DIN rail mounting.
    d. Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:
        1) Gastight connections.
        2) Visual status indication of MOV status on the input and output circuits.
        3) Dry contact rated for remote status indication.
    e. Approvals:
        1) Tested in accordance with IEC 61643-11.
        2) Tested in accordance with UL 1283.
        3) Tested in accordance with UL 1449.
        4) Surge protection minimum requirements: Withstand a minimum 10-kA test current of an 8/20 µs waveform in accordance with IEEE C62.41.1 Category C Area.
    f. Manufacturers: One of the following or equal:
        1) Phoenix Contact, Type SFP Filter.
        2) ASCO, Model 277.
2. 24 VDC control panel power SPD:
    a. Provide SPD for 24VDC power circuits.
    b. Provide surge protection at DC power supply output.
    c. DIN rail mounting.
    d. Attach wiring to the SPD by means of a screw-type cable clamping terminal block:
        1) Optical status indicator.
        2) Dry contact rated for remote status indication.
    e. Approvals:
        1) Tested in accordance with IEC 61643-11.
    f. Manufacturers: One of the following or equal:
        1) Phoenix Contact, Plugtrab PLT-SEC-T3-24-FM-UT.
3. Panel mounted control, signal, and data line SPD:
    a. General:
        1) This section applies to SPD located in a control panel, field panel, network junction box, or marshalling panel.
        2) Approvals:
            a) Tested in accordance with IEC 61643-21.
            b) Tested in accordance with UL 497B.

3) SPD shall consists of 2 parts:
a) Base module:
(1) DIN rail mounting:
(a) Grounded to DIN rail via mounting rail foot.
b) Plug protection module:
(1) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
4) Provide indirect shield ground style SPD unless otherwise noted.
5) Provide ability to locally identify and indicate SPD health.
6) SPD shall be provided with controller module with dry contact for remote status monitoring of SPD device health.
7) SPD modules shall be compatible with signal, communication bus type, data type, or control power being protected.
8) Provide dedicated SPD for each signal, communication bus type, or data line being protected.

b. Manufacturers: One of the following or equal:
1) Phoenix Contact, Plugtrab PT-IQ Series.
2) Dehn, Blitzductor XTU Series.

4. Copper Ethernet SPD:
a. Protects network equipment from lightning or other surge events.
b. Suitable for Gigabit networks.
c. Compatible with shielded Cat 6 cabling with shielded RJ-45 ports.
d. Compliant with PoE standards IEEE 802.3af and 802.3at.
e. Nominal discharge surge current: 10 kA.
f. Approvals:
1) Tested in accordance with IEC 61643-21.
2) Tested in accordance with UL 497B.
g. Manufacturers: One of the following or equal:
1) Phoenix Contact, DT-LAN-CAT6+.
2) Weidmuller, VDATA CAT6.
3) Eaton/MTL, ZoneBarrier.

5. Field device mounted SPD:
a. Conduit entry mounting:
1) Provide parallel or through wiring configurations as required by the application:
a) Use parallel wiring configuration if there is an available cable gland at the device.
b) Use through wiring configuration if there is no available cable gland at the device.
2) Provide Screw connections compatible with field device.
b. NEMA 4X stainless steel material housing.
c. Approvals:
1) Tested in accordance with IEC 61643-21.
d. 4-wire field device:
1) Module shall provide simultaneous protection of signal cable, communication bus, or data line, and power supply line:
a) Maximum continuous voltage:
(1) DC:
(a) Signal: 32 VDC.
(b) Power supply: 255 VDC.

(2) AC:
(a) Signal: 22.6 VAC.
(b) Power supply: 255 VAC.
2) Manufacturers: The following, engineer knows of no equal:
a) Endress+Hauser, HAW569-CB2C.
e. 2-wire or 3-wire field device:
1) Module shall provide protection for the signal cable, communication bus or data line.
2) Manufacturers: One of the following or equal:
a) Endress+Hauser, HAW569 Series.
b) Phoenix Contact, Surgetrab S-PT Series.
c) Eaton/MTL, TP Series.

J. Horns and beacons:
1. Beacons/horn combination units:
a. Manufacturers: The following or equal:
1) Edwards, Multi-Status LED 108i with tone module.
b. LED Colors: Red, Green, and Amber.
c. Power: 120VAC.
d. Provide accessories such as pipe mount flange, pipe extensions, corner mount brackets, or wall mount brackets as needed.
e. Horn rated 80 dB minimum at 10 feet.
2. Dedicated beacon unit:
a. Manufacturers: One of the following or equal:
1) Federal Signal Corp., Starfire Series.
2) Allen-Bradley, 855 B *-* 10 Series.
3) Edwards, 102 Series.
3. Dedicated horn unit:
a. Electromechanical:
1) Manufacturers: One of the following or equal:
a) Federal Signal, 350 or 31X Series.
b) Edwards, 878EX or 879EX Series.
b. Electronic:
1) Manufacturers: One of the following or equal:
a) Federal Signal, 300GCX or 300X Series.
b) Allen-Bradley, 855H or 855XH Series.
c) Edwards, 5530M or 5533MD Series.
c. Rated for 80 dB minimum at 10 feet.

K. Power supplies:
1. Design power supply system so that either the primary or backup supply can be removed, repaired or replaced, and returned to service without disrupting the system operation.
2. Convert 120 VAC to 24-volt DC or other DC voltages required or as required for the application.
3. Provide redundant backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.
4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure in either a 1+1 or N+1 configuration as required:
a. Provide automatic switchover upon module failure.
b. Alarm contacts monitored by the PLC.

5. Provide protective isolation between power supply units either by means of Diodes, Diode Modules, MOSFET Modules, or use power supplies with built in redundancy. Power supplies with built in redundancy must actively isolate each power supply and be designed as such.
6. Sized to provide 40-percent excess rated capacity.
7. UL 508C listed to allow full-rated output without de-rating.
8. Provide fuse or short-circuit protection.
9. Provide a minimum of 1 set of dry contacts for each power supply configured to change state on failure for monitoring and signaling purposes.
10. Output regulation: Within 0.05 percent for a 10-percent line change or a 50-percent load change.
11. Operating temperature range: 32 degrees to 140 degrees Fahrenheit.
12. Touch-safe design: All connection terminals to be protected against accidental touch.
13. DIN rail mounting on 35-millimeter rail:
    a. Mount the power supply in the proper orientation as recommended by the manufacturer to ensure adequate thermal dispersion without derating the power supply.
14. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
15. Manufacturers: One of the following or equal:
    a. Fully redundant:
        1) Phoenix Contact, Quint Power Supply with SFB technology.
            a) Phoenix Contact, Quint.
        2) IDEC, PS5R Series:
        3) Sola.
        4) PULS.
    b. Redundancy module:
        1) Phoenix contact, o-ring redundancy module.

L. Limit switches:
1. NEMA Type 4X.
2. AC contact rating 120 volts, 10 A.
3. DC contact rating 125 volts, 0.4 A.
4. Provide robust actuation mechanism not prone to degradation.
5. Provide complete actuator mechanism with all required hardware.
6. Allows for contact opening even during contact weld condition.
7. UL approved.
8. Operating temperature range: 0 degrees to 230 degrees Fahrenheit.
9. Manufacturers: One of the following or equal:
    a. Allen-Bradley, 802 Series.
    b. Honeywell, HDLS Series.
    c. Omron, D4 Series.
    d. Eaton, E47, E49, E50.
    e. ABB.

M. Panel mount quick connector:
1. Keyed insertion plug.
2. Threaded cap to protect connection when not in use.
3. Material: Stainless steel.
4. Pre-wired pigtails.

5. Indoor/Outdoor:
    a. Rating: Meets or exceeds panel rating.
    b. Manufacturers: One of the following or equal:
        1) Amphenol.
        2) Sealcon.
6. Hazardous (Classified) Areas:
    a. UL listed and labeled for area as indicated on the Drawings.
    b. Manufacturers: The following or equal:
        1) Amphenol HDE Series.

2.08 ACCESSORIES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide panels with an inside protective pocket to hold the panel drawings. Ship panels with 1 copy of accepted Shop Drawings including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.

C. Provide 15-inch floor stands or legs where needed or as indicated on the Drawings.

D. Provide a folding shelf for enclosures that contain programmable controllers. The shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.

E. Provide nameplate to each panel as indicated on the Drawings:
1. Provide as specified in Section 16075 - Identification for Electrical Systems on all internal and external instruments and devices.
2. Provide a nameplate with the following markings that is plainly visible after installation:
    a. Manufacturer’s name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
    b. Supply voltage, phase, frequency, and full-load current.
    c. Power source or circuit ID.
    d. Short-circuit current rating of the panel based on one of the following:
        1) Short-circuit current rating of a listed and labeled assembly.
        2) Short-circuit current rating established utilizing an approved method.

F. Provide a window kit where indicated on the Drawings or where a transmitter with display is mounted inside a control panel. The window shall meet the following requirements:
1. Safety plate glass.
2. Secured by rubber locking seal.
3. Allow full viewing of devices issuing visual process data or diagnostics.

G. Lighting:
1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
    a. Covered or guarded.
    b. Provide On-Off door-activated switches where indicated on the Drawings.
    c. 120-volt, single-phase, 15-amp style plug.

d. Provide 4,000 K, 900 Lumens - LED fixture.
    1) Provide additional fixtures for every 36 inches of width.

H. Receptacles:
1. Provide 1 duplex receptacle located every 6 feet of enclosure width, spaced evenly along the back mounting panels.
2. GFCI, 120-volt, single-phase, 15-amp style plug.
3. Provide circuit breaker or fuse to limit receptacle draw to 5 amperes.

I. Grounding:
1. Provide the following:
    a. Grounding strap between enclosure doors and the enclosure.
    b. Equipment grounding conductor terminals.
    c. Provide equipment grounding busbar with lugs for connection of all equipment grounding wires.
    d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding busbar.
2. Identify equipment grounding conductor terminals with the word “GROUND,” the letters “GND,” the letter “G,” or the color green.
3. Signal cable shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
5. Design so that removing a device does not interrupt the continuity of the equipment-grounding circuit.
6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
8. Unless otherwise noted, connect all exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment-grounding circuit.
9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.

J. Provide sunshades and insulation for all outdoor installations.

K. Automatic Transfer Switch:
1. Manufacturer:
    a. TSI Power Corporation.
2. Redundant 120VAC power feeds to a single 120VAC output:
    a. Capable of handling out-of-phase and/or asynchronous AC sources.
    b. Selectable transfer time 20ms, 40ms or 1 sec.
    c. Built in circuit breakers.
    d. Audible alarms.
    e. LED status indicators.
    f. DB9 communication interface.
3. Power:
    a. 4800VA max.
4. Voltage:
    a. 95-135VAC (both sources).
    b. 47-63 hertz.
    c. Nominal voltage better than 2 percent from no load to full load.

5. Alarm contacts (through DB9):
    a. Loss of primary voltage source.
    b. Loss of secondary voltage source.
6. Mounting:
    a. Shelf.
    b. Rack.
    c. Wall.

2.09 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES

A. Finishes:
    1. Metallic (non-stainless):
        a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.
        b. Scratches or blemishes shall be filled before finishing. One coat of zinc phosphate shall be applied per the manufacturer's recommended dry-film thickness and allowed to dry before applying the finish coat.
        c. Finish coat shall be a baked polyester-urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
        d. Exterior of enclosures located outdoors shall be UV-resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
    2. Stainless steel:
        a. Stainless enclosures shall be provided with a Number 4 brushed finish - not painted.

B. Colors:
    1. Exterior color of panels mounted indoors shall be manufacturer's standard light gray.
    2. Exterior of panels mounted outdoors shall be manufacturer's standard white.
    3. Panel interiors shall be manufacturer's standard white.

2.12 SOURCE QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed:
    1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install enclosures so that their surfaces are plumb and level within 1/8-inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to drywall is not permitted.

B. Install the enclosure per guidelines and submitted installation instructions to meet the seismic requirements at the project site.

C. Provide floor stand kits for wall-mounted enclosures larger than 48 inches high.

D. Provide concrete housekeeping pads for freestanding enclosures.
   1. Refer to the structural typical details.

E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
   1. Undercoat floor-mounted panels.

F. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

G. All holes for field conduits, etc. shall be cut in the field. There shall be no additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miscut holes shall require that the entire enclosure be replaced.

H. Protect all wiring from sharp edges and corners.

I. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the Conduit Schedule but shall be shown on the Loop Drawings prepared by the Contractor.

J. Provide individually fused analog input module points with blown-fuse indicator lights, mounted external of the module on the output terminal strip.

K. Side panels:
   1. Side panels shall be kept free off all control equipment and devices. Any deviation must be sent to the engineer in writing asking for a deviation.

3.04 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

3.05 REPAIRS/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17712

CONTROL SYSTEMS: UNINTERRUPTIBLE POWER SUPPLIES 10 KVA AND BELOW

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Single-phase double conversion uninterruptible power supplies rated 10 kVA and below.

1.02 REFERENCES

A. As specified in Sections 16050 - Common Work Results for Electrical and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Federal Communications Commission (FCC):
   1. FCC Part 15, Class A.
   2. FCC Part 15, Class B.

C. Institute of Electrical and Electronic Engineers (IEEE):
   1. 519 - IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
   2. 1184 - IEEE Guide for Batteries for Uninterruptible Power Supply Systems.
   3. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.

D. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

E. Underwriters Laboratories, Inc. (UL):
   1. UL 1778 - Standard for Uninterruptible Power Supply Systems and Equipment.

1.03 DEFINITIONS

A. As specified in Sections 16050 - Common Work Results for Electrical and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Specific definitions:
   1. Critical load: Load supplied by the UPS.
   2. MOV: Metal oxide varistor.

1.04 SYSTEM DESCRIPTION

A. Provide complete, factory-assembled, wired, and tested, true on-line double conversion UPS equipment including, but not limited to, rectifier, DC bus, inverter, battery charger, batteries, automatic bypass, and ancillary components as specified in this Section and as indicated on the Drawings.

