TECHNICAL SPECIFICATIONS

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

SLEEPY HOLLOW STEELHEAD REARING FACILITY RAW RAW WATER INTAKE AND WATER SUPPLY UPGRADE

SPECIFICATIONS
Divisions 1 to 17

May 2018

1420 Fifth Avenue, Suite 600 | Seattle, Washington 9810
(206) 883-9300

Tetra Tech Project No. 135-124674-15001

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Monterey Peninsula Water Management District
Sleepy Hollow Steelhead Rearing Facility

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SECTION 01010

SUMMARY OF WORK

PART 1 - GENERAL

1.1 SUMMARY

A. The work covered by this contract includes:

1. Constructing upgrades to the existing Sleepy Hollow Steelhead Rearing Facility (SHSRF) including a new river intake and pumping system, upgrades to the intake water treatment system, a new pre-engineered metal building and equipment for RAS/Treatment, new settling tank, and earthwork and piping improvements.
2. Maintaining Facility operation during construction.
3. Demolition.

B. The above description is for general information only. Provide all work required by the Contract Documents.

1.2 CONTRACT DOCUMENTS

A. The contract drawings indicate the general arrangement and location of equipment, pipe, fixtures, outlets, etc. Follow the indicated positions as closely as possible. The exact location of the various items is subject to building construction and the actual equipment furnished by the Contractor. Contractor shall verify the location of all items furnished, installed, or connected.

B. The Drawings are not to be scaled. All implied locations shall be determined at the building site after field measurements have been taken.

C. Should interferences or discrepancies prevent the installation of any part of the work, the Engineer shall be notified and will determine the steps necessary to complete the true development of the intent of the Drawings and Specifications.

1.3 TIME OF COMMENCEMENT AND COMPLETION

A. Notice to Proceed: Within ten calendar days after the execution of the Contract, written Notice to Proceed will be provided by Owner to Contractor or as required in the General Conditions. Contractor shall begin the Work upon receipt of the Notice to Proceed. Notwithstanding any other provision of the Contract, Owner shall not be obligated to accept or to pay for any Work furnished by Contractor prior to delivery of the Notice to Proceed, whether or not Owner has knowledge of the Work.

B. The calendar work day count will commence on the date specified in the Notice to Proceed or as required in the General Conditions.

C. Substantial Completion

1. Substantial completion of the Work and completion of all items of Work shall be as set forth in the Agreement.

1.4 SPECIFICATIONS

A. The following standard specifications, including current revisions and supplements may be referred to in these Contract Documents to establish minimum standards for materials, construction, and inspection procedures. Unless otherwise shown or specified, the provisions for measurement and payment contained in such standard specifications will not apply.

1. Caltrans Standard Specifications, 2015, as prepared by the California State Transportation Agency.
2. American Society for Testing Materials (ASTM).
3. American Water Works Association (AWWA).
4. American National Standard Institute (ANSI).
5. National Association of Sewer Service Companies (NASSCO).
6. Manual on Uniform Traffic Control Devices (MUTCD).

B. In case of conflict between the several parts of the specifications and between the various referenced standard specifications, the most stringent shall govern as determined by the Engineer. Where these specifications refer to recognized standards, such as ASTM, Federal Specifications, N.F.P.A., the reference shall be to the latest edition, unless specified otherwise.

1.5 CONTRACTOR'S COPIES OF CONTRACT DOCUMENTS

A. Owner will provide Contractor with two sets of full-size drawings, five sets of half size drawings, and five sets of specifications. At least one complete set of Contract Documents, including one full-size set of Drawings shall be kept at the site of construction in good condition, and at all times available to the Owner and Engineer. Additional copies of the Contract Documents, if required, will be furnished by the Engineer at net cost of reproduction to the Contractor.

1.6 COORDINATION OF WORK WITH OWNER AND OTHERS

A. Contractor shall coordinate its work with other contractors who may be working on and or in the Project area and cooperate with them. Contractor shall also coordinate its activities with Owner.

1.7 PERMITS AND FEES

A. The acquisition of all permits required, and payment of all fees, inspection charges and other similar costs shall be the responsibility of Contractor. Owner will reimburse Contractor for payments made to cover the cost of all permits.

1.8 CLEANUP AND SITE MAINTENANCE

A. Contractor shall clean daily all dirt, gravel, construction debris and other foreign material resulting from its operations from all streets and roads in the vicinity of the Work and shall maintain a clean, orderly and safe construction site at all times during prosecution of the Work. If required by the Engineer, Contactor shall use wash trucks or street sweepers fitted with spray misters to minimize dust.

1.9 EXISTING UTILITIES

A. In general, the locations of existing major underground utilities and some minor utilities are indicated on the Drawings. This information has been obtained from utility maps and from oral descriptions provided by the various agencies involved. Owner does not guarantee the accuracy or completeness of this information, and it is to be understood that other above ground or underground facilities not shown on the Drawings may be encountered during the course of the Work.

B. Contractor shall notify all utility companies and public agencies affected by the construction 48 hours prior to excavation.

1.10 RESTORATION OF STRUCTURES AND SURFACES

A. General: Whenever any of the Work is accomplished on or through property other than that owned by Owner, Contractor shall furnish Owner, before final acceptance of the Work by Owner, a written release from the subject property owner or an authorized representative of the owner of the property affected, stating that the restoration of structures and surfaces has been satisfactorily accomplished. If in the opinion of the Owner the release is arbitrarily withheld, the Owner may, at its sole discretion, accept the portion of the Work involved and cause final payment therefore to be made.

B. In addition to the requirements of any applicable utility permit, street use permit or franchise relating to this Contract, Contractor shall, as a minimum for any restoration work, conform to standard plans and specifications of the agency which controls the use of the right-of-way in which this construction work is performed.

C. Existing stakes and marks: All section, section subdivision, property corners, plat, U.S.C. and G.S., U.S.G.S., and other official monuments or bench marks, shall be carefully preserved or replaced. In the event any such monument or marker is disturbed as a result of Contractor's operations, Contractor shall replace or reset the monument or marker in a manner satisfactory to the Engineer and shall provide a survey map to be recorded with the County. Replaced or reset monuments shall be of acceptable type and quality, and shall be, located so as to clear existing utilities or any other interferences. They shall be placed in a manner consistent with good and recognized engineering and surveying practices.