B. UPS loads as indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Product data:
   1. Manufacturer and model number.
   2. Catalog data.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
      d. Weight.
   4. Ratings:
      a. Input voltage.
      b. Output voltage.
      c. Input/output power factor.
      d. Efficiency.
      e. Harmonic distortion.
      f. Runtime.
   5. Noise specifications.
   6. Heat dissipation.
   7. Warranties and maintenance contracts:
      a. Documentation to demonstrate conformance to specifications noted in this Section.
      b. Descriptive package of offerings of preventative and full service maintenance contracts for both UPS system and batteries.
      c. Extended warranty options available.
   8. All communications requirements such as software, cards, etc.
   9. Alarms and status available for remote monitoring and system health.

C. Shop drawings:
   1. Power distribution block diagrams.
   2. Front and rear views of equipment enclosures:
      a. Front elevation including all control and indicating devices.
   3. Support points and weight of overall equipment.
   4. Schematic and control wiring diagrams including, but not limited to:
      a. Line and load terminals.
      b. Alarm and status terminals.
      c. Manual maintenance bypass switch terminals.
      d. External Battery or Step-down/Step-up Transformers if any.
      e. External wiring requirements for all communication signals.
   5. Switching and overcurrent protective devices.

D. Calculations:
   1. Include derating for temperature and elevation as necessary.
   2. UPS sizing computation:
      a. Apply safety factors as specified in this Section.
      b. Provide itemized list of critical loads, including individual VA and watt ratings.
   3. Battery time calculation based on specified runtime for total load with the safety factor multiplied to it. Table/graph for back-up time calculation.

4. Load calculation shall include power for all shown in the power distribution drawing, which include but not limited to PLC power supply, field instruments (120VAC and 24VDC), Instrument power, Ethernet switches, and I/O modules. Refer to Network Drawings for additional information and notes.
5. Total battery recharge time as a function of capacity utilized.

E. Design data:
1. Design mounting and anchorage for seismic design criteria specified in Section 01612 - Seismic Design Criteria:
a. Provide seismic kits as required to meet design criteria.

F. Record documents:
1. Provide Record Drawings of installed unit(s) including layout and wiring.

G. Manufacturer's field reports.

H. Operation and maintenance manuals:
1. System instruction manuals that describe troubleshooting, installation, operations, and safety procedures.
2. Recommendations for maintenance procedures and intervals.
3. Battery data/replacement information.
4. Parts list.

1.06 QUALITY ASSURANCE

A. Manufacturer qualifications:
1. A minimum of 10 years experience in the design, manufacture, and testing of solid-state UPS systems.
2. ISO 9001 certified.

B. Regulatory requirements for complete UPS system:
1. UL listed per UL Standard 1778.
2. IEEE C62.41, Categories B.
3. FCC 15:
a. Greater than 2,000 VA - Class A.
b. Less than 2,000 VA - Class B.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Double conversion true online UPS system:
   1. One of the following or equal:
      a. Vertiv, Liebert GXT5 Series.
      b. Eaton, 9PX Series.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Design requirements:
   1. The minimum VA rating of the UPS shall be greater than or equal to the safety factor (as indicated in the UPS schedule) times the connected load or 700 VA, whichever is greater.
   2. UPS System Input:
      a. Input Voltage:
         1) Less than or equal to 3 kVA UPS:
            a) 120VAC within 3 percent, single-phase, 2-wire plus ground (L1, N, G).
         2) Greater than 3 kVA UPS:
            a) 208VAC within 5 percent, single-phase, 3-wire plus ground (L1, L2, N, G).
         3) Frequency: 60 hertz.
            a) Auto sensing on initial power up.
            b) User configurable.
      b. Input current harmonic distortion (THDi%):
         1) Less than or equal to 5 percent at full load operation.
      c. Input power factor:
         1) Greater than or equal to 0.99 lagging at rated load.
      d. Input connections:
         1) As specified and as indicated on the Drawings.

3. UPS Inverter:
    a. Output Voltage:
        1) Less than or equal to 3kVA UPS:
            a) Standard:
                (1) 120VAC.
            b) User selectable:
                (1) 100VAC, 110VAC, 120VAC, 125VAC.
        2) Greater than 3kVA UPS:
            a) Standard:
                (1) 208VAC.
            b) User selectable:
                (1) 200VAC, 208VAC, 220VAC, 230VAC, 240VAC.
    b. AC-AC Efficiency:
        1) Greater than or equal to 89 percent at full rated resistive linear load.
    c. Transient recovery time:
        1) To nominal voltage within 100 milliseconds.
    d. Voltage regulation:
        1) Within1 percent steady state.
    e. Output Voltage Distortion (THDV%):
        1) Linear load: Less than 2 percent.
        2) Non-linear load: Less than 5 percent.
    f. Output power factor:
        1) The load power factor range shall be 0.65 lagging to 1.0 (unity) leading without power derating.
    g. Current overload capability:
        1) The UPS shall attempt to clear overloads while maintaining normal operation before transferring to bypass.
        2) Bypass transfer thresholds shall follow inverse time-current characteristic that operates when the load exceeds the nameplate rating of the UPS.
        3) Transfer load to bypass when overload capacity is exceeded.
4. Batteries:
    a. Internal battery shall utilize valve-regulated, non-spillable, lead acid (VRLA) cells.
    b. UPS shall have capability for connection of external battery modules to extend total available run time. External batteries shall match the UPS in aesthetics and color.
5. Mounting:
    a. Provide mounting brackets as required and as indicated on the Drawings.
6. Cooling:
    a. UPS shall have integral forced air cooling.
7. Output connections:
    a. Receptacles:
        1) Less than or equal to 3kVA UPS:
            a) Provide a minimum of four NEMA Type 5-15R or Type 5-20R receptacles.
            b) Provide at least one NEMA Type L5-30R receptacle.
        2) Greater than 3kVA UPS:
            a) Provide a minimum of four NEMA Type 5-20R receptacles.
            b) Provide at least one NEMA Type L14-30R receptacle.
        3) Provide hardwired connections as required and as indicated on the Drawings.

B. Environmental requirements:
   1. Operating ambient temperature:
      a. UPS module: 50 degrees Fahrenheit to 104 degrees Fahrenheit (10 degrees Celsius to 40 degrees Celsius).
      b. Battery: 68 degrees Fahrenheit to 86 degrees Fahrenheit (20 degrees Celsius to 30 degrees Celsius).
   2. Operating altitude: as specified in Section 01610.
   3. Project site conditions as specified in Sections 16050 - Common Work Results for Electrical and 17050 - Common Work Results for Process Control and Instrumentation Systems Surge protection:
      a. UPS shall confirm to ANSI C62.41, Category B.
   4. Audible noise:
      a. Less than 46 dB at 1 meter.

C. Communications:
   1. Relay outputs:
      a. The UPS shall contain on the rear panel a terminal block to provide low voltage signals for On Battery, Low Battery, Any Mode Shutdown and Battery Mode Shutdown.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions.

B. Do not utilize extension cords, adapters, or other electrical connectors for UPS input.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIRS/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Perform inspections and test procedures before UPS startup:
   1. Inspect equipment for signs of damage.
   2. Verify installation as indicated on the Drawings and specified in the Specifications.
   3. Inspect cabinets for foreign objects.
   4. Verify neutral and ground conductors are properly sized and terminated.
   5. Inspect battery cases.
   6. Inspect batteries for proper polarity.
   7. Check power and control wiring for tightness.
   8. Check terminal connectors for tightness.
   9. Ensure connection and voltage of the battery string(s).

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.12 SCHEDULES

TAG	MINIMUM RUNTIME	INPUT VOLTAGE / CONNECTION	SAFETY FACTOR	NOTES
UPS-5	15 Minutes	120 V / Hardwired	1.5	Free standing

END OF SECTION

SECTION 17720

CONTROL SYSTEMS: PROGRAMMABLE LOGIC CONTROLLERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Programmable logic controller (PLC) based control systems hardware.
   2. Development software to be used with the specified PLC hardware.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Institute of Electrical and Electronics Engineers (IEEE).

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Specific definitions:
   1. CPU: Central processing unit.
   2. I/O: Input/Output.

C. Specific definitions:
   1. Development operating software: The software provided by the PLC manufacturer for use in programming the PLC.
   2. Application software: The software that is programmed specifically for the Project.

1.04 SYSTEM DESCRIPTION

A. Provide all PLC hardware as indicated on the Drawings and as specified in this Section.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Product data:
   1. CPU:
      a. Processor type.
      b. Processor speed.
      c. Memory.
      d. Internal processor battery backup time.

2. I/O modules:
    a. Type.
    b. Standard wiring diagram.

C. Calculations:
1. Submit calculations or documented estimate to verify that memory requirements of this Section are met, including spare requirements. If possible, use PLC manufacturer's calculation or estimating worksheet.
2. Submit calculations to verify that spare I/O requirements of this Section are met.
3. Submit calculations to verify that PLC power supply requirements of this Section are met.

D. Product data:
1. Programming languages.
2. Operating system requirements.

E. Control logic:
1. Fully annotated copy of programmed PLC logic.
2. Cross-referenced index of all PLC registers or points.

F. Provide application software for the specific Project process requirements:
1. Fully annotated copy of programmed PLC logic in its native format.
2. Cross-referenced index of all PLC registers or points.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide PLC hardware manufactured at facilities certified to the quality standards of ISO 9001.

C. Additional requirements:
1. Provide PLC system components by a single manufacturer:
    a. Third-party communication modules may be used only for communication or network media functions not provided by the PLC manufacturer.
2. Use PLC manufacturer approved hardware, such as cable, mounting hardware, connectors, enclosures, racks, communication cable, splitters, terminators, and taps.
3. All PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects, and produced by manufacturers regularly engaged in the manufacture of these products.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. In addition to the spare parts requirements specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
   1. CPU: 1 spare for each type of CPU in the system.
   2. I/O cards: 3 spares for each type of I/O card in the system.
   3. Power supplies: 2 spares for every power supply in the system.
   4. Network/communications cards: 1 spare for every network or communications card in the system.
   5. Remote adapter: 1 spare for every remote adaptor in the system.
   6. Chassis: 1 spare for each chassis size in the system.
   7. Communication cable: 1 spare for each type of cable used in the system.

C. Installed spare requirements:
   1. I/O points:
      a. Provide total of 25 percent spare I/O capacity for each type of I/O at every PLC and remote inputs and outputs (RIO).
      b. Wire all spare I/O points to field terminal blocks in the same enclosure the PLC resides in.
   2. PLC backplane capacity:
      a. Provide 25-percent or 3 spare backplane slots, whichever is greater, in all racks containing I/O.
   3. PLC memory:
      a. Provide 50-percent spare program volatile memory.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following, no equal:
   1. Rockwell Automation:
      a. ControlLogix, L7.

B. The PLC programming software system shall be manufactured by PLC hardware manufacturer:
    1. Rockwell Software:
        a. Studio 5000.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Programmable logic controller:
    1. Construction:
        a. Furnish plug-in modular system.
        b. Provide PLCs capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
            1) Temperature: 0 to 60 degrees Celsius.
            2) RFI: 80 to 1,000 MHz.
            3) Vibration: 10 to 500 hertz.
            4) Humidity: 0 to 95 percent.
        c. Provide internal power supplies designed to protect against overvoltage and frequency distortion characteristics frequently encountered with the local power utility.
        d. Design the PLC system to function as a standalone unit that performs all of the control functions described in this Section completely independent from the functions of the HMI system PC-based operator interfaces:
            1) Failure of the HMI system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
    2. CPU:
        a. Configure each CPU so that it contains all the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
        b. Capable of interfacing with all discrete inputs, analog inputs, discrete outputs, analog outputs, and communication cards to meet the specified requirements.
        c. Capable of supporting and implementing closed-loop floating-point math and PID control that is directly integrated into the CPU control program.
    3. Memory:
        a. Non-volatile memory: On-board complementary metal-oxide-semiconductor (CMOS), electrically erasable programmable read-only memory (EEPROM), PCMCIA, compact flash card, or SD card.
        b. Supply with sufficient memory to implement the specified control functions plus a reserve capacity as specified with the requirements of this Section:
            1) Reserve capacity:
                a) Totally free from any system use.
            2) Programmed in a multi-mode configuration with multiple series or parallel contacts, function blocks, counters, timers, and arithmetic functions.

4. Programming:
    a. Provide a system where processors are programmed by:
        1) Portable laptop computer both locally and via the PLC control network.
5. PLC power supply:
    a. Input: 120 VAC.
    b. Mounted in the PLC housing or as indicated on the Drawings.
    c. Sized to power all modules mounted in that housing including an average module load for any empty housing slots plus 50 percent above that total.
6. PLC input/output, I/O modules:
    a. General:
        1) Compatible with all of the PLCs being furnished under the contract and by the same manufacturer as the PLCs.
        2) Provide I/O modules that:
            a) Isolate in accordance with IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.
            b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
            c) Accept dual-ended inputs.
        3) The use of common grounds between I/O points is not acceptable.
        4) Provide modules that are removable without having to disconnect wiring terminals:
            a) Utilize a swing-arm or plug-in wiring connector.
        5) Provide at each PLC the I/O modules for the following:
            a) Designated future I/O points contained in the I/O Lists and/or shown on the P&IDs, control schematics, or described in the control strategies.
            b) Installed spare capacity in accordance with the requirements of this Section.
            c) Wire all spares provided to the field terminal strip.
        6) Condition, filter, and check input signals for instrument limit conditions.
        7) Filter, scale, and linearize the raw signal into an engineering-units-based measurement.
        8) Alarm measurements for high, low, rate-of-change limits, and alarm trends.
        9) Provide external fuses mounted on the field connection terminal block for all discrete input, discrete output, and analog input I/O points.
        10) When multiple cards of the same I/O type are provided and parallel equipment, instrumentation, or redundant processes exist, distribute I/O among cards to ensure that a single card failure will not render an entire process unavailable.
    b. Discrete input modules:
        1) Defined as contact closure inputs from devices external to the input module.
        2) Provide inputs that are optically isolated from low-energy common-mode transients to 1,500 volts peak from users wiring or other I/O modules.
        3) Individually isolated inputs.
        4) With LEDs to indicate status of each discrete input.
        5) Input voltage: 24VDC.