D. All waterways, channels, drainage ditches, drains, culverts and similar facilities that are damaged by actions of Contractor shall be restored as nearly as possible to their original condition. Where necessary, Contractor shall provide temporary facilities or temporarily realign such watercourses to maintain a continuously serviceable facility until it is restored to its original location and condition. Restoration of such facilities shall be as shown and specified.

1.11 CONSTRUCTION STAKING

A. Owner has provided horizontal control points and vertical datum benchmarks as noted on the Drawings. Contractor shall provide all construction staking.

1.12 GEOTECHNICAL STUDIES

A. A geotechnical investigation has been performed for the project and is titled Sleepy Hollow Rearing Facility, RAS/Treatment Building and Wet Well, Carmel Valley, CA by Pacific Crest Engineering, Inc. for Monterey Peninsula Water Management District, Monterey, CA dated April 2018. The report may be obtained from the District. Contractor shall make its own deductions and conclusions as to the nature of the materials to be excavated and the difficulties which may arise from subsurface conditions.

1.13 EXCESS MATERIALS AND DEBRIS

A. Disposal of excess materials and debris shall be in accordance with applicable federal, state and local laws. Contractor may not dispose of excess materials or debris on the Project sites. There is no designated disposal site.

1.14 ARCHAEOLOGY

A. During construction, if artifacts or any other archaeological objects are discovered, Contractor shall stop construction immediately and notify Owner. Owner will notify the appropriate authorities. Contractor shall cooperate with authorities investigating the find.

1.15 EMERGENCY RESPONSE

A. At the preconstruction meeting, Contractor shall provide Owner with a list of phone numbers of those employees responsible for responding to emergency calls outside normal working hours concerning Contractor's Work.

B. Upon failure to immediately respond to a problem with corrective action, Owner may respond without further notice to Contactor and deduct all costs thereof from any payments due or coming due Contactor. Owner shall not be required to act in any situation and nothing shall relieve Contactor of its duties in this regard.

1.16 TRAFFIC CONTROL

A. Traffic shall not be affected by the Work unless Contractor has an approved traffic control and maintenance plan.

B. Contractor shall provide all lighting, barricades, cones, signs, and flaggers necessary to direct traffic during working hours and at all other times as required to ensure the public safety and promote safe vehicular travel.

C. All traffic control measures shall meet the requirements of the MUTCD.

1.17 AS-BUILT DRAWINGS

A. Contactor shall be required to provide complete, accurate as-built data to the Engineer prior to final payment. The Engineer will furnish one additional set of construction plans for final as-built recording. As-built data shall be kept current daily and available for review daily by the Engineer. Prior to authorization of each monthly progress pay estimate, the Engineer will review Contactor's current as-built plans for completeness and accuracy.

1.18 “OR EQUAL” CLAUSE

A. In order to establish a basis of quality, certain processes, types of machinery and equipment or kinds of material may be specified on the plans or herein by designating a manufacturer’s name and referring to brand or product designation. It is not the intent of these specifications to exclude other processes, equipment or materials of a type and quality equal to those designated. When a manufacturer’s name, brand or item designation is given, it shall be understood that the words “or equal” follow such name or designation, whether in fact they do so or not. If Contractor desires to furnish items of equipment by manufacturers other than those specified, he shall secure the approval of Engineer prior to placing a purchase order.

B. No extras will be allowed Contractor for any changes required to adopt the substitute equipment. Therefore, Contractor’s proposal for an alternate shall include all costs for any modifications to the plans, such as structural and foundation changes, additional piping or changes in piping, electrical changes or any other modifications which may be necessary or required for approval and adoption of the proposed alternate equipment. Approval of alternate equipment by Engineer before or after bidding does not guarantee or imply that the alternate equipment will fit the design without modifications.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 01010

SECTION 01060

REGULATORY AND SAFETY REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies regulatory requirements applicable to this project that include, but shall not be limited to, Environmental Protection Agency, Occupational Safety and Health Administration (OSHA), Cal/OSHA, and other applicable federal, state and local governmental regulations.

1.2 WATER AND AIR POLLUTION CONTROL

A. During the term of the Contract, Contractor's operations shall conform to applicable laws and regulations of the California Environmental Protecion Agency (CalEPA), and other agencies of the State and Federal government, as well as, local Ordinances and Resolutions designed to prevent, control and abate water and air pollution.

B. During all phases of the Work, or when directed, protect work sites, storage, and disposal areas from washout and erosion. Take precautions to control or abate dust nuisance and air pollution by cleaning up, sweeping, sprinkling, covering, enclosing or sheltering work areas, and stockpiles, and by promptly removing from paved streets earth or other material which may become airborne or may be washed into waterways or drainage systems.

C. The Contractor is required to submit for approval an erosion control plan prior to the start of site work.

1.3 NOISE

A. Measures shall be taken to minimize noise. The Contractor shall review the site and understand the relationship of the site to surrounding facilities.

1.4 SAFETY AND HEALTH REGULATIONS

A. The Contractor shall comply with safety and health regulations for construction.

1.5 POSTING OF REGULATIONS

A. The Contractor shall comply with all Cal/OSHA posting regulations as well as State and Federal Labor Law requirements.

1.6 RESPONSIBILITY FOR DAMAGE

A. The Contractor shall bear sole responsibility for damage to completed portions of the project or to property located off the project caused by erosion, siltation, run-off, or other related items during the construction of the project.

B. The Contractor shall also bear sole responsibility for any pollution of rivers, streams, groundwater or other waters which may occur as a result of construction operations. The Contractor shall exercise all necessary precautions throughout the life of the project to prevent pollution, erosion, siltation, and property damage.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 01060

SECTION 01091

REFERENCE STANDARDS

PART 1 - GENERAL

1.1 QUALTIY ASSURANCE

A. Titles of sections and paragraphs: Captions accompanying specification sections and paragraphs are for convenience of reference only, and are not to be used to define the limits of subcontracts.

B. Applicable publications: Whenever in these Specifications references are made to published specifications, codes, standards, or other requirements, it shall be understood that wherever no date is specified, only the latest specifications, standards, or requirements of the respective issuing agencies which have been published as of the date that the Work is advertised for bids, shall apply; except to the extent that said standards or requirements may be in conflict with applicable laws, ordinances, or governing codes. No requirements set forth herein or shown on the Drawings shall be waived because of any provision of, or omission from, said standards or requirements.

C. Without limiting the generality of other requirements of the Specifications, all work specified herein shall conform to or exceed the requirements of applicable codes and the applicable requirements of the following documents to the extent that the provisions of such documents are not in conflict with the requirements of these Specifications nor the applicable codes.

D. In case of conflict between codes, reference standards, drawings and the other Contract Documents, as determined by Owner, the most stringent requirements shall govern. Conflicts shall be brought to the attention of the Engineer for written clarification and directions prior to ordering or providing any materials or labor. The Contractor shall bid the most stringent requirements.

E. Applicable standard specifications: The Contractor shall construct the Work specified herein in accordance with the requirements of the Contract Documents and the referenced portions of those referenced codes, standards, and specifications listed herein; (except, that wherever references to "Standard Specifications" are made, the provisions therein for measurement and payment shall not apply).

F. References herein to "OSHA Regulations for Construction" shall mean Title 29, Part 1926, Construction Safety and Health Regulations, Code of Federal Regulations (OSHA), including all changes and amendments thereto.

G. References herein to "OSHA Standards" shall mean Title 29, Part 1910, Occupational Safety and Health Standards, Code of Federal Regulations (OSHA), including all changes and amendments thereto.

H. The contractual relationship of the parties to the Contract, the du-ties and responsibilities of Owner, Contractor and Engineer mentioned in any reference document shall be governed by General Conditions contained herein.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. The following documents or agencies may be referenced in the Contract Documents.

AA	Aluminum Association
AABC	Associated Air Balance Council
AAMA	Architectural Aluminum Manufacturer's Association
AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
AATCC	American Association of Textile Chemists and Colorists
ACI	American Concrete Institute
ADC	Air Diffusion Council
AEIC	Associated Edison Illumination Companies
AFBMA	Anti-Friction Bearing Manufacturer's Association, Inc.
AGA	American Gas Association
AGC	Associated General Contractors of America
AGMA	American Gear Manufacturer's Association
AHAM	Association of Home Appliance Manufacturer's
AI	The Asphalt Institute
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
AMCA	Air Moving and Conditioning Association
ANS	American Nuclear Society
ANSI	American National Standards Institute, Inc.
APA	American Plywood Association
API	American Petroleum Institute
APWA	American Public Works Association
AREA	American Railway Engineering Association
ARI	Air-Conditioning and Refrigeration Institute
ASA	Acoustical Society of America
ASAE	American Society of Agricultural Engineers
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASLE	American Society of Lubricating Engineers
ASME	American Society of Mechanical Engineers
ASPA	American Sod Producers Association
ASQC	American Society of Quality Control
ASSE	American Society of Sanitary Engineers
ASTM	American Society for Testing and Materials
AWPA	American Wood Preservers Association
AWPI	American Wood Preservers Institute
AWS	American Welding Society
AWWA	American Water Works Association
BBC	Basic Building Code, Building Officials and Code Administrators International
BHMA	Builders Hardware Manufacturer's Association
CBM	Certified Ballast Manufacturers
Cal/OSHA	California Occupational Safety and Health Agency
CalEPA	California Environmental Protecion Agency
CDA	Copper Development Association

CEMA	Conveyors Equipment Manufacturer's Association
CGA	Compressed Gas Association
CLPCA	California Lathing and Plastering Contractors Association
CLFMI	Chain Link Fence Manufacturer's Institute
CMA	Concrete Masonry Association
COE	Corp of Engineers
CRSI	Concrete Reinforcing Steel Institute
CSI	Construction Specifications Institute
CWS	Clean Water Services
DCDMA	Diamond Core Drill Manufacturer's Association
DOE	Department of Ecology
DOT	Department of Transportation
EEI	Edison Electric Institute
EIA	Electronic Industries Association
EJCDC	Engineer's Joint Contract Documents Committee
EJMA	Expansion Joint Manufacturer's Association
EPA	Environmental Protection Agency
ETL	Electrical Test Laboratories
FGMA	Flat Glass Marketing Association
FM	Factory Mutual
FS	Federal Specification
GA	Gypsum Association
IBC	International Building Code
ICBO	International Conference of Building Officials
ICC	Interstate Commerce Commission
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society
IME	Institute of Makers of Explosives
IMIA	International Masonry Industry All-Weather Council
IP	Institute of Petroleum (London)
IPC	Institute of Printed Circuits
IPCEA	Insulated Power Cable Engineers Association
ISA	Instrument Society of America
ISO	International Organization for Standardization
ITE	Institute of Traffic Engineers
MBMA	Metal Building Manufacturer's Association
MFMA	Maple Flooring Manufacturer's Association
MIL	Military Specification
ML/SFA	Metal Lath/Steel Framing Association
MPTA	Mechanical Power Transmission Association
MTI	Marine Testing Institute
NAAMM	National Association of Architectural Metal Manufacturer's
NACE	National Association of Corrosion Engineers
NBS	National Bureau of Standards
NCCLS	National Committee for Clinical Laboratory Standards
NEBB	National Environmental Balancing Bureau
NEC	National Electrical Code
NEMA	National Electrical Manufacturer's Association
NESC	National Electric Safety Code
NFPA	National Fire Protection Association
NGLI	National Lubricating Grease Institute