6) Provide input module points that are individually fused with blown-fuse indicator lights, mounted external of the module on the output terminal strip:
    a) Coordinate external fuse size with the protection located on the module, so that the external fuse opens first under a fault condition.

c. Discrete output modules:
    1) Defined as contact closure outputs for ON/OFF operation of devices external to the output module:
        a) Triac outputs may be used, with the permission of the Engineer. Care must be used in applying this type of module to ensure that the leakage current through the output device does not falsely signal or indicate an output condition.
    2) Optically isolated from inductively generated, normal mode and low-energy common-mode transients to 1,500 volts peak.
    3) LEDs to indicate status of each output point.
    4) Output voltage: 120VAC.
    5) Individually isolated outputs.

d. Analog input modules:
    1) Signal type: Provide 4-20 mA for most applications; other levels are acceptable to interface to vendor control panels.
    2) Analog-to-digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
    3) The analog-to-digital conversion updated with each scan of the processor.
    4) Individually isolated each input.
    5) Coordinate the size of the external fuse with the protection located on the module, so that the external fuse opens first under a fault condition.

e. Analog output modules:
    1) Signal type: Provide 4-20 mA for most applications; other levels are acceptable to interface to vendor control panels.
    2) Individual isolated output points each rated for loads of up to 1,000 ohms.

7. Communications modules:
    a. Network communications modules:
        1) General:
            a) Install communications modules in the PLC backplane.
        2) Ethernet:
            a) Ports: 1.
            b) Communication rate: 100 Mbit/s.
            c) Allen-Bradley ControlLogix - 1756-EN2T.
        3) Modbus:
            a) Ports: 1.
            b) Each port individually configurable as Modbus Master or Slave.
            c) Prosoft, MVI56E-MNET.
        4) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.

8. PLC backplane housing:
    a. Mount the PLC power supply, CPU, communications module, and I/O modules in a suitable standard PLC backplane or housing.

b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
c. Provide a blank slot filler module for each spare slot.

B. HMI system interface:
1. As specified in Section 17733 - Control Systems: Network Materials and Equipment.

C. PLC programming software:
1. Furnish operating software capable of monitoring and/or controlling the PLCs via the PLC data network:
a. Contain diagnostics to collect troubleshooting and performance data and display it in easy to understand graphs and tables.
b. Monitor devices at each drop on the PLC data network for proper communications.
c. Provide the ability to program all PLCs on the PLC data network from the Engineer's console.
2. PLC programming laptop/desktop operating system:
a. Microsoft Windows 10.
3. The PLC programming software shall be suitable for the PLCs specified above.
4. PLC programming software for all programming, monitoring, searching, and editing:
a. Usable both on-line, while connected to the PLC, and off-line.
b. The operating software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical function blocks.
c. Capable of disabling/forcing all inputs, outputs, and coils to simulate the elements of the ladder logic; forced elements shall be identifiable by means of color change.
d. Include a search capability to locate any address or element and its program location.
e. Display at the EC, PLC status information, such as faults and communication errors and amount of memory remaining.
5. The PLC programming software shall support the following programming languages:
a. Ladder Diagram.
b. Function Block Diagram.
6. Generate a PLC program printout, which is fully documented, through the PLC programming software:
a. Fully documented program listings include, as a minimum, appropriate rungs, address, and coils shown with comments to clarify to a reader what that segment of the program accomplishes on an individual line-by-line basis.
b. Include a sufficient embedded comment for every rung of the program explaining the control function accomplished in said rung.
c. Use a mnemonic associated with each contact, coil, etc. that describes its function.
d. Utilize the tag and loop identification as contained in the P&IDs:
1) If additional internal coils, timers, etc. are used for a loop, they shall contain the loop number.
e. Provide a cross-reference report of program addresses.

7. Software functions automatically without operator intervention, except as required to establish file names and similar information:
    a. Furnish the operating system software that is the standard uncorrupted product of the PLC manufacturer with the following minimum functions:
        1) Respond to demands from a program request.
        2) Dynamic allocation of the resources available in the PLC. These resources include main memory usage, computation time, peripheral usage, and I/O channel usage.
        3) Allotment of system resources based on task priority levels such that a logical allocation of resources and suitable response times are ensured.
        4) Queuing of requests in order of priority if one or more requested resources are unavailable.
        5) Resolution of contending requests for the same resource in accordance with priority.
        6) Service requests for execution of one program by another.
        7) Transfer data between programs as requested.
        8) Management of all information transfers to and from peripheral devices.
        9) Control and recovery from all program fault conditions.
        10) Diagnose and report real-time hardware device errors.
8. Program execution:
    a. Application software - program execution scheduled on a priority basis:
        1) A multilevel priority interrupt structure is required.
        2) Enter into a list of pending programs a program interrupted by a higher priority program:
            a) Resume its execution once it becomes the currently highest priority program.
        3) Schedule periodic programs.
        4) Base the allocation of resources to a time-scheduled program on its relative priority and the availability of resources.
9. Start-up and restart:
    a. Provide software that initializes and brings a PLC or any microprocessor-based hardware unit from an inactive condition to a state of operational readiness.
    b. Initialization:
        1) Determination of system status before start-up of initializing operating system software and initializing application software.
        2) Loading of all memory-resident software, initializing timers, counters, and queues, and initialization of all dynamic database values.
10. Shutdown:
    a. Where possible, provide orderly shutdown capability for shutdowns resulting from equipment failure, including other PLC processor failures, primary power failure, or a manually entered shutdown command.
    b. Upon loss of primary power, a high-priority hardware interrupt initiates software for an immediate, orderly shutdown.
    c. Hardware is quickly and automatically commanded to a secure state in response to shutdown command or malfunction.
    d. Alarm PLC failure at the operator interface level.

11. Diagnostics:
    a. Furnish diagnostic programs with the PLC software package to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures.
    b. Use the manufacturer's standard diagnostic routines as much as possible.
    c. Furnish diagnostic software and test programs for each significant component in the control system.
    d. As a minimum, provide diagnostic routines to test for power supply, central processing unit, memory, communications, and I/O bus failures.
12. Calendar/time program:
    a. The calendar/time program to update the second, minute, hour, day, month, and year and transfer accurate time and date information to all system-level and application software.
    b. Variations in the number of days in each month and in leap years must be handled automatically by the program.
    c. The operator must be able to set or correct the time and date from any operator interface, only at the highest security level.
13. Algorithms:
    a. Implementation of algorithms for the determinations of control actions and special calculations involving analog and discrete data.
    b. Algorithms must be capable of outputting positional or incremental control outputs or providing the product of calculations.
    c. Algorithms must include alarm checks where appropriate.
    d. Provide, as a minimum, the following types of algorithms:
        1) Performs functions such as summing several variables, raising to a power, roots, dividing, multiplying, and subtracting.
        2) A switch algorithm, which reads the current and value from its input address and stores it as the value of its output address. 2 types of switches shall be accommodated: 2 outputs with 1 input and 1 output with 2 inputs.
        3) A 3-mode proportional-integral-derivative, PID, controller algorithm, with each of the 3 modes independently adjustable, supports both direct and reverse-acting modes.
        4) Lead, lag, dead time, and ratio compensators.
        5) Integration and totalization of analog process variables.
14. Furnish a comprehensive database for the analog inputs, calculated values, control modules, and outputs:
    a. In addition, provide spare database points for future expansion.
15. One integrated database can be utilized for all types of analog points or separate databases for each type; in either case, the database for each point must include all specified aspects.
16. All portions of the database must be available for use by the display, report, and other specified software modules.
17. All of the data fields and functions specified below must be part of the point definition database at the operator interface. Provide the capability to define new database points through the point display specified below as well as modifying defined points through these displays. This point definition and modification must include all of the features and functions defined below. The analog database software must support the following functions and attributes:

a. Analog input signal types:
    1) Provide software at the remote terminal units (RTUs) and PLCs to read variable voltage/current signals and pulse duration/frequency type analog input signals.
b. Input accuracy:
    1) Inputs must be read with an accuracy of within 0.05-percent full-scale or better.
    2) Data conversion errors must be less than 0.05-percent full-scale.
    3) Pulse accumulation error less than or equal to 1 count of actual input count at a scan rate of once per minute.
    4) Maintain for a minimum of 1 year the system accuracy stated above without adjustments.
c. Blocking:
    1) Provide mechanisms to inhibit or block the scanning and/or processing of any analog input through the operator interface.
    2) For any input so blocked, the operator may manually enter a value to be used as the input value.
d. Filtering:
    1) For each analog input, provide a first order lag digital filter with an adjustable filter factor.
e. Linearizing:
    1) Where analog inputs require square root extraction or other linearization, provide a mechanism to condition the filtered data before the process of scaling and zero suppression takes place.
f. Calculated values:
    1) Provide means to allow for pseudo-inputs calculated by algebraic and/or Boolean expressions utilizing real inputs, other calculated values, constants, etc.
    2) These values must be handled the same as real inputs in terms of record-keeping, alarming, etc.
g. Scaling and zero suppression:
    1) Provide a conversion program to convert input values into engineering units in a floating-point format.
h. Alarms:
    1) Provide an alarm program to check all analog variables against high-high, high, low, and low-low alarm limits.
    2) When an analog value exceeds a set limit, it must be reported as an alarm based on individually set priority level for each alarm point.
    3) Provide an adjustable hysteresis band in order to prevent excessive alarms when a variable is hovering around an alarm limit.
    4) Must be possible to inhibit alarms based on external events, e.g., lock-out low pump flow alarm when the pump is off.
i. Averages:
    1) Provide a program to calculate and store hourly, daily, and monthly averages of analog variables.
    2) Continuously compute averages, e.g., the average for the current period to the present point in time must be stored in memory and available for use in displays, etc.
    3) Update hourly averages each minute or at the polling interval for the selected variable.
    4) Update daily averages at least once each hour and calculate using the results of the hourly averages.

5) Update monthly averages at least once each day and calculate using the results of the daily averages.
6) At the end of each averaging period, store the average values for the period on the hard disk for historical record-keeping and reset the present period average register to the present value of the variable.
7) The active database must include the present period average and previous period average for each variable and averaging period.

j. Totals:
1) Provide a program to calculate and store hourly, daily, and monthly totalization of analog variables.
2) Assign a scaling factor to each variable to convert to the appropriate units based on a 1-minute totalizing interval.
3) Assign a separate factor for each totalizing interval.
4) Variables for which totalization is inappropriate must have scaling factors of zero.
5) At the end of each totalizing period, store the totalized values for the period on the hard disk for historical record-keeping and reset the present period totalization register to zero.
6) The active database must include the present period total and previous period total for each variable and totalizing period.

k. Engineering units:
1) Provide software to allow the system and the operator to convert all the measured analog variables to any desired engineering units.
2) The operator must be able to view displays and generate reports of any measured variable in one or more engineering units such as flow in gpm, mgd, cfs, and acre-feet per day.
3) Pre-program the conversion of the engineering units, and, if not pre-programmed, the operator must be able to program new engineering unit conversions by using simple methods, e.g., multiplication of the database attributes by a constant.
4) The programming method must be at a level and compatible with the specified training of the operator and the Owner's personnel.
5) New conversions must not require the services of a special programmer and/or special, high-level, programming training.

l. Control modules:
1) For each control function configured, whether processed at the RTU, PLC, or operator interface, maintain a file of necessary data including input values, setpoints, constants, intermediate calculated values, output value and limit clamps, etc.
2) Input and output assignments, setpoints, and constants must be adjustable by the operator through the operator interface.
3) Provide control algorithms for manual control with output values adjustable by the operator.

m. Analog outputs:
1) Analog outputs must be maintained as part of the database.
2) These outputs must be adjustable manually by the operator through the operator interface or through automatic control algorithms.

18. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

D. General control functions:
    1. Analog control functions:
        a. PID, lead/lag, signal select, alarm, limit, delay, and time base.
        b. Furnish the control system complete with a library of mathematical/calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR, and NXOR functions.
        c. All math utilities must be linkable to process data points or manual inputs via control block configuration.
        d. By linking control blocks to data points, the math library must support system unit conversion and calculation requirements.
    2. Discrete control functions:
        a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays, and time base.
    3. Software support:
        a. Retain in firmware all control and logic functions at each RTU and PLC and in RAM at the operator interface.
        b. Call each function as required by the configured controls to perform the intended function.
    4. Control and status discrepancies:
        a. Generate a discrepancy/fail alarm for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status:
            1) For example, the system commands to start (call), and the pump fails to start (run status report back), within predetermined operator-programmable time delay (time disagree), then a discrepancy (fail) alarm shall be generated.
        b. Involuntary change in the device's status must also generate an alarm:
            1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.
        c. Each command, status, and alarm must cause the color of the symbol to change.
        d. Because many discrete final control elements have a cycle time in excess of the scan interval, provide each control output with an associated delay period selected to be longer than the operating period of the control element:
            1) Delay periods for each final control element must be adjustable at the operator interface.
            2) List all time delays in the final documentation.
    5. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

E. Control configuration:
    1. Provide software to allow control strategies to be developed, and their operation initiated through the operator interface.
    2. Provide standardized control point displays for defining the control functions including the function type, input/output addresses, setpoints, tuning constants, etc.

3. Provide a mechanism to link separate control functions together into an integrated control strategy.
4. Provide a mechanism to download operational/control setpoints developed at any operator interface to any PLC or RTU for operational implementation.
5. Provide a mechanism to define and implement operational/control setpoints locally at the PLC or RTU, and to upload them to the operator interface for operational record-keeping.
6. Perform control configurations on-line at the operator interface; the PLC or RTU may be taken off-line when being configured or downloaded.