NMA	National Microfilm Association
NWMA	National Woodwork Manufacturers Association
OSHA	Occupational Safety and Health Administration
PCA	Portland Cement Association
PCI	Prestressed Concrete Institute
PS	Product Standard
RIS	Redwood Inspection Service
RVIA	Recreational Vehicle Industry Association
RWMA	Resistance Welder Manufacturer's Association
SAE	Society of Automotive Engineers
SAMA	Scientific Apparatus Makers Association
SDI	Steel Deck Institute
SDI	Steel Door Institute
SIS	Swedish Standards Association
SJI	Steel Joist Institute
SMA	Screen Manufacturers Association
SMACCNA	Sheet Metal and Air Conditioning Contractors National Association
SPR	Simplified Practice Recommendation
SSBC	Southern Standard Building Code, Southern Building Code Congress
SSPC	Steel Structures Painting Council
SSPWC	Standard Specifications for Public Works Construction
TAPPI	Technical Association of the Pulp and Paper Industry
TFI	The Fertilizer Institute
UL	Underwriters Laboratories, Inc.
WCLIB	West Coast Lumber Inspection Bureau
WCRSI	Western Concrete Reinforcing Steel Institute
WIC	Woodwork Institute of California
WRI	Wire Reinforcement Institute, Inc.
WWPA	Western Wood Products Association

B. Standard Specifications

1. Where indicated in these Contract Documents, Work shall be in accordance with the referenced sections of the Caltrans Standard Specifications, 2015, prepared by the California State Department of Transportation, hereinafter referred to as "Standard Specifications."
2. The Specifications of these Contract Documents shall supersede any provisions of the Standard Specifications in conflict herewith.
3. Reference to measurements and payment in the Standard Specifications do not apply to this Contract.
4. References to Engineer, department, secretary, State or other similar terms in the Standard Specifications shall mean Owner.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 01091

SECTION 01300

SUBMITTALS

PART 1 - GENERAL

1.1 SUBMITTAL REQUIREMENTS

A. All submittals shall be electronic copies unless hardcopies are specified. Electronic copies shall be in PDF format unless otherwise specified.

B. General:

1. All submittals shall be identified by project title, and number and shall include Contractor's name, date and revision date. In addition, shop drawings, product data and samples shall include names of subcontractor and supplier, applicable specification section number and Contractor's stamp, initialed or signed, certifying to review of submittal, verification of field measurements and compliance with Contract Documents.
2. All submittals shall be accompanied by a submittal transmittal form. Equipment numbers shall be listed for items being submitted. A separate form shall be used for each specific item, class of material, equipment, and items specified in separate, discrete sections, for which the submittal is required. Submittals for various items shall be made with a single form when the items taken together constitute a manufacturer's package or are so functionally related that expediency indicates checking or review of the group or package as a whole.
3. A unique number, sequentially assigned, shall be noted on the transmittal form accompanying each item submitted. Original submittal numbers shall have the following format: "XXX"; where "XXX" is the sequential number assigned by the Contractor. Resubmittal shall have the following format: "XXXY"; where "XXX" is the originally assigned submittal number and "Y" is a sequential letter assigned for resubmittals; i.e., A, B, or C being the 1st, 2nd, and 3rd resubmittals, respectively. Submittal 25B, for example, is the second resubmittal of Submittal 25.
4. Submittal Completeness: Submittals which do not have all the information required to be submitted are not acceptable and will be returned without review.

C. Shop drawings: Show the information, dimensions, connections and other details necessary to ensure that the shop drawings accurately interpret the contract documents. Show adjoining work in such detail as required to indicate proper connections. Where adjoining connected work requires shop drawings or product data, submit such information for review at the same time so that connections can be accurately checked.

D. Product data: Modify product data by deleting information which is not applicable to the project or by marking each copy to identify pertinent products. Supplement standard information, if necessary, to provide additional information applicable to project. It is recognized that in some cases manufacturer’s product data will be adequate and further shop drawings as stated in the specifications may not be required, unless requested by the Engineer.

E. Samples

1. Submit 2 (unless specific number is specified) of each sample required by the specifications. Samples shall show the quality, type, range of color, finish and texture of the material intended to be furnished for the work.
2. Samples shall become the property of the Owner unless specifically stated otherwise, and will not be incorporated in the work.

F. Review Procedure: Unless otherwise specified, within 14 days after receipt of the submittal, the Engineer will review the submittal. The returned submittal will indicate one of the following actions:

1. If the review indicates that the material, equipment, or work method is in general conformance with the design concept and complies with the Drawings and specifications, submittal copies will be marked "NO EXCEPTION TAKEN" and given review action 1. In this event the Contractor may begin to implement the work method or incorporate the material or equipment covered by the submittal.
2. If the review indicates that limited corrections are required, copies will be marked 'NOTE MARKINGS" and given review action 2. The Contractor may begin implementing the work method or incorporating the material and equipment covered by the submittal in accordance with the noted corrections. Where submittal information will be incorporated in O&M data, a corrected copy shall be provided, otherwise no further action is required.
3. If the review reveals that the submittal is insufficient or contains incorrect data, copies will be marked "COMMENTS ATTACHED". If the comments are of a nature that can be confirmed without a resubmittal, copies will be further marked "CONFIRM" and given review action 3. If the comments require a revision and resubmittal, copies will be further marked "RESUBMIT" and given review action 4. Except at its own risk, the Contractor shall not undertake work covered by this submittal until the attached comments have been either confirmed by a separate written communication or the submittal has been revised, resubmitted and returned marked with "NO EXCEPTIONS TAKEN" or "NOTE MARKINGS".
4. If the review indicates that the material, equipment, or work method is not in general conformance with the design concept or in compliance with the Drawings and specifications, copies of the submittal will be marked "REJECTED" and given review action 5. Except at its own risk, the Contractor shall not undertake work covered by such submittals until a new submittal is made and returned marked either "NO EXCEPTIONS TAKEN" or "NOTE MARKINGS".

G. Effects of Review of Contractor's Submittals: Review of Drawings, method of work, or information regarding materials or equipment the Contractor proposes to provide, shall not relieve the Contractor of its responsibility for errors therein and shall not be regarded as an assumption of risks or liability by the Engineer on behalf of the Owner, and the Contractor shall have not claim under the Contract on account of the failure, or partial failure, of the method of work, material, or equipment so reviewed. A mark of "NO EXCEPTIONS TAKEN" or "NOTE MARKINGS" shall mean that the Engineer has no objection to the Contractor, upon the Contractor's own responsibility, using the plan or method of work proposed, or providing the materials or equipment proposed.