F. Remote inputs and outputs (RIOs):
1. Compatible with all of the PLCs being furnished under this Contract, shall be by the same manufacturer as the PLCs, and, as a minimum, include:
   a. Power supply.
   b. Rack.
   c. Backplane.
   d. Communications module.
   e. I/O modules.
   f. Enclosure.
2. Provide all cables and software needed for a complete and operational RIO system as specified in the Contract Documents.
3. Provide a group of pre-assigned diagnostic registers to report RIO system faults to the driver PLC.
4. The control system must continue operation should a fault occur on a single RIO drop:
   a. Upon clearing the fault, restart communications to that drop automatically.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Utilize personnel to accomplish or supervise the physical installation of all elements, components, accessories, or assemblies:
   1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.

C. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.

D. General:
   1. The control system logic program shall reside at the PLC level.

E. Use the tag and loop identifications found on the P&IDs for all tags used and/or assigned as part of the application software work provided by the ICSC.

F. Program the PLC logic using the following language(s):
   1. Ladder Diagram.
   2. Function Block Diagram.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Provide a minimum of 4 CD/DVD copies of the following:
   1. Application software:
      a. Finalized fully annotated copy of programmed PLC logic in its native format.
      b. Cross-referenced index of all PLC registers or points.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Tailor training specifically for this Project that reflects the entire control system installation and configuration.

C. Perform training by pre-approved and qualified representatives of the ICSC and/or manufacturer of the PLC hardware and programming software:
   1. A representative of the ICSC may perform the PLC hardware training only if the representative has completed the manufacturer's training course for the PLC hardware.
   2. A representative of the ICSC may perform the PLC programming software training only if the representative has completed the manufacturer's training course for the PLC programming software.

3.11 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17730

CONTROL SYSTEMS: PCS COMPUTER EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Industrial Panel Computers.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Specific definitions:
   1. CAL: Client access license.
   2. RAID: Redundant array of independent disks.
   3. SNMP: Simple network management protocol.

1.04 SYSTEM DESCRIPTION

A. Provide all PCS computer equipment identified in the Contract Documents.

B. Miscellaneous requirements:
   1. All material used in satisfying the equipment requirements shall be new and unused and must be actively marketed by the original equipment manufacturer for new applications at the time of the factory demonstration test. The Contractor shall not use equipment destined for installation or spare parts for the Owner's system for any reason other than development and testing of the system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Shop drawings:
   1. Prepare and submit a seismic mounting installation detail drawing for review.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Commonality:
   1. The PCS system shall utilize the same brand and type of computer for like functions throughout the system.
   2. Where possible, use the same processor family throughout.
   3. Use a single PC computer manufacturer throughout the Project, including those used for diagnostics and maintenance.

B. Manufacturers:
   1. As indicated below.

C. Systems management architecture:
   1. All processors, servers, workstations, network software, bridges, and other manageable objects shall have simple network management protocol (SNMP) agents included.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. The hardware identified in this Section is considered the minimum, acceptable configuration. It is the Contractor's responsibility to upgrade and expand the hardware configuration if necessary to satisfy software and system performance requirements of the Project.
   2. Proposed substitutions must meet or exceed the specifications of the equipment listed.

B. Industrial panel computer:
   1. Industrial panel-mounted monitor with separate PC-architecture computer running the Windows 7 PRO, or newer, operating system:
      a. Provide a complete set of backup/restore recovery DVD's such that the computer may be restored to factory condition in the event of a catastrophic hard drive failure. Software recovery from a partition on the hard disk drive is not acceptable.
      b. Provide a complete set of all required cables and software.
      c. Provide manufacturer's user and maintenance manuals.
      d. Industrial panel-mounted monitor:
         1) Display size: minimum 15 inches.
         2) Aspect ratio: 16:9.
         3) Resolution: minimum 1024 by 768.
         4) Type: Active Matrix Color TFT LCD display with resistive antiglare touchscreen.
         5) Rating: NEMA Type 4X.
         6) Faceplate/bezel material: Stainless steel.
         7) MTBF: Minimum 50,000 hours.
         8) Operating temperature: 0 - 55 Degrees Celsius.
         9) Operating relative humidity: 20 - 90 percent non-condensing.
         10) Power supply: 24 VDC.
         11) Manufacturers: The following, no equal:
            a) On Logic Rugged Panel PC Touch Screen with Intel Core i5 CPU and Ignition Software.
      e. Computer shall meet the following minimum requirements:
         1) Processor speed: Intel Core 2 DUO, 2.0 GHz or better.
         2) Main memory: 4GB DDR 533 MHz.
         3) Hard disk: 320 GB, Serial ATA, 7,200 rpm; buffer cache 8.0 MB minimum.
         4) Video card: 64 MB DDR RAM.
         5) Serial RS232 port.
         6) 2 PCI slots.
         7) 4 USB slots.
         8) 8X DVD/RW SATA.
         9) Network port: 10/100 Base TX, Ethernet LAN.
         10) Power supply: 120 VAC.
         11) Manufacturers: One of the following, no equal:
            a) On Logic Rugged Panel PC with Intel Core i5 CPU and Ignition Software.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. General:
   1. Each display monitor shall be secured to the console or other work surface.
   2. Install equipment and cabling so that, in the event of an earthquake, seismic movement will not damage cables. In particular, provide appropriate slack in cables.

C. Each device with a unique IP address shall be individually labeled with it IP address. The labeling must be printed; handwritten labels will not be accepted.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Training:
   1. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17733

CONTROL SYSTEMS: NETWORK MATERIALS AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Materials and equipment used in process control and LAN networks including:
      a. Network switches.
      b. Patch panels and other data network hardware.
      c. Related accessories.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 802.1X – Standard for Local and Metropolitan Area Networks—Port-Based Network Access Control.
   2. 802.3 - Standard for Ethernet.
   3. 802.3ab - Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan Area Networks - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications - Physical Layer Parameters and Specifications for 1000 Mb/s Operation over 4 pair of Category 5 Balanced Copper Cabling, Type 1000BASE-T.
   4. 802.3u - Standards for Local and Metropolitan Area Networks: Supplement - Media Access Control (MAC) Parameters, Physical Layer, Medium Attachment Units, and Repeater for 100Mb/s Operation, Type 100BASE-T (Clauses 21-30).
   5. 802.11b - Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher Speed Physical Layer (PHY) Extension in the 2.4 GHz band.

C. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
   1. 568-C.3 - Optical Fiber Cabling Components Standard.

D. Underwriters Laboratories, Inc. (UL).

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Product data:
   1. Include information on all network equipment.
   2. Manufacturer’s operation and installation instructions.

C. Shop drawings:
   1. Complete set of drawings including but not limited to:
      a. System block diagram showing relationship and connections between devices provided under this Contract and existing equipment. Include manufacturer and model information, and address settings.
      b. Network riser diagram.
      c. Network port diagram, which physically locates all ports within the facility, and identifies their patch panel and switch port.
      d. Construction drawings for all equipment cabinets, including dimensions, identification of all components, preparation and finish data, and nameplates.
      e. Electrical connection diagrams.
      f. Complete grounding requirements.
   2. Furnish data sheets for each component together with a technical product brochure or bulletin:
      a. Manufacturer's model number.
      b. Project equipment tag.
   3. Complete and detailed bills of materials broken up by each cabinet. Each bill of material item will include the following:
      a. Quantity.
      b. Description.
      c. Manufacturer.
      d. Part numbers.

D. Test reports:
   1. As specified in Sections:
      a. 16125 - Fiber Optic Cable and Appurtenances.
      b. 17950 - Commissioning for Instrumentation and Controls.
   2. Signed test results as described in this Section.
   3. Test results shall include:
      a. Narrative describing the test procedures followed.
      b. Block diagram of test set up.
      c. Manufacturer’s information on test equipment used.
      d. Detailed test results.
      e. A narrative summarizing the results of the testing and identifying any further action required.

E. Operating manuals:
   1. Complete installation, operation, calibration, and testing manuals as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

F. Record drawings:
   1. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
   2. Electrical connection diagrams shall be revised to reflect any changes made in the field and submitted as record drawings.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 SEQUENCING (NOT USED)

1.09 SCHEDULING (NOT USED)

1.10 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.11 SYSTEM START-UP (NOT USED)

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 COMMISSIONING (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 SYSTEM DESCRIPTION

A. Provide all network equipment identified in the Contract Documents.

2.03 EXISTING PRODUCTS (NOT USED)

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

A. Ethernet switches:
   1. Managed Process Floor Ethernet switches:
      a. Manufacturers: The following, no equal:
         1) Rockwell, Stratix 5700.
      b. Properties:
         1) Hardware:
            a) Power supply:
               (1) Provide redundant power supplies.
               (2) 24 VDC, 170 watts per power supply.
            b) No fans or moving parts.
         2) Performance:
            a) Enclosure:
               (1) All metal housing.
               (2) 15g Shock for 11ms minimum.
            b) 10/100BASE-TX RJ-45 Copper Ports (quantity as indicated on the Drawings).
            c) 1,000BASE-T RJ-45 Copper Ports (quantity as indicated on the Drawings).
            d) 1,000Base-SX LC Duplex Fiber Ports (quantity as indicated on the Drawings).
            e) Capable of performing basic switching without special programming or configurations. Additional features available through software setup includes but not limited to:
               (1) SNMP.
               (2) VLAN.
               (3) QoS.
               (4) Port Mirroring.
               (5) DHCP Server
            f) IGMP Snooping with Ethernet/IP plug & play compatibility.
            g) 802.1d, 802.1w, 802.1D RSTP.
         3) Environment:
            a) Operating temperature range: 32 to 140 degrees Fahrenheit.
            b) Humidity: 10 to 95 percent, non-condensing.
         4) Connector type:
            a) Fiber: SFP.
            b) Copper: RJ-45:
               (1) Quantity of copper and fiber ports as required to provide connections as indicated on the Drawings: As required to provide the number of connections required plus 20 percent spare ports of each type used.
         5) Mounting:
            a) DIN Rail mounting.

B. Patch panels:
   1. Fiber optic patch panels:
      a. General:
         1) All optical fiber cables shall be provided with strain relief and terminated at a fiber patch panel. Final connections between the patch panel and the fiber optic network equipment shall be made via factory tested fiber optic patch cords.

2) All fiber cable strands shall be terminated at the patch panels, no loose fiber strands are allowed.
3) Provide space for excess fiber and provide strain relief for the fiber cable.
4) Fiber cables shall be installed such that the outer sheath of the cable is carried into the interconnect enclosure or patch panels before breaking out buffer tubes.
5) Connector Type: LC.

b. DIN Rail mounted:
1) Manufacturers: One of the following or equal:
a) Hirschmann, MIPP.
b) DINSpace, SNAP XL.
c) Corning.
2) Properties:
a) Use for the termination of a single cable inside of cabinets, in small enclosures or as indicated on the plans.
b) DIN rail mounted cable interconnects shall be provided as complete units including the housing, the connector panels and the fiber connectors.

C. Copper patch panels:
1. General:
a. Final connections between the patch panel and network equipment shall be by patch cords.
b. All cables shall be terminated at the patch panels.
c. Cables shall be installed such that the outer sheath of the cable is carried into the interconnect enclosure or patch panel before breaking out conductors.
d. Maintain twist of broken out conductors in accordance with TIA standards.
e. Provide factory tested copper patch cords as required to support all network devices:
1) Provide 25 percent spare copper patch cords.
f. UL listed.
2. Accessories:
a. Removable rear cable management bracket.
b. Rear individual port labels.
c. Front color-coded individual port labels.
3. DIN Rail mounted:
a. Manufacturers: One of the following or equal:
1) Hirschmann, MIPP.
2) DINSpace, SNAP Cu.

D. Network Address Translation (NAT) Router:
1. General:
a. Provide NAT routers as shown on the drawings for configuration of electrical equipment within the plant control system.
2. Manufacturers: The following, no equal:
a. Allen Bradley 9300-ENA.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Provide LC duplex patch cords to connect the interface cards provided with the associated patch panels.

B. Furnish accessories as specified in Section 17730 - Control Systems: PCS Computer Equipment.

2.09 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide installation and configuration for the new and existing managed Ethernet switches. Provide configuration of the Ethernet switch network for a complete, functioning plant control system as indicated on the Drawings and as specified in this Section:
   1. Refer to SCADA block diagrams for all new network connections.
   2. Provide configuration for all managed Ethernet switches and other components including but not limited to VLAN (virtual local area network), additional Plant PLC communication cards and separate managed Ethernet switches as required, such that there is isolation of the following networks:
      a. Field and PLC I/O network: This includes the connections between the Plant PLC and:
         1) Plant PLC expansion racks.
         2) Plant PLC remote I/O (RIO) racks.
         3) Field Networks.
         4) HMI(s) part of a Plant PLC.
         5) Vendor furnished Ethernet network components.
      b. Valve Actuator network: This includes the connections between the Plant PLC and the valve master stations.
      c. Process Control network: This includes the connections between the Plant PLC and other Plant PLCs.
      d. SCADA network: This includes the connections between the various SCADA equipment including but not limited to servers (existing), workstations and printers.

e. Security network: This includes any security hardware with Ethernet communication as provided by the security/telephone/internet sub-contractor.

3. The process floor managed Ethernet switches for the process control network shall be configured and programmed for rapid fail over protection.
4. The enterprise level managed Ethernet switches shall be configured for a communication protocol that is compatible with the process control network's rapid fail over protocol.

C. All racks shall be level and plumb.

D. Install Velcro wrap on all cable bundles within the network rack/enclosure.

E. All cables and equipment shall be installed in strict conformance with the manufacturer's recommendations:
1. Cables shall be installed avoiding sharp bends.
2. Install cable using lubricant designed for cable pulling.
3. Cable ties or other cable supports shall be installed without crimping the LAN cables.
4. Install LAN cables without splices.
5. Installed bend radii shall not exceed 4 times the cable diameter.
6. Terminated all pairs at the jack and the patch panel.

F. Install cables a minimum of 40 inches away from electrical motors and transformers.

G. Install cables a minimum of 12 inches away from fluorescent lighting.

H. Individual pairs will be untwisted less than 1/2-inch at termination points.

I. All cables and terminations shall be labeled with cable designations as specified in Section 16075 - Identification for Electrical Systems.

J. Each data port shall be individually labeled with its patch panel/switch port ID:
1. Labeling must be printed - no handwritten labels will be allowed.

K. At the completion of the wiring installation, provide the following documentation:
1. A plan-view of the premise(s) showing the jack numbering scheme.
2. A printed certification report for the entire wiring installation showing compliance with all EIA/TIA specifications for data cable.
3. Reports such as those generated by Fluke DSP cable certification equipment meet this requirement.
4. Each device with a unique IP address shall be individually labeled with its IP address. The labeling must be printed; handwritten labels will not be allowed.

L. Managed Ethernet switches:
1. Configure switches to prevent broadcast storms.
2. Installations utilizing Rockwell PLCs and multicast messaging shall employ IGMP and snooping on all Rockwell components.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING

A. Perform all firmware installations, configuration and other set up, as required, to place the network into proper operation.

3.09 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. After completion of the cable system tests and before placing the system in operation, power up all devices installed on the LAN and verify communication between the devices.

C. Verify that all equipment is operable on the network simultaneously. Confirm that all network device communications settings are properly configured.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17950

COMMISSIONING FOR INSTRUMENTATION AND CONTROLS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Testing requirements that apply to process control and instrumentation systems for the entire Project.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Electronics Industries Alliance (EIA).

C. Telecommunications Industry Association (TIA).

1.03 DEFINITIONS

A. As specified in Sections 01756 - Commissioning and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Specific definitions:
   1. Complete End-to-End Testing (CEET) - Signals are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
   2. Loop Validation Tests - Signals are tested from the field device to the PLC.
   3. Platform Testing: Testing of the PLC and SCADA/HMI at the manufacturer's shop to demonstrate the program's functionality based upon specified and designed control requirements.
   4. PTO: Profibus Trade Organization.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330 - Submittal Procedures.

B. General:
   1. Reference additional detailed test submittal scheduling and prerequisite requirements as specified in the Sequencing article of Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Overall test plan:
   1. Develop the PCIS system test submittals in consultation and cooperation with all applicable subcontractors.

2. Develop and submit an overall testing plan for the PCIS. The overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.
3. Describe the test phases as they apply specifically to this Project and each process system.
4. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
5. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
6. Provide examples of proposed forms and checklists.

D. Test procedures:
1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
2. Provide a statement of test objectives for each test.
3. Prepare specific procedures for each process system.
4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
6. Describe the expected role of the Engineer, as well as any requirements for assistance from Owner's staff.
7. Provide the forms and checklists to be used.

E. Test forms:
1. Submit completed calibration forms, test forms, and checklists.
    a. Test forms shall include the detailed test procedures, or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
    b. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
    c. Sample test forms at the end of this Section show the minimum required content:
        1) The sample test forms have not been customized for this Project.
        2) Contractor shall develop and submit test forms customized for the Project and meeting the specified test and submittal requirements.

F. FAT procedure additional minimal requirements:
1. Prepare and submit a FAT procedure which includes:
    a. Control system testing block diagram.
    b. Estimated test duration.

G. Details on the simulator construction, components, and operation. Testing binders:
   1. Sub-system to be tested, provide and submit a test binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
   2. Fill out in advance headings and all other information known before the test.
   3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
   4. Include or list reference material and provide separately at the time of the test.
   5. Record test results and verify that all test requirements and conditions have been met.

H. Test reports:
   1. At the conclusion of each test, submit a complete test report, including all test results and certifications.
   2. Include all completed test binders, forms, and checklists.
   3. Submission, review, and acceptance of each test report is required before the start of the sub-system.

1.06 QUALITY ASSURANCE

A. Test personnel:
   1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Installation supervision:
   1. Provide as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 COMMISSIONING

A. Commissioning as specified in Section 01756 - Commissioning.

B. Testing and training phase:
   1. Source testing:
      a. Manufacturer services: Provide as specified in the table below.

Section Number	Section Title	Source Testing (Witnessed or Non-Witnessed)
17101 - Specific Control Strategies	Specific Control Strategies	Witnessed
17710 - Control Systems - Panels, Enclosures, and Panel Components.	Control Systems - Panels, Enclosures, and Panel Components	Witnessed
17950 - Commissioning for Instrumentation and Controls	Commissioning for Instrumentation and Controls	Witnessed

      b. Prerequisite requirements:
         1) Engineer approval of the hardware and equipment source testing submittal, Manufacturer Certificate of Source Testing, is required before proceeding to Preliminary FAT.
      c. Preliminary FAT (Pre-FAT):
         1) The purpose of the Pre-FAT is to provide assurance that the HMI/SCADA system is ready for the full, witnessed FAT, in terms of both stability and functionality.
            a) Debugging of software and troubleshooting of hardware shall occur during and before the pre-FAT, not during the FAT.
            b) Contractor shall fully test the HMI/SCADA system and fix all deficiencies found before the FAT.
         2) Conduct utilizing test procedures approved by Engineer.

3) Owner shall have the right to witness any or all of the Pre-FAT testing and shall be notified in writing 20 days before the start of the pre-FAT.
4) Submit a letter, signed by the Contractor's project manager or company officer, certifying that integrated system hardware and software has been tested and confirmed to be fully operational and in compliance with the requirements specified in the Contract Documents and is fully ready for the full, witnessed FAT.
    a) Attach the completed pre-FAT test forms, signed by the Contractor's staff.
5) Engineer approval of the pre-FAT submittal is required before proceeding to FAT.

d. FAT hardware and communications testing:
1) Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
2) The complete PCIS system including operator stations, servers, network equipment, printers, PCMs, PLCs, RTUs, LCPs, CCS, peripherals, communications equipment, and other HMI/SCADA equipment, shall be assembled, connected, and software loaded for a fully functional FAT of the integrated system.
3) Testing simulation:
    a) Inputs and outputs shall be simulated and proper control and system operation shall be validated.
    b) FAT shall make use of simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the HMI/SCADA system.
        (1) The use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator shall not be allowed.
        (2) The simulator may consist of a PLC, operating under a HMI/SCADA software package, or other approved software that has its I/O points wired to PLC's I/O points.
        (3) Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.
4) Additional source tests are specified in other sections of the Instrumentation and Control Specifications.
5) Owner shall have the right to witness any or all of the FAT testing and shall be notified in writing 20 days before the start of the FAT.
6) Verify communications between the hardware and the programmer's software comply with specified requirements:
    a) For systems that contain RTUs or remote communications with other devices, the complete communications system must be factory tested, including actual interfacing with telephone company equipment and/or the actual radios used for radio based telemetry systems.

7) Panel inspections:
   a) Engineer will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the accepted shop drawings:
      (1) Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.
   b) Inspection forms:
      (1) Provide panel inspection forms as part of the FAT procedures submittal.
      (2) A sample FAT control panel form has been provided at the end of this Section.
8) I/O test:
   a) Engineer will verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including all operator interface devices.
   b) Test methodology:
      (1) Discrete inputs:
         (a) Apply appropriate input from simulator at panel terminal, observe input card indicator, observe data value at each indicated data address, and observe data received at field wiring terminals or operator interface screen.
      (2) Discrete outputs:
         (a) Issue commands from operator interface screen or PLC, verify output card indicator light, and measure response at field wiring terminals or multimeter.
      (3) Analog inputs:
         (a) Apply appropriate analog input signal at panel terminals on simulator, observe data value at each indicated data address, and observe data properly received at field wiring terminals or operator interface screen.
         (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.
      (4) Analog outputs:
         (a) Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at field wiring terminals or multimeter.
         (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.
   c) Test forms to include, but not be limited to the following data:
      (1) PLC and panel number.
      (2) I/O type.
      (3) I/O tag name.
      (4) Rack/slot/number of I/O point.
      (5) Check-off for correct response for each I/O point.
      (6) Comments field.
      (7) Initials of individual performing test.

(8) Date test was performed.
(9) Witness signature lines.

9) System configuration test:
   a) Demonstrate and test the setup and configuration of operator stations, servers, development stations, and peripherals.
   b) Demonstrate utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
   c) Demonstrate the proper operation of peripheral hardware.
   d) Demonstrate general HMI/SCADA functions.
   e) Demonstrate proper operation of log-on and other security access functions.
   f) Demonstrate the proper operation of all historical data storage, trend, display, backup, and report functions.
   g) Test automatic fail over of redundant equipment.
   h) Demonstrate the proper operation of the alarm display and acknowledgement functions.
   i) Test forms:
      (1) For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.
      (2) List the specific tests and steps to be conducted.
      (3) For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
         (a) Include signature and date lines.

10) Engineer approval of the FAT Communication Testing activities is required before proceeding to FAT Platform Testing.

e. FAT Platform Testing - Control logic test:
   1) Verify the PLC, HMI and SCADA, provides monitoring and control functionality based upon specified and designed control requirements.
   2) Testing requirements:
      a) Demonstrate each function described in the Control Strategies.
      b) Demonstrate in detail how each function operates under a variety of operating scenarios:
         (1) Test to verify the application of each general control strategy function to each specific control strategy or loop description.
      c) Demonstrate the proper operation of the programming and configuration for each control strategy or loop description:
         (1) Test each strategy or loop description on a sentence by sentence and function by function basis.
         (2) Loops with similar or identical logic must each be tested individually.
         (3) Test the boundaries of each numeric operator input by entering values outside of the allowable range.
      d) Demonstrate the proper operation of all digital communication links and networks:
         (1) Verify each digital communication I/O point.

e) Failure testing: Demonstrate how the system responds to and recovers from abnormal conditions including, but not limited to: equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to HMI and/or SCADA hardware), process equipment failure, and high system loading conditions.

3) Test forms:
   a) Submit completed test forms for each loop including but not limited to the fully revised and approved control strategy.
   b) Identify the cause and effect as each I/O point is toggled through the simulator:
      (1) Identify and track proper and/or improper operation of the loop.
   c) Note any deficiencies or operational changes on the forms for correction and documentation:
      (1) Include signature and date lines.

4) Engineer approval of the FAT submittal is required prior to shipment of system components.

2. Owner training:
   a. Demonstration requirements are specified in this Section.

Table 1

Course Title	Minimum Course Length (hours per session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
System Overview	8	5	1
Operator Training - Basic	16	5	1
Operator Training - Advanced	8	5	1
PLC Hardware	2	3	1
PLC Software	2	3	1
Follow-Up Training	4	5	1
Instrument Training	4	3	1

3. Training course requirements:
   a. System overview training:
      1) Furnish training courses that give the Owner's supervisory level personnel and overview of all elements of the PCIS system that focus on the overall functional aspect of elements of the control system and provide an understanding of the interaction of the various components.
      2) Furnish a training course that gives the Owner's supervisory level personnel and overview of the new Contractor-provided elements of the PCIS system. Focus on the overall functional aspects of each new elements of the control system, particularly the mechanical system vendor-provided control packages.

b. Operator training:
    1) Furnish training courses that instruct system operators in the efficient operation of all aspects of the PCIS that include not only the general operation of the control system but also the operation of specific system features.
    2) Furnish training courses that instruct system operators in the efficient operation of Contractor-provided aspects of the PCIS that include not only the general operation of each control system but also the operation of specific system features.
    3) Operator's training shall include the following for each vendor package and programmable device:
        a) Control system overview: Architecture, equipment functions, software components, etc.
        b) Display navigation, overview, and types of displays.
        c) Process and equipment monitoring and control: Basic principles and operation.
        d) Logging ON and OFF the system and description of the security and access system.
        e) Alarm subsystem.
        f) Trending: Provide a thorough session on how to use all trending functions.
        g) Reports: How to access, print, and review content.
        h) Control strategies: Present an average 15-minute review of each control strategy, including a hands-on demonstration of screens and operator functions for each.
        i) Instruction on the use of all operational functionality alarm logging, trending, displays, database, reports, and control software developed for the Project and incorporated in the installed PCIS system.
c. PLC hardware training:
    1) Furnish training on PLC hardware and on related components, including battery backup equipment, UPSs, LOI hardware, control circuits, and analog circuits.
    2) Furnish training on PLC hardware principles, product features, proper installation, operation, troubleshooting, and maintenance.
    3) PLC training may be provided by manufacturer's certified trainers.
d. PLC software training:
    1) Furnish training on PLC software.
    2) 2 types of training are required, basic and project-specific:
        a) Basic PLC software training covers the principles of PLC programming and the specific features and function of the PLC products used on this Project, provided by one of the PLC manufacturer's certified trainers.
        b) Project-specific PLC software training covers the programming conventions, new standardized software modules, specific control strategy programs, and documentation created for the Work performed under this Contract. This training includes the specific knowledge needed to modify, expand, duplicate, troubleshoot, and repair the PLC programs provided under this Contract, provided by a qualified member of the ICSC who is thoroughly familiar with the delivered system, and is one of the senior programmers who programmed the PLCs for this Project.

e. Follow-up training:
    1) Provide a series of on-site follow-up training classes beginning after process start-up of the SCADA/PCIS system. The intent for these classes is to provide the Owner's personnel the opportunity for a review and "refresher" of the training topics and material after they have had some experience using the system.
    2) Mutually schedule and develop the content of these classes with the Owner no later than 1 month before the beginning of the first session:
        a) Schedule at the Owner's discretion on non-consecutive days spaced out over the process start-up and warranty period.
f. Instrumentation training:
    1) Furnish training covering all instruments and control panels.
    2) Furnish the specified quantity of training, allocated to cover new instruments and hardwired controls as specified in this Section and specifically determined in the accepted training plan.
    3) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the instruments furnished within this Project.
    4) Furnish training on the operation of new hardwired controls.

4. Recording training sessions:
    a. Record all training.
    b. Produce audio-visual presentations by recording the actual training sessions of the Owner's personnel.
    c. Furnish digital video disk (DVD) format.
    d. These disks become the property of the Owner and cover, in detail, the training for the specific hardware and software of all the systems provided for the Project.
    e. Provide all the necessary cameras and recording equipment.
5. Installation testing:
    a. Calibration:
        1) Performed by Contractor and ICSC.
        2) Calibrate and adjust all instruments, devices, valves, and systems, in conformance with the component manufacturer's instructions and as specified in these Contract Documents.
        3) Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
            a) Calibration for discrete devices:
                (1) Calibrate and adjust devices for reliable operation and to avoid nuisance tripping.
            b) Calibration for ultrasonic and radar level devices:
                (1) Provide Echo Transmission and signal quality on level transmitters including guided and unguided units:
                    (a) Submit printout of the actual transmission and parameters.
                (2) Adjust mounting, as required, to obtain accurate readings.
                (3) Post mounting: Provide any additional calibration required by manufacturer.
            c) Calibrating analog transmitters:
                (1) Components having adjustable features are to be set accurately for the specific conditions and applications of this installation.