1.2 SCHEDULE

A. The Contractor shall provide the following schedules and submit them not later than 10 days after notice to proceed.

1. Contractor's construction schedule:

    a. The Contractor will be required to prepare and submit to the Engineer for review an overall construction schedule covering all work to be performed.
    b. The schedule shall indicate the sequence of the work, the time of starting and completion of each part and the installation dates for major items.
    c. The schedule shall be submitted to the Engineer for review. This schedule shall be revised and resubmitted as necessary until it is acceptable to the Engineer. Action on payment requests will be contingent upon receipt of an acceptable construction schedule.
    d. The construction schedule shall include, but not be limited to, the following item:

        1) Shop drawing receipt from Contractor, submitted to Engineer, review and return to Contractor.
        2) Material and equipment order, delivery and installation and checkout.
        3) Piping installation.
        4) Backfilling, grading, seeding and paving.
        5) Earthwork.
        6) Subcontractor’s item of work.
        7) Final cleanup.
        8) Testing activities.
        9) Substantial Completion.
        10) Allowance for inclement weather.
        11) Final Completion.

    e. The construction schedule shall be a series of line diagram showing a step by step sequence of each construction activity. Construction activities proceeding simultaneously should be shown as parallel lines. Each activity shall be labeled and the estimated number of days to complete the activity shall be shown on the schedule.
    f. Should the Contractor fail to meet any critical dates within the schedule, the Contractor shall immediately undertake appropriate action which shall assure an acceptable return to the approved construction schedule.
    g. The Contractor will be required to accept the risk of any delays caused by the rate of progress of the work to be performed under the above contract, and that in the event the Contractor is delayed in the prosecution and completion of their work because of such conditions, they shall have no claim for damages or contract adjustment.

2. Contractor's list of subcontractors: Establish the items of work proposed to be accomplished by subcontractors, the name and address of each proposed subcontractor and the date proposed to award each subcontract.
3. Schedule of submittals: Establish for each item for which shop drawings, product data or samples are required, the date of submission will be made and the date approval is required for the installation to be completed in accordance with the Construction Schedule.
4. The Contractor's list of subcontractors and schedule of submittals shall be based upon the Contractor's progress schedule so that the work can progress in accordance with the approved progress schedule.

B. The Contractor shall immediately advise the Engineer of any proposed changes in their submitted schedules. If, in the opinion of the Engineer, any submitted schedule is inadequate to ensure completion of work within the time limit, or is otherwise not in accordance with the specification, or if the work is not being adequately or properly prosecuted in any respect, the Engineer shall have the right to require the Contractor to submit new schedules providing for proper and timely completion of the work. In accordance with the General Conditions, progress payments may be held until an acceptable updated schedule is provided.

C. During the term of this Contract, the Engineer may require any schedule to be modified so that the changes in the work of this Contract or related contracts (if any) are properly reflected in the schedule.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 01300

SECTION 01400

QUALITY CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Work under this Section includes all testing required by the Contract as specified herein and further specified in the technical sections.

1.2 BUILDING CODE

A. Conform to the requirements of the most recent addition of the International Building Code (IBC), including California Codes for building, structural, mechanical, electrical, plumbing and as required.

1.3 TESTING METHODS

A. All tests shall be made in accordance with commonly recognized standards of national organizations unless alternate specific testing methods are set forth in the technical specifications.

1.4 COSTS

A. The Contractor shall employ and pay for an independent testing laboratory to perform all testing services as specified in the technical sections. Additional inspection and tests required because of defective work or ill-timed notices are performed at the Contractor's expense.

1.5 QUALITY ASSURANCE

A. Samples: The Contractor shall supply samples if and when required by the Specifications or the Engineer. These samples or test specimens shall be prepared and furnished with information as to their source in such quantities and size as may be required for proper examination and tests, with all freight charges prepaid. All samples shall be submitted before shipment of materials to the site of the work and in ample time to permit the making of proper tests, analysis, examination, rejections and resubmissions before the time required to incorporate the materials into the work. No such materials shall be used in work until they have been reviewed in writing by the Engineer. Samples of materials will be retained by the Engineer for reference and comparison purposes.

B. Certification: Producers and associations which have instituted approved systems of quality control and have been, approved by the building department may submit certifications of compliance in lieu of further testing. Concrete mixing plans, plants producing fabricated

concrete products certified by building department lumber and plywood grademarks by approved associations and materials for equipment bearing Underwriter's Laboratory label require no further plan inspection and testing, unless more restrictive requirements are required, or otherwise specifically required in the specifications.

1.6 COMPACTION TESTING

A. Compaction testing shall be completed by the Contractor's certified testing laboratory at the sole expense of the Contractor. Testing shall occur as the pipe is installed to verify compliance with compaction requirements in accordance with Sections 02221 and 02222. Prior to the start of construction, the Contractor shall obtain and provide the Engineer with a certified Standard Proctor test for each type of backfill material used in the trench at his sole expense. Material used to complete the certified Proctor test shall be taken from the pit used to provide backfill and shall be no more than two weeks old from the date the Proctor test was completed and the date submitted by the Contractor to the Engineer. All costs associated with testing shall be considered incidental to the project.

B. A minimum of two compaction tests shall be performed for every 150 feet of trench backfill. All compaction tests shall be taken at locations and depths as directed by the Engineer or Engineer's field representative. A minimum of one test out of every four will be at or below half trench depth. Contractor or Contractor's field testing agent shall provide the Engineer with a certified copy of the compaction test results within 48 hours of taking the test. All tests shall be recorded, including all failed tests and retests. Contractor will not be allowed to have more than 450 feet of pipe in place at any one time that has not met the required compaction specifications. All failed compaction tests shall not only require the Contractor to recompact and test again, but shall include two additional compaction tests at other locations as determined by the Engineer. Contractor shall provide Engineer or Engineer's representative 24 hours written notice prior to the start of any compaction testing.

C. Payment will be considered only for trench excavation, backfill and pipe that have met the required compaction testing specifications, and results submitted to the Engineer. Areas not meeting specified compaction shall be recompacted and methodology for future backfill efforts modified to meet the requirements.