(2) Test and verify that components and/or systems are within the specified limits of accuracy.
(3) Calibration points:
(a) Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to NIST.
(4) Field verify calibration of instruments including units that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.

d) Analyzer calibration:
(1) Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical representatives.
(2) Submit completed instrument calibration sheets for every field instrument and analyzer.
(3) Calibration tags:
(a) Attach a calibration and testing tag to each instrument, piece of equipment, or system.
(b) Sign the tag when calibration is complete.

e) Calibration for industrial networking test equipment.
f) Submit calibration documentation.

b. Loop check:
1) Performed by the Contractor.
2) Cabling installed, terminated, and labeled.
3) Perform continuity check of wiring to each field device through intermediate devices to field terminals in the cabinet.
4) Complete loop check form for each device.
5) Submit loop check test results before proceeding to the next step.

c. Loop validation tests:
1) Performed by the Contractor, ICSC, and manufacturer's representative, working together, and witnessed by the Owner or Owner's representative.
2) Perform tests on the signal from each field device through intermediate devices to the I/O module on the PLC.
a) The PLC may or may not be connected to the network.
3) Engineer approval of the loop validation test submittal is required before proceeding to CEET.

d. LAN cable post-testing:
1) Performed by Contractor and ICSC.
2) After installing the cable and connectors, test all cables using the LAN certification to confirm the installation meets the requirements of the specification.
3) Provide test documentation that includes the cable number, total length of cable, a permanent hard copy, as well as a-USB or CD copy of all traces.
a) After installing connectors:
(1) Perform cable end-to-end testing on all installed cables from both ends of the cable.
(2) Test shall include cable system performance tests and confirm the absence of wiring errors.

(3) Submit a signed test report presenting the results of the cable testing.
(4) Repair or replace any portions of the system not meeting TIA/EIA standards for installed cabling. Repaired sections shall be retested.

4) Submit final documentation (including traces), using the approved test form, to the Engineer upon successful completion of the testing.
5) Engineer approval of the LAN cable post-testing submittal is required before proceeding to CEET.
6) Network Operations Testing:
   a) Performed by Contractor/ICSC, Network Tester, and Owner's representative working together.
   b) General requirements:
      (1) The network performance is monitored and measured using non-intrusive test equipment and procedures in accordance with the Referenced standards:
         (a) Profibus networks.
      (2) Modifications required as a result of network operations validation and shall be in conformance with the applicable standards from Profibus organization, North America, PTO.
   c) Online evaluation:
      (1) Confirm specified slave devices appear on the live list.
      (2) Evaluate data traffic between master and each slave to confirm proper slave configuration and performance.
      (3) Inspect waveform capture for evidence of excessive noise.
      (4) Evaluate and report any failed or questionable network tests.
      (5) Evaluate and report network error codes and related symptoms.
   d) Network Operations Validation and Testing Report:
      (1) Prepare a report that documents the results of the qualification and testing activities include, but not limited to, the following:
         (a) Document the installed condition of the network and provide baseline values for future network maintenance and testing activities.
         (b) Executive summary for each network including the following:
            - Inspection and test results for each network.
            - Calculated network parameters.
            - Recommendations.
            - Description of test procedures and required test equipment.
            - Network agency specifications.
         (c) Manufacturer's specifications and guidelines:
            - Include applicable manufacturer's specifications and guidelines.
            - Manufacturer's specifications and guidelines may supersede the specifications of the applicable governing body for the associated network but at a minimum must meet the governing body's requirements.

e) Submit final report of the industrial network testing to the Engineer upon successful completion of the testing.

7) Engineer approval of the industrial network testing submittals is required before proceeding to CEET.

e. Complete End-to-End Testing (CEET):

1) Performed by Contractor, ICSC, and manufacturer's representative working together, with assistance from the OWNER or the inspection staff, as needed:
   a) The participants need to be dedicated full-time to CEET.
   b) ICSC will provide staff to verify input signals at, and create output signals from, an HMI or Engineering Workstation.
   c) Contractor and ICSC will be responsible for creating field signals and verifying proper operation of final control elements.

2) Prerequisites:
   a) CEET cannot begin until the successful completion of the preceding tests:
      (1) Calibration.
      (2) Loop check.
      (3) Loop validation tests.
      (4) LAN cable post-testing.
      (5) Industrial network testing.

3) Testing description:
   a) This testing is to ensure all I/O signals operate to the intent of the design from the field device to the HMI and all other auxiliary controls and indicators in the PCS.
   b) Connect PLC to the network to test signals from the field device through the PLC program, the network, and to the operator's HMI graphic screens. The outputs will be energized for a duration long enough to verify proper operation of the final control element.
   c) SCADA screens:
      (1) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
      (2) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
      (3) Retest any loop following any necessary corrections.

4) Check control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the HMI/SCADA system:
   a) Use actual process inputs wherever available.
   b) Issue commands from the HMI/SCADA system and verify proper responses of field devices:
      (1) Test SCADA system inputs from field device to SCADA system operator workstations:
         (a) Track responses through trend charts in the HMI/SCADA system.
      (2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.

5) Discrete device testing:
    a) Exercise each field device providing a discrete input to the HMI/SCADA system in the field and observe the proper operation shall be observed at the operator workstation:
        (1) Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
        (2) Exercise starters, relay contacts, switch contacts, and observe proper operation.
        (3) Calibrate and test instruments supplying discrete inputs, and observe proper operation.
    b) Test each device accepting a discrete output signal from the HMI/SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:
        (1) Stroke valves through outputs from the HMI/SCADA system, and confirm proper directional operation. Confirm travel limits and any feedback signals to the HMI/SCADA system.
        (2) Exercise motors starters from the HMI/SCADA system and verify proper operation through direct field observation.
        (3) Exercise solenoids and other field devices from the HMI/SCADA system and verify proper operation through direct field observation.
6) Analog device testing:
    a) Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
    b) Apply provisional settings on controllers and alarm setpoints.
7) Analog input:
    a) Exercise each field device monitoring the analog signal, through the HMI/SCADA system.
        (1) Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements, and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
8) Analog output:
    a) Exercise each field device requiring an analog command signal, through the HMI/SCADA system.
        (1) Vary the output from the PLC HMI/SCADA system and measure the end device position, speed, etc. to confirm the proper operation of the device for the supplied analog signal.
        (2) Manually set the output from the HMI/SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
9) Submit completed test forms:
    a) Discrete instrument input devices:
        (1) Switch setting, contact action, and dead band.

(2) Valve position switches:
(a) Response in the PLC as the valve is stroked from the PLC.
(b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
(3) Operator interface switches (control stations and other pilot devices) and associated response.
(4) Starter and drive auxiliary device contact response.
(5) Response of all other discrete inputs to the PLC.
(6) Test equipment used and associated serial numbers.

b) Discrete output devices:
(1) Observed response of field device to the discrete output from the PLC.
(2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.
(3) Test equipment used and associated serial numbers.

c) Analog input devices:
(1) Calibration range.
(2) Calibration data: Input, output, and error at each test value.
(3) Analog input associated PLC register address.
(4) Value in PLC register at each test point.
(5) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).
(6) Test equipment used and associated serial numbers.

d) Analog output devices:
(1) Calibration range.
(2) Test value at each test point.
(3) Analog output associated PLC register address.
(4) Control variable value at field device at each test point.
(5) Physical device response at each test point:
(a) Response to be actual valve position, or motor speed, etc.
(6) Test equipment used and associated serial numbers.

10) Failure testing:
a) Demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
(1) Equipment failure.
(2) Communications sub-system error.
(3) Power failure.
(4) Process equipment failure.
(5) High system loading conditions.

11) Engineer approval of the CEET submittals is required before proceeding to Functional Testing.

6. Functional testing:
a. General:
1) Testing to demonstrate proper operation of systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
2) Performed by Contractor, ICSC, and manufacturer's representative working together, with assistance from the OWNER or the inspection staff, as needed.

3) Additional tests are specified in other Instrumentation and Control Sections.
4) Follow approved detailed test procedures and check lists for Functional Test activities.

b. Control logic operational validation:
1) The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the HMI/SCADA system, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.
2) Demonstrate control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, Electrical Specifications, and Mechanical Equipment Specifications.
3) Test in detail on a function-by-function and sentence-by-sentence basis.
4) Thoroughly test hardware and software functions.
5) Including all hardwired and software control circuit interlocks and alarms.
6) Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify all logic and control is achieved.
7) Control logic validation tests to include, but not limited to: a repeat of all control logic tests from the FAT, modified and expanded to include all field instruments, control panels, circuits, and equipment.

c. Loop tuning:
1) Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
2) Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates. As a minimum, achieve 1/4-wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
3) If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.
4) Functional validation sheets:
a) Document each Functional test on an approved test form.
b) Document loop tuning with a report for each loop, including two-pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by Contractor and Engineer.

c) Include on the form, functions which can be demonstrated on a loop-by-loop basis:
(1) Loop number and P&ID number.
(2) Control strategy, or reference to specification tested.
(3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the Functional test. Otherwise, create new forms.

d) For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
(1) Specification page and paragraph of function demonstrated.
(2) Description of function and/or text from specification.
(3) Test procedures: use the FAT loop test checklist forms modified to meet the specific testing conditions of the Functional test.

5) Functional certification:
a) Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.
(1) Including all test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that all Functional test requirements have been satisfied.

7. Clean Water Facility Testing:
a. ICSC shall be onsite to support Clean Water Test activities and provide functional changes as required.

C. Process Start-up Phase:
1. Process Start-up:
a. ICSC shall be onsite to support Process Start-up activities and provide functional changes as required.
2. Process Operation Period:
a. ICSC shall be available to support Process Operational Period and provide functional changes as required.
3. PCIS Optimization and Fine-Tuning:
a. General:
1) After the Process Operational Period, test PCIS system for additional 60 days as specified in this Section to identify issues and make corrections, as needed.
2) This is part of the Work that must be completed as a condition of substantial completion and final completion for the entire Project.
3) The complete PLC control and HMI/SCADA system must run continuously for the duration of the PCIS Optimization and Fine-Tuning.
4) Test and use the entire process control system under standard operating conditions.
5) Exercise all system functions.

6) Log failure, any system interruption and accompanying component, subsystem, or program failure including time of occurrence, duration of each failure, failure classification, and cause:
    a) Provide a competently trained technician or programmer on call for the Project Site during all normal working days and hours from the start of the PCIS Optimization and Fine-Tuning until final acceptance of the system:
        (1) Response time to the Project Site: 24 hours or less, for a major failure.

b. SCADA system testing:
    1) Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates "normal" system operation.
    2) Failure of the HMI/SCADA system during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications:
        a) Corrective action is required before restarting the PCIS Optimization and Fine-Tuning.
    3) Only those components, sub-systems, and systems covered in this Section and supplied under this Contract shall be considered for this acceptance test. Problems and failures of other systems shall not be considered as part of this test, except as they display the capabilities of this system to detect failures.
    4) Failures:
        a) Classify failures as either major or minor:
            (1) Minor failure:
                (a) A small and non-critical component failure or software problem that can be corrected by the Owner's operators.
                (b) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
                (c) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
                (d) Failure of one printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator station, and repairs can be made and equipment returned to service within 3 working days.
            (2) Major failure:
                (a) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
                (b) Cause termination of the PCIS Optimization and Fine-Tuning.
                (c) Start a new acceptance test when the causes of a major failure have been corrected.

(d) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.

5) Technician report:
   a) Each time a technician is required to respond to a system malfunction, they must complete a report, which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
   b) If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
   c) If a technician has performed work but no report is written, then a major failure is considered to have occurred.
   d) Each report shall be submitted within 24 hours to the Engineer and the Owner, or its representative.

3.07 FIELD QUALITY CONTROL (NOT USED)

3.01 RE-INSTALLATION (NOT USED)

3.02 ADJUSTING (NOT USED)

3.03 CLEANING (NOT USED)

3.04 PROTECTION (NOT USED)

3.05 SCHEDULES

A. Example test forms:
   1. Example test forms are attached at the end of this Section. They may be used as a starting point for the development of Project-specific test forms for this Project.
   2. The example test forms are not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

END OF SECTION

	FACTORY ACCEPTANCE TEST - CONTROL PANELS	

1. GENERAL INSPECTION

A. Structural Inspection

- ☐ Verify Lifting Lugs Installed
- ☐ Verity enclosure has lock and lock is functional
- ☐ Confirm that seismic bracing components are provided per manufacturer's installation instructions

B. Exterior Inspection

- ☐ Cabinet exterior is clean, scratch, and dent free
- ☐ Inspect externally for corrosion and damage
- ☐ Verify enclosure door opens and closes easily
- ☐ Verify enclosure has a 3-point latch
- ☐ Verify enclosure has a flange mounted disconnect (where voltages greater than 120 VAC enter the cabinet)
- ☐ Verify enclosure has the appropriate NEMA rating (1, 1G, 12, 3R, 4, 4X, etc.)
- ☐ Verify enclosure is the appropriate size (not grossly larger than design, and will still fit in the plant)

Nameplates

- ☐ Cabinet has identification nameplate
- ☐ All door labels are straight, spelled correctly, and match the tagging defined in the Contract
- ☐ Cabinet has a nameplate that includes the following:
  - ☐ Power source(s)
  - ☐ Integrator's Logo
  - ☐ Circuit ID(s)
  - ☐ Short Circuit KAIC ratings
- ☐ If labels are screwed to door, silicone was utilized to cover screw holes (Labels screwed to the door of a NEMA 4/4X panel technically violates the NEMA rating.)