D. The Contractor shall assume full responsibility of the means and methods applied to the compaction of trench backfill. Testing identified above is the minimum, and the Contractor, at his own discretion, may conduct additional testing as he deems necessary, to ensure the entire trench meets the specified compaction requirements. Any subsequent settlement of the trench during the warranty period shall be considered to be the result of improper compaction and shall be promptly corrected by the Contractor at no additional charge to the Owner.

1.7 CONTRACTOR'S RESPONSIBILITY

A. Access: Furnish free access to various parts of the work and assist testing inspection personnel in performance of their duties at no additional cost to the Owner

B. Concealed work: When directed by the Engineer, the Contractor shall open for inspection any part of the work which has been concealed. Should the Contractor refuse or neglect such a request, the Owner may employ any other person to open up the same or do so himself. If any

parts of the work have been concealed in violation of the Engineer's instructions or, if on being opened, it is found not to be in accordance with the terms of the contract documents, the expense of opening and recovering, whether done by the Contractor or not, shall be charged to the Contractor.

C. Data: Furnish samples, records, drawings, certificates and similar data as may be required by testing and inspection personnel to assure compliance with the contract documents

D. Notices: The Contractor shall notify the Engineer not less than 48 hours before work requiring inspection is started. The Contractor shall schedule portions of the work requiring inspection and additional testing by the Engineer, so that the agency's time on the project is continuous and as brief as possible. Provide notice to the Engineer 48 hours prior to concealment.

1.8 INSPECTORS

A. Appointment: The Engineer or Owner may appoint inspectors to inspect any and all portions of the work. Such inspection may extend to any or all parts of the work, and to the preparation or manufacture of materials to be used.

B. Authority of Inspector: Inspectors are not authorized to revoke, alter, enlarge or relax the provisions of the Contract Documents, and the inspector is placed on the work to keep the Engineer informed as to the progress of the Work and the manner in which it is being done. He may also call the attention of the Contractor to any deviations from the plans or specifications. Failure of the inspector or the Engineer to call the attention of the Contractor to faulty work or deviation from the Contract Documents shall not constitute acceptance of said work. An inspector is not authorized to approve or accept any portions of the Work or to issue instructions contrary to the contract documents. The inspector will exercise only such additional authority as may be specially delegated to him by the Engineer, notice of which will be given in writing to the Contractor.

1.9 TEST REPORTS

A. Independent testing and inspection agency and/or agencies will prepare logs, test reports and certificates applicable to specific tests and inspections. Reports shall include description of method of test, identification of samples and portions of the work tested. They shall state description of location of work, time and date of obtaining and testing samples, weather and climatic conditions, and evaluation of results of tests, including recommendations for action. Electronic copies shall be submitted to the Owner, Engineer and Contractor.

1.10 DEFECTIVE WORK

A. Remove and replace any work found defective or not complying with requirements of contract documents, at no additional cost to the Owner.

B. Work will be checked as it progresses, but failure to detect any defective work or materials shall not in any way prevent later rejection when such defect is discovered, nor shall it obligate the Engineer for final acceptance.

C. Owner reserves the right to conduct their own quality assurance testing, obtain material samples and to test products for compliance with pertinent requirements of the Contract Documents, irrespective of prior testing and/or certification of the products by the manufacturer.

1. The Contractor shall cooperate as required for collecting and forwarding the required samples without charge, and in ample time to permit testing prior to use, and provide safety measures and devices to protect those who take the samples.
2. In the absence of any reference specification, materials shall meet the specifications and requirements of the American Society for Testing and Materials (ASTM) or the American Association of State Highway and Transportation Officials (AASHTO). When there is not pertinent coverage under ASTM or AASHTO, the material shall meet specifications and requirements of applicable commercial standards. Lacking such coverage, materials shall meet requirements established by reputable industry for a high-quality product of the kind involved.
3. The Contractor shall not rely on Owner testing for his own performance required to meet the requirements outlined within the Contract Documents. Copies of test results will be provided to Contractor upon Contractor’s written request to the Owner.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 01400

SECTION 01500

TEMPORARY FACILITIES AND CONTROLS

PART 1 - GENERAL

1.1 PUBLIC SAFETY AND CONVENIENCE

A. The Contractor shall comply with all rules and regulations of the city, state and county authorities regarding the closing of public streets or highways to the use of public traffic. No roads shall be closed to the public except by express permission of the Engineer. The Contractor shall conduct the work so as to ensure the least possible obstruction to traffic and normal commercial pursuits.

B. The Contractor shall protect all obstructions within traveled roadways with approved signs, barricades and lights where necessary or where ordered by the Engineer for the safety of the public. The convenience of the general public and residents along the Work area and the protection of persons and property are of prime importance and shall be provided for in an adequate and satisfactory manner. Access to all residences and businesses in the project area shall be maintained at all times.

C. Whenever the Contractor's operations create a hazardous condition, he shall furnish flagperson and guards as necessary to give adequate warning to the public of any dangerous condition encountered.

D. The Contractor shall patrol daily the traffic control area and reset all disturbed signs and traffic control devices immediately. All nonapplicable signs shall be removed or covered during periods not required. All signs and barricades necessary for nighttime traffic control shall be fully reflectorized. The Contractor shall provide and maintain, at his own expense, all labor, tools, materials, and equipment required to maintain traffic, including flagging.

1.2 CONSTRUCTION UTILITIES AND MISCELLANEOUS FACILITIES

A. General: The Contractor shall provide the temporary facilities and controls as hereinafter specified and as required by law.

B. Power: Unless otherwise specified, the Contractor shall provide all necessary power and special connections to power lines.

C. Water: Potable and nonpotable water are not available for the Contractor’s use on the work site. The Contractor shall provide all water necessary for its operations.

D. Sanitary facilities: The Contractor shall provide adequate toilet facilities for all workmen and Owner's representatives employed on the work. The Contractor shall maintain the same in a sanitary condition from the beginning of the Work until completion and shall then remove the facilities and disinfect the premises. All portions of the Work shall be maintained at all times in a sanitary condition. Potable water (both hot and cold) shall be available for hand washing.