Door Devices

- ☐ All devices penetrating the outside of panel have gaskets, silicone or both
- ☐ All door devices are installed (HMIs, Pilot Devices, etc.)
- ☐ Door mounted equipment is mounted straight and square
- ☐ All exterior or door mounted equipment present and accounted for, installed and securely fastened
- ☐ NEMA classification has not been violated due to penetrations
- ☐ Door mounted equipment has the same NEMA rating as the panel
- ☐ All door mounted equipment installed at the correct height
- ☐ All door mounted equipment installed in the correct positions and order (layout of door mounted equipment is grouped properly and in a logical manner)
- ☐ Doors with multiple penetrations have adequate bracing (if needed)
- ☐ Visually check condition of indicators , controllers and annunciators
- ☐ Check that pilot lights illuminate correctly
- ☐ Check the Push-To-Test function
- ☐ Ensure correct pilot light color

Peripheral Devices

- ☐ Horn / Beacon is installed (where required)
- ☐ Silence and Reset pushbutton

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1. GENERAL INSPECTION (continued)

C. Interior Inspection

- ☐ Cabinet is cleaned of marks and dirt.
- ☐ Inspect internally for corrosion and damage.
- ☐ Back panel is clean of marks and dirt.
- ☐ Interior of panel vacuumed and shall be free of all debris.
- ☐ Check that the panel roof is clean and clear of foreign materials.
- ☐ Bottom of panel has been cut out (where bottom entry is required), with angle iron welded around the bottom perimeter. Re-painting has been performed.
- ☐ If internal light door limit switch is provided, ensure the light automatically turns "on" when the doors are open.
- ☐ Check that a document pocket has been provided.
- ☐ Intrusion alarms (where required).

Interior Labeling

- ☐ All panel mounted equipment has identification labeling, by using either a Brothers or Phenolic type tags.
- ☐ Verify that door mounted components are mounted square and symmetrical.
- ☐ Verify that nameplates are straight, legible, and spelled correctly.
- ☐ All terminal blocks are identified/labeled with permanent labels including tight end blocks and caps.
- ☐ All wiring shrink labeled and or phased correctly to the specifications.
- ☐ All wire labels shrunk completely rotated and aligned alike for easy identification.
- ☐ All fuses and circuit breakers are labeled with ID and current rating.
- ☐ System Integrator's label or labels installed on door.
- ☐ Panel manufacturer model/serial number tag is present.
- ☐ All required safety/warning tags installed and straight.
- ☐ Correct UL (typically UL 508) or cUL tag installed and registered and all other associated tags installed and straight (the UL tag might not be installed in the panel at the factory test. If the panel is modified due to changes during the factory test or a punch list generated from the factory test, the UL labeling would need to be re-applied. Some UL shops do not apply the UL label until the panel is released to be shipped.).

Wireways

- ☐ Plastic wire way covers installed properly.
- ☐ Plastic wireways have no sharp edges.
- ☐ No wire Ties inside the wireways.
- ☐ No sharp edges on wire ties.
- ☐ Separation: White duct is used for DC voltages, Gray duct is used for AC voltages.
- ☐ Ensure wiring duct is not over-full, includes provision for 20% more wiring and the cover may easily be installed. Panduit recommends 50% duct fill, but 40% is a better practice.

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1. GENERAL INSPECTION (continued)

C. Interior Inspection (continued)

Wiring

- ☐ Visually check terminals and condition of internal wirings
- ☐ Verify that the control panel has been assembled and wired as designed
- ☐ Verify that all components are operational and perform the functions intended
- ☐ Verify that all components are sized appropriately for the application
- ☐ Verify that equipment control circuits function as intended
- ☐ Back of door wiring is labeled and neatly formed
- ☐ Back panel to door wiring has sufficient bending radius with spiral wrap
- ☐ Wire connection has been verified wired to correct points within the panel
- ☐ Individual wires have been given a pull test to verify a good terminal connection
- ☐ Wire and cable minimum bending radius have not been violated
- ☐ All equipment installed straight and square to back panel
- ☐ Wire colors are correct:
  - ☐ Black and White > AC hot and neutral, respectively
  - ☐ Red > AC control signals
  - ☐ Blue > DC power and control (Blue w/White stripe for DC ground)
  - ☐ Yellow > Foreign voltages (those still present when panel power is disconnected)
  - ☐ Green > AC equipment ground
  - ☐ Black > TSP (+)
  - ☐ White> TSP(-)
- ☐ Analog wiring shields are continuous (connected by a dedicated terminal block for such shields)
- ☐ Analog shield wires are grounded within the panel, where not otherwise grounded at the transmitter itself
- ☐ Discrete inputs are separately fused or protected by a circuit breaker on a “per loop” basis
- ☐ Intrinsic Safety Wiring
  - ☐ Ensure wiring associated with intrinsic safety circuits or intrinsic safety barriers is kept away from all other wiring by UL minimum distances or by a physical (grounded metal) barrier preventing non-intrinsically safe wiring from coming in contact with intrinsically safe circuits or wiring
- ☐ Verify all spare terminals are installed according to the percentage listed in the specifications

Grounding

- ☐ Equipped with “Blackburn” or other grounding type lug
- ☐ Lug is securely fastened to the panel structure
- ☐ Verify Grounding bar is installed
- ☐ Verify Isolated ground bar is installed

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2. POWER TEST

A. AC Power

- ☐ AC Power is routed correctly within the panel, and is isolated from DC and network wiring.
- ☐ All fuses are installed and sized properly.
- ☐ All breakers are installed and sized properly.
- ☐ 24 VDC Power Supplies are functional.
- ☐ 24 VDC Power fail contacts are functional.
- ☐ 24 VDC power supplies are redundant, and have diode modules enabling the hot swap-over between supplies.
  - ☐ 24 VDC supplies are equipped with dry contact failure alarms, wired as PLC inputs to signal failure of any DC power supply. Such alarm inputs to the PLC have been tested as being functional.
- ☐ Dedicated receptacle is wired to receive a dedicated AC supply.
- ☐ Verify continuity for all DC commons, ground and AC neutrals.
- ☐ Verify that the CP temporary input power is connected correctly and is the correct voltage.
- ☐ Close the CP main circuit breaker(s).
- ☐ Verify that voltages at subsequent circuit breakers are correct.
- ☐ Close circuit breakers.
- ☐ Verify that power feeding interruptible and uninterruptible power supplies is correct.
- ☐ Turn on power supplies if they are not already on.
- ☐ Verify that voltages at distribution terminals are correct.
- ☐ Energize any remaining hardware such as the PLC.

B. Uninterruptible Power Supply (UPS)

- ☐ Mounted appropriately within the cabinet, on a dedicated shelf, or rear of a swing-out sub panel.
- ☐ Is equipped with maintenance bypass switch (or at least plug/receptacle means for bypassing the unit).
- ☐ Test all UPS alarms (on inverter, failure, battery failure etc.)
- ☐ Turn off the AC power supply and verify that the UPS will be switched on to supply the designated vital loads in the control panel.

3. CONTROLS & AUXILIARY DEVICES TEST

- ☐ Verify all interposing and auxiliary relays are functioning.
- ☐ Verify panel lights are functioning.

Ventilation and Heating

- ☐ If ventilation fans are fitted, check the fans operate correctly any associated air filters are clean and not blocked.
- ☐ Verify components are installed in the correct orientation for proper air flow.

4. HARDWIRED INTERLOCK AND SAFETY TEST

- ☐ Verify that hardwired interlocks through the control panel as shown on schematic drawings are functioning. For example, outlet high pressure switch interlock to a pump.
- ☐ Verify that all hardwired safety devices through the control panel is functioning. For example, the pull cord emergency stops of conveyors.

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5. PLC TEST

A. Components

☐ PLC interior High Temperature alarm is installed, wired to the PLC, and is shown to be functional.

☐ Relays have transient suppression across their coils. This is particularly important for DC coil relays, where diodes in reverse polarity are often used.

☐ TVSS is installed across the main incoming 120 VAC.

PLC and PLC Rack

☐ Verify all cards are securely seated.

☐ Ensure clearance around PLC rack has been met, such that convective heat transfer is not impeded by devices erroneously mounted in the “no encroachment” area. Confirm with manufacturer clearance recommendations.

B. PLC I/O Test

☐ Furnish **I/O test forms** and test all the listed input and output points as follows:

☐ Discrete Inputs: Simulate a field contact closure by “shorting” across the appropriate terminal blocks. Observe the transition between a logical “0” and “1” in the PLC software.

☐ Discrete Outputs: Force the output bit to toggle between logical “0” and logical “1” using the PLC software. Measure contact resistance at the wired terminal blocks using a digital meter selected for the “ohms” setting.

☐ Analog Inputs: Connect a signal generator to the appropriate terminal blocks. Tailor the connection depending on whether a 2-wire or 4-wire simulation is required. Modulate the 4-20mA signal. Observe the associated PLC internal memory register to transition between 0-65535 or if scaled in engineering units, between 0 and the maximum scaled engineering unit. The latter method is preferred.

☐ Analog Outputs: Force the output register to a value between 0-65535 or 0-100%, if the scaling block can be manipulated. Observe the measured 4-20mA value increment and decrement using a digital ammeter.

C. Redundant Controllers (where required) Test

☐ Remove Communication cable from primary PLC to verify switching to backup PLC

☐ Remove Communication cable from backup PLC to verify switching back to primary PLC

☐ Remove Power cable from primary PLC to verify switching to backup PLC

☐ Remove Power cable from backup PLC to verify switching back to primary PLC

D. PLC Control Logic Verification

☐ The PLC control strategy is verified by following the Control Logic Verification Form based on the specifications. Each control strategy will be verified by simulating the process and checking the state or value of PLC outputs. The results of equipment status and alarms and process instrument values and trends shall also be verified on the Plant SCADA graphic screens stored in a temporary SCADA computer. Since all PLC input and output wiring has been verified and some field devices are not available during Factory Acceptance Testing, certain inputs will be simulated either by means of additional hardware and/or software as described below.

☐

☐

☐ DI states are either simulated by hardwired switches or forced inputs using a programming terminal.

☐ For example, when starters and drives are not provided as part of the contract, jumpers may be installed from the output call relays to the running confirmation inputs to simulate the running state of the motors.

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5. PLC TEST (continued)

D. PLC Control Logic Verification (continued)

Typical Fault Logic

- ☐ If the fault input is high and the disable (if applicable) for the fault is not high and the common disable (if applicable) is not high begin timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output. If the fault alarm is a shutdown alarm stop the associated motor and latch the alarm so that it remains present even if the condition clears.
- ☐ The fault condition must return to normal and the alarm must be reset for a latched alarm to clear.

Typical Fail to Start Logic

- ☐ If the motor is called to run (call output high) and no running feedback is received (running input is low) and the fail to start and common alarm disables (if applicable) are not high start timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output, stop calling the motor and latch the alarm.

6. HMI OR OIT TEST

HMI / OIT Functionality

- ☐ Communication with PLC
- ☐ Screen Layouts
- ☐ Screen Navigation
- ☐ Set Point Entry
- ☐ Animation
- ☐ Color Correctness (Green=Run, Red=Off, Amber=Alarm, or the agreed upon convention)
- ☐ Alarms
- ☐ Acknowledge and Reset
- ☐ Security / Access Levels / Passwords

7. NETWORK COMMUNICATION TEST

A. Network Components

- ☐ Fiber optic cabling terminates in a patch panel
- ☐ Media converters are installed and functional
- ☐ Terminating resistors have been installed for trunk/tap topologies or where required
- ☐ Wire and cable bending limitations have not been violated

B. Networking Functions

- ☐ Verify data transfer via the network to different PLCs as shown on the Network Block Diagrams
- ☐ Verify network traffic rate and error margin is acceptable

PROJECT NAME:	_____	TEST DATE:	_____
FACILITY NAME:	_____	TESTED BY:	_____
PROCESS AREA:	_____	COMPANY:	_____
NETWORK ID:	_____	PAGE:	_____
WITNESSED BY:	_____	SIGNATURE:	_____

8. FAT DOCUMENTATION AND RECORD

Panel Documentation

- ☐ As-built panel drawings showing actual panel construction and devices arrangement and c/w Bill of Material.
- ☐ Panel schematic and interconnection drawings.
- ☐ P&ID drawings and schematic drawings for the process area controlled by the panel that is to be tested.
- ☐ I/O list test forms of the process area to be tested.
- ☐ FAT procedure of the process area to be tested.
- ☐ Test record forms of the process area to be tested. Forms shall include area for signature of responsible test personnel.
- ☐ Hard copy of the PLC application program of the process area to be tested.
- ☐ Hard copy of the HMI/OIT graphic screens of the process area to be tested.

9. FAT TOOLS AND SOFTWARE

- ☐ Simulation software if required
- ☐ Digital volt meter Fluke 87
- ☐ Process meter Fluke 787
- ☐ Laptop computer with PLC application program
- ☐ Temporary SCADA computer with HMI software and applicable graphic screens
- ☐ Jumper wires

PROJECT NAME:	_____	TEST DATE:	_____
FACILITY NAME:	_____	TESTED BY:	_____
PROCESS AREA:	_____	COMPANY:	_____
NETWORK ID:	_____	PAGE:	_____
WITNESSED BY:	_____	SIGNATURE:	_____

	INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

	☐ No	☐ Yes
INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?		

REMARKS: _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

	☐ No	☐ Yes
INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?		