E. Equipment storage: The Contractor shall be responsible for storing equipment and materials.

F. Constructions signs: No commercial or advertising signs shall be allowed on the site of the Work.

G. Contractor shall provide a suitable staging area for storage of materials and equipment. Contractor cannot store materials in the right-of-way without Owner's written permission.

1.3 BARRIERS

A. The Contractor shall erect and maintain guard rails or other suitable barriers where required.

1.4 FIRE PREVENTION CONTROL

A. General: Take all precautions necessary and required to prevent fires. Comply with the requirements of local authorities having jurisdiction.

B. Fuel for cutting and heating torches shall be gas only, and shall be contained in Underwriter's Laboratory approved containers.

C. Provide and maintain a 20 pound capacity, dry-chemical type fire extinguisher in the immediate vicinity of the work when welding tools or torches of any type are in use.

D. Do not use volatile liquids for cleaning agents or as fuels for motorized equipment or tools within building, except with the written approval of the Engineer.

1.5 RUBBISH REMOVAL

A. General:

1. Clean up the debris resulting from work at least once a day and more often, if it interferes with the work of others or presents a fire hazard. Closely pile debris where directed.
2. Remove and dispose of all debris at once if it presents a fire hazard, or when directed.

1.6 DISCONTINUANCE, CHANGES AND REMOVAL

A. A.When directed and no longer required, remove the temporary facilities specified herein. If any of the permanent systems are used for temporary facilities, restore them to "as new" condition. Material used for temporary facilities, which are removed, shall become the property of the Contractor which shall be removed from the site by the Contractor.

1.7 SECURITY

A. The Contractor is responsible for security of his own operations at all times.

1.8 PROJECT SIGNS

A. The Contractor shall provide and install project signs where necessary to inform the public of any construction activity having impact on public access and use of the adjacent lands, roads, or streams. Signs shall be placed at least 48 hours prior to related operations and shall be removed promptly upon completion of the project.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 01500

SECTION 01568

EROSION AND POLLUTION CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. It shall be the responsibility of the Contractor to prevent pollution of air, water and soil resulting from his operations.

B. The Contractor shall perform work required to prevent soil from eroding or otherwise entering onto all paved areas and into natural watercourses, ditches, and public sewer systems and to prevent dust attributable to his operations from entering the atmosphere. This work shall be in accordance with Federal, State and Local codes.

C. Water containing suspended material from any part of the Contractor's operations shall be clarified before discharging to drains or streams.

D. Noise pollution shall be minimized through the use of proper mufflers on all construction equipment.

PART 2 - PRODUCTS

2.1 GENERAL

A. Dust palliatives (additives) shall conform to the Standard Specifications.

B. Other erosion control structures and products as shown on the drawings.

PART 3 - EXECUTION

3.1 STREETS, AND SIDEWALKS

A. Streets, haul roads and (if directed by the Owner's Representative) detours and bypass roads shall be swept by automatic self-contained sweepers as required to keep them free of dirt or debris.

B. Excessive dirt on pavements and gravel roadways shall be removed by means of hand shoveling or appropriate mechanical equipment and the area swept as directed above.

C. Sidewalks and driveways shall be cleaned by means of shovels and hand brooms or appropriate mechanical equipment.

D. Dust on unsurfaced streets or parking areas and any remaining dust on surfaced streets shall be controlled with an approved dust palliative as directed by the Owner's Representative.

E. The Contractor shall comply with the above requirements on a daily basis. If the Contractor fails to perform the above work in a satisfactory manner, the Owner's Representative may stop all work, except cleanup operations, until the Contractor has satisfactorily complied with the above requirement.

3.2 WATER DISCHARGED TO DRAINS OR STREAMS

A. The Contractor shall construct and maintain filters, sedimentation traps, or stilling basins with overflows to clarify waters containing suspended materials from fill areas, excavations, deep wells, well points and disposal sites before discharging to drains or streams. Refer to Section 02222, Excavation, Compaction and Backfill for Utilities, for desilting requirements prior to disposal of dewatering water.

END OF SECTION 01568

SECTION 01730

OPERATING AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall submit technical operation and maintenance (O&M) information for each item of mechanical, electrical, and instrumentation equipment in an organized manner and in the Technical Specifications of the Contract Documents. O&M information, instructions, and data shall be provided for each maintainable material and piece of equipment. It shall be written so that it can be used and understood by the Owner's operation and maintenance staff.

B. Schedule: Except where indicated otherwise, technical O&M information shall be submitted in initial draft form to the Engineer not later than 90 days prior to any startup, system testing or operator training. Subsequent drafts shall be provided by the Contractor within 30 days from the date of Contractor's receipt of review comments from the Engineer. The approved Operation and Maintenance Manual must be available prior to any startup, system testing, or operator training.

C. Record Drawings: The Contractor shall maintain one set of Drawings at the Site for the preparation of record drawings. On these, it shall mark every project condition, location, configuration, and any other change or deviation which may differ from the Contract Drawings at the time of award, including buried or concealed construction and utility features that are revealed during the course of construction. Special attention shall be given to recording the horizontal and vertical location of buried utilities that differ from the locations indicated, or that were not indicated on the Contract Drawings. Said record drawings shall be supplemented by any detailed sketches as necessary or as Contractor is directed, to fully indicate the WORK as actually constructed. These record drawings are the Contractor's representation of as-built conditions, and shall be maintained up-to-date during the progress of the WORK. Using erasable colored pencils (not ink or indelible pencil), indicate in green when showing information deleted from the Drawings, red when showing information added to the Drawings, and blue and circled in blue to show notes. Notes shall identify relevant Change Orders by number and date. Preparation of record drawings shall conform to the following:

1. Date entries.
2. Call attention to entry by "cloud" drawn around area or areas affected.
3. Legibly mark to record actual changes made during construction, including, but not limited to:

    a. Horizontal and vertical locations of existing new Underground Facilities and appurtenances, and other underground structures, equipment, or WORK. Reference to at least two measurements to permanent surface improvements.
    b. Location of internal utilities and appurtenances concealed in the construction referenced to visible and accessible features of the structure.
    c. Locate existing facilities, piping, equipment, and items critical to the interface between physical conditions or construction and new construction.

d. Changes made by Addenda and Field Orders, Work Change Directives, Change Orders, Written Amendments, and Engineer's written interpretations and clarifications using consistent symbols for each and showing appropriate document tracking number.