FIELD CALIBRATION CHECK

CONTACT NO.	FUNCTION	FOR SIGNAL	CONTACT IS TO	AT SPECIFIED VALUE FOR	ACTUAL TRIP POINT WAS
1	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____
2	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____
3	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____
4	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____

NOTE: PERM IS ABBREVIATION FOR PERMISSIVE

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

REMARKS: _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? No Yes

INSTRUMENT TYPE ☐ TRANSMITTER ☐ CONTROLLER ☐ INDICATOR

☐ OTHER DESCRIPTION _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

BENCH CALIBRATION CHECK

INPUT RANGE = _____

HEAD CORRECTION = _____

CALIBRATED SPAN = _____

OUTPUT RANGE = _____

☐ LINEAR

☐ SQUARE ROOT

% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

FIELD CALIBRATION CHECK

INPUT RANGE = _____

OUTPUT RANGE = _____

% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ DIRECT ☐ REVERSE

☐ ACTION VERIFIED AT 50% SPAN

☐ ACTION VERIFIED AT _____ SPAN

CONTROLLER SETTINGS								
SETTING	**GAIN**	**PB**	**RESET (INTEGRAL)**	**DERIV. (RATE)**	**HIGH LIMIT**	**LOW LIMIT**	**ELEV. ZERO**	**ZERO SUPP**
PRE-TUNE								
POST-TUNE								

PRE-TUNE SETTINGS					
	GAIN	**PB**	**RESET (REPEAT/MIN)**	**RESET (MIN/REPEAT)**	**DERIVATION (MINUTES)**
FLOW	1.0	100	10	0.1	N/A
LEVEL	1.0	100	MIN.	MAX.	N/A
PRESSURE	2.0	50	2.0	0.5	N/A
TEMP.	4.0	25	0.1	10	OFF

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	ANALYZERS **INSTALLATION AND CALIBRATION CHECKLIST**	

☐ No ☐ Yes

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

TYPE OF INSTRUMENT _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, IF TRUE

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? No Yes

☐ VALVE TAG NO. _____ SERIAL NO. _____

☐ TRANSDUCER TAG NO. _____ SERIAL NO. _____

☐ SOLENOID TAG NO. _____ SERIAL NO. _____

☐ VOLUME BOOSTER TAG NO. _____ SERIAL NO. _____

☐ POSITIONER _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

TRANSDUCER CHECK					
INPUT RANGE =			OUTPUT RANGE =		
CALIBRATED SPAN =			CALIBRATED SPAN =		
BENCH					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		
FIELD					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		

CHECK BELOW, IF TRUE:

☐ BENCH CALIBRATED PER ABOVE _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

- ☐ VALVE SPECIFICATION NO. _____
- ☐ TRANSDUCER SPECIFICATION NO. _____
- ☐ SOLENOID SPECIFICATION NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS _____

- ☐ VALVE DETAIL NO. _____
- ☐ TRANSDUCER DETAIL NO. _____
- ☐ SOLENOID DETAIL NO. _____

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

VALVE CHECK			
FLOW CHECK	☐ PROCESS FLOW DIRECTION THROUGH THE VALVE IS CORRECT		
SAFETY CHECK	ON LOSS OF AIR VALVE FAILS ☐ OPEN ☐ CLOSE	ON LOSS OF POWER SOLENOID FAILS ☐ TO VENT ☐ TO VALVE	
TRAVEL CHECK	FULL OPEN AT _____ PSI	FULL CLOSED AT _____ PSI	MEASURED TRAVEL _____ INCHES
SEATING CHECK	☐ ON BENCH ☐ IN-LINE	RESULTS	ACTUATOR BENCH SET
POSITIONER CHECK			
VALVE FULL OPEN AT _____ PSI TO POSITIONER			
VALVE FULL CLOSED AT _____ PSI TO POSITIONER			
VOLUME BOOSTER CHECK			
BYPASS VALVE (GAIN) ADJUSTING SCREW BACKED OUT _____ TURNS FROM CLOSED TO ENSURE QUICK BUT STABLE OPERATION (TYPICALLY 1-1/2 TO 2 TURNS)			

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	DEVICENET INSTALLATION TESTING	

DeviceNet Network _____

Network Installation Characteristics

Architecture	Baud Rate	Trunk Media	Drop Media
☐ Single Master	☐ 125 kBaud	☐ Thick Round	☐ Thick Round, Unshielded
or			
☐ Multi Master	☐ 250 kBaud	☐ Thin Round	☐ Thin Round, Shielded
☐ Redundant Power Supplies	☐ 500 kBaud		☐ Thick Round, Shielded

☐ Per Network

Installed Node List

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15
☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20 ☐ 21 ☐ 22 ☐ 23 ☐ 24 ☐ 25 ☐ 26 ☐ 27 ☐ 28 ☐ 29 ☐ 30 ☐ 31
☐ 32 ☐ 33 ☐ 34 ☐ 35 ☐ 36 ☐ 37 ☐ 38 ☐ 39 ☐ 40 ☐ 41 ☐ 42 ☐ 43 ☐ 44 ☐ 45 ☐ 46 ☐ 47
☐ 48 ☐ 49 ☐ 50 ☐ 51 ☐ 52 ☐ 53 ☐ 54 ☐ 55 ☐ 56 ☐ 57 ☐ 58 ☐ 59 ☐ 60 ☐ 61 ☐ 62 ☐ 63

☐ All nodes present and in accordance with network drawings/specifications

☐ ODVA approved devices

☐ Nodes/devices accessible for inspection and maintenance

☐ Nodes/devices properly addressed

Comments: _____

Media Inspection

Trunk Cable	Drop Cable	Installation
☐ ODVA approved	☐ ODVA approved	☐ No evidence of physical damage
☐ Labeling complete	☐ Labeling complete	☐ Installed in protective raceway
☐ Cable/conductor terminations	☐ Cable/conductor terminations	☐ Bending radius not exceeded
☐ Terminating resistors at ends	☐ Maximum drop length < 20'	☐ Cable supports in place
		☐ V- and shield are grounded
		☐ Clearance from high temperature/voltage sources
		☐ No installation subject to vibration

Comments: _____

Network Power Supplies

Power Supply Equipment	Supply Source (120 VAC)	Network Power Tap (24 VDC)
☐ ODVA compliant	☐ Overcurrent protection	☐ Overcurrent protection
☐ Quantity and ratings	☐ Conductor size	☐ Conductor size

Comments: _____

CHECKED BY (COMPANY)	ACCEPTED BY (COMPANY)
SIGNATURE	SIGNATURE
DATE	DATE

PROFIBUS
INSTALLATION QUALIFICATION AND TESTING

General Network Description

The Profibus network serves the RO pretreatment, blended water, and concentrate processes and consists of both DP and PA slave devices. The master is located in programmable logic controller, PLC-900. Profibus DP repeaters are deployed in the network to essentially support a radial network topology from each process control panel.

Network Design Characteristics

ARCHITECTURE			BAUD RATE (kbits/sec)		
MASTER	☐ SINGLE	☐ REDUNDANT	☐ 9.6	☐ 187.5	☐ 3,000
TOTAL NODE COUNT ≤ 126	☐		☐ 19.2	☐ 50	☐ 6,000
REPEATER COUNT	_____		☐ 93.75	☐ 1,500	☐ 12,000
CASCADED REPEATER COUNT <9	_____				
NODE COUNT PER DP SEGMENT <32	☐				
DP/PA SEGMENT COUPLERS	_____				
REDUNDANCY (DP/PA COUPLERS	_____				
ACTIVE TERMINATORS	☐				
PROFIBUS DIAGNOSTICS	☐ PA ONLY	☐ DP & PA			
SURGE PROTECTION FOR SLAVES LOCATED OUTSIDE		☐			
SURGE PROTECTION FOR MEDIA ENTERING THE CONTROLLER CABINET		☐			
INTRINSIC SAFETY WIRING: REQUIRED FOR ANY PA NETWORK		☐			

INSTALLED NODE LIST

☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	☐ 11	☐ 12	☐ 13	☐ 14	☐ 15				
☐ 16	☐ 17	☐ 18	☐ 19	☐ 20	☐ 21	☐ 22	☐ 23	☐ 24	☐ 25	☐ 26	☐ 27	☐ 28	☐ 29	☐ 30	☐ 31				
☐ 32	☐ 33	☐ 34	☐ 35	☐ 36	☐ 37	☐ 38	☐ 39	☐ 40	☐ 41	☐ 42	☐ 43	☐ 44	☐ 45	☐ 46	☐ 47				
☐ 48	☐ 49	☐ 50	☐ 51	☐ 52	☐ 53	☐ 54	☐ 55	☐ 56	☐ 57	☐ 58	☐ 59	☐ 60	☐ 61	☐ 62	☐ 63				
☐ 64	☐ 65	☐ 66	☐ 67	☐ 68	☐ 69	☐ 70	☐ 71	☐ 72	☐ 73	☐ 74	☐ 75	☐ 76	☐ 77	☐ 78	☐ 79				
☐ 80	☐ 81	☐ 82	☐ 83	☐ 84	☐ 85	☐ 86	☐ 87	☐ 88	☐ 89	☐ 90	☐ 91	☐ 92	☐ 93	☐ 94	☐ 95				
☐ 96	☐ 97	☐ 98	☐ 99	☐ 100	☐ 101	☐ 102	☐ 103	☐ 104	☐ 105	☐ 106	☐ 107	☐ 108	☐ 109	☐ 110	☐ 111				
☐ 112	☐ 113	☐ 114	☐ 115	☐ 116	☐ 117	☐ 118	☐ 119	☐ 120	☐ 121	☐ 122	☐ 123	☐ 124	☐ 125	R 126	R 127				

☐ ALL NODES PRESENT IN ACCORDANCE WITH NETWORK DESIGN DOCUMENTS.

LEGEND

- M MASTER NODE PRESENT AT THIS ADDRESS
- D PROFIBUS DP NODE PRESENT AT THIS ADDRESS
- P PROFIBUS PA NODE PRESENT AT THIS ADDRESS
- R RESERVED ADDRESS
- ☐ NO DEVICE PRESENT AT THIS ADDRESS

COMMENTS *(Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)*

PROJECT NAME: _____ TEST DATE: _____

FACILITY NAME: _____ TESTED BY: _____

PROCESS AREA: _____ COMPANY: _____

NETWORK ID: _____ PAGE: _____

WITNESSED BY: _____ SIGNATURE: _____

PROFIBUS
INSTALLATION QUALIFICATION AND TESTING

Media Inspection

CABLING	DP NETWORK	PA NETWORK SEGMENTS			
PI COMPLIANT	☐	☐	☐	☐	☐
LABELING COMPLETE	☐	☐	☐	☐	☐
GROUNDING	☐	☐	☐	☐	☐
CABLE AND CONDUCTOR TERMINATIONS	☐	☐	☐	☐	☐
NO STUB LINES (DP ONLY)	☐	☐	☐	☐	☐
TERMINATING RESISTORS (IN PLACE)	☐	☐	☐	☐	☐
DEDICATED DIAGNOSTICS BUS	☐	☐	☐	☐	☐
INSTALLATION					
NO EVIDENCE OF PHYSICAL DAMAGE	☐	☐	☐	☐	☐
INSTALLATION IN PROTECTIVE RACEWAY	☐	☐	☐	☐	☐
CLEARANCES FROM HIGH TEMPERATURE SOURCES	☐	☐	☐	☐	☐
CLEARANCES FROM HIGH VOLTAGE SOURCES	☐	☐	☐	☐	☐
BEND RADIUS	☐	☐	☐	☐	☐
NO INSTALLATION SUBJECT TO VIBRATION, SHOCK, HIGH FLEX, CHEMICALS, OR MOISTURE	☐	☐	☐	☐	☐
TERMINATING RESISTORS TURNED ON AT CORRECT LOCATION	☐	☐	☐	☐	☐

COMMENTS *(Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)*

Device Inspection

DEVICE QUANTITY/TYPE	INSTALLATION
☐ TOTAL SLAVE COUNT	☐ NO EVIDENCE OF PHYSICAL DAMAGE
☐ MOST UPDATED DEVICE DRIVER INSTALLED?	☐ ACCESSIBLE FOR INSPECTION AND MAINTENANCE
☐ INSTALLED DEVICES COMPLY WITH DRAWINGS AND SPECIFICATIONS	☐ FDT COMPLIANT DEVICES
☐ PI COMPLIANCE DEVICES	
☐ DIAGNOSTICS MODULE INSTALLED	

COMMENTS *(Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)*

Power Supplies

ACTIVE TERMINATIONS	COUPLERS	REPEATERS
☐ SOURCE LOCATION	☐ SOURCE LOCATION	☐ SOURCE LOCATION
☐ OVERCURRENT PROTECTION	☐ OVERCURRENT PROTECTION	☐ OVERCURRENT PROTECTION
☐ CONDUCTOR SIZE	☐ CONDUCTOR SIZE	☐ CONDUCTOR SIZE
☐ GROUNDING	☐ GROUNDING	☐ GROUNDING

COMMENTS *(Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)*

PROJECT NAME: _____ TEST DATE: _____

FACILITY NAME: _____ TESTED BY: _____

PROCESS AREA: _____ COMPANY: _____

NETWORK ID: _____ PAGE: _____

WITNESSED BY: _____ SIGNATURE: _____

PROFIBUS
INSTALLATION QUALIFICATION AND TESTING

DP Network Media Testing

DESCRIPTION	SEGMENT ID					
TRUNK LENGTH (feet)						
ALLOWABLE TRUNK LENGTH AT SPECIFIED DATA RATE:						
MEASURED TRUNK LENGTH:						
SPARE TRUNK LENGTH						
RESISTANCE MEASUREMENTS (ohms)						
NETWORK CABLE: NO TERMINATIONS						
ONE TERMINATION						
TWO TERMINATIONS						
POWER SUPPLY VOLTAGE (volts DC)						
ACTIVE TERMINATOR						
REPEATER CP1100-RPT1						
REPEATER CP1000-RPT1						
REPEATER CP1000-RPT2						
REPEATER CP2700-RPT1						

CABLE TESTS	PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL
TESTED FOR SHORT CIRCUIT BETWEEN SIGNAL LINES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR SHORT CIRCUIT BETWEEN SIGNAL LINES AND SHIELD	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR SHIELD CONTINUITY	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR OPEN SIGNAL LINES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR CROSSED SIGNAL LINES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR CORRECT TERMINATOR POSITION	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
CORRECT CABLE TYPE AND LENGTH	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR SECURE AND TIGHT CONNECTORS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

COMMENTS *(Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)*

PROJECT NAME: _____ TEST DATE: _____

FACILITY NAME: _____ TESTED BY: _____

PROCESS AREA: _____ COMPANY: _____

NETWORK ID: _____ PAGE: _____

WITNESSED BY: _____ SIGNATURE: _____