4. Dimensions of Schematic Layouts: Show record drawings, by dimension, the centerline of each run of items such as are described in previous subparagraph above.

a. Clearly identify the item by accurate notation such as "cast iron drain," "galv. water," and the like.
b. Show, by symbol or note, vertical location of item ("under slab," "in ceiling plenum," "exposed", and the like.
c. Make identification so descriptive that it may be related reliably to Specifications.

1.2 QUALITY ASSURANCE

A. Preparation of data shall be done by personnel:

1. Trained and experienced in maintenance and operation of the described products.
2. Completely familiar with requirements of this Section.
3. Skilled as a technical writer to the extent required to communicate essential data.
4. Skilled as a draftsman competent to prepare required drawings.

1.3 FORM OF MANUALS

A. Format: Data to be provided in a series of 3 ring binders, each binder designated as a "Volume". Volumes to be numbered sequentially and organized in a systematic fashion. Should a volume contain multiple equipment sections, each section to be separated by a labeled index tab.

1. Identify each volume cover and spine with typed or printed title "Operating and Maintenance Instruction". List title of project and equipment contents as applicable.
2. Each volume to contain a complete table of contents for all volumes.

1.4 CONTENT OF MANUAL

A. List with each product, the name, address and telephone number of:

1. Subcontractor or installer.
2. Maintenance Contractor, as appropriate.
3. Identify the area of responsibility of each.
4. Local source of supply for parts and replacement.
5. Include only those sheets which are pertinent to the specific product.

B. Content, for each unit of equipment and system, as appropriate:

1. Description of unit and component parts.

a. Function, normal operating characteristics, and limiting conditions.

b. Performance curves, engineering data and tests.
c. Complete nomenclature and commercial number of all replaceable parts.

2. Operating procedures:

a. Startup, break-in, routine and normal operating instructions.
b. Regulation, control, stopping, shutdown and emergency instructions.
c. Summer and winter operating instructions.
d. Special operating instructions.

3. Maintenance procedures:

a. Routine operations.
b. Guide to "troubleshooting".
c. Disassembly, repair and reassembly.
d. Alignment, adjusting and checking.

4. Servicing and lubrication schedule:

a. List of lubricants required.

5. Manufacturer's printed operating and maintenance instructions.
6. Description of sequence of operation by control manufacturer.
7. Original manufacturer's parts list, illustrations, assembly drawings and diagrams required for maintenance.

a. Predicted life of parts subject to wear.
b. Items recommended to be stocked as spare parts.

8. As-installed control diagrams by controls manufacturer.
9. Each Contractor's coordination drawings.

a. As-installed color-coded piping diagrams.

10. Charts of valve tag numbers, with the location and function of each valve.
11. List of original manufacturer's spare parts, manufacturer's current prices, and recommended quantities to be maintained in storage.
12. Other data as required under pertinent sections of specifications.

C. Content, for each electric and electronic system, as appropriate.

1. Description of system and component parts.

a. Function, normal operating characteristics, and limiting conditions.
b. Performance curves, engineering data and tests.
c. Complete nomenclature and commercial number of replaceable parts.

2. Circuit directories of panelboards.

a. Electrical service.
b. Controls.

c. Communications.

3. As-installed color-coded wiring diagrams.
4. Operating procedures:

   a. Routine and normal operating instructions.
   b. Sequences required.
   c. Special operating instructions.

5. Maintenance procedures:

   a. Routine operations.
   b. Guide to "troubleshooting".
   c. Disassembly, repair and reassembly.
   d. Adjustment and checking.

6. Manufacturer's printed operating and maintenance instructions.
7. List of original manufacturer's spare parts, manufacturer's current prices, and recommended quantities to be maintained in storage.
8. Other data as required under pertinent sections of specifications.

D. Drawings

1. Supplement product data with drawings as necessary to clearly illustrate:

   a. Relations of component parts of equipment and systems.
   b. Control and flow diagrams.

2. Coordinate drawings with information in project record documents to assure correct illustration of completed installation.
3. Do not use project record documents as maintenance drawings.

E. Written text, as required to supplement product data for the particular installation.

1. Organize in a consistent format under separate headings for different procedures.
2. Provide a logical sequence of instruction for each procedure.

F. Copy of each warranty, bond and service contract issued.

1. Provide information sheet for City personnel, give:

   a. Proper procedures in the event of failure.
   b. Instances which might affect the validity of warranties or bonds.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 01730

SECTION 01756

TESTING, TRAINING, AND FACILITY START-UP

PART 1 - GENERAL

1.1 DEFINITIONS

A. Factory Testing: A test or tests conducted on an equipment item or system at the place of fabrication by the manufacturer.

B. Functional Test: A test or tests in the presence of the Engineer and Owner to demonstrate that the installed equipment or system meets manufacturer's installation and adjustment requirements and other requirements specified including, but not limited to, noise, vibration, alignment, speed, proper electrical and mechanical connections, operating temperature, thrust restraint, proper rotation, and initial servicing. Functional tests are typically performed on individual components of a system.

C. Startup Test Period:

1. Startup of the entire facility shall be considered complete when, in the opinion of the Engineer, the facility has operated in the manner intended for 10 continuous days without significant interruption. A significant interruption will require the startup then in progress to be stopped and restarted after corrections are made.

D. Significant Interruption: May include any of the following events:

1. Failure of Contractor to maintain qualified onsite startup personnel as scheduled.
2. Failure to meet specified performance for more than 4 consecutive hours.
3. Failure of any critical equipment unit, system, or subsystem that is not satisfactorily corrected within 4 hours after failure.
4. Failure of noncritical unit, system, or subsystem that is not satisfactorily corrected within 8 hours after failure.
5. As may be determined by Engineer.

E. A day is defined as 24 continuous hours unless noted otherwise.

1.2 SUBMITTALS

A. Action Submittals:

1. Equipment Supplier’s Certificate of Installation as required.
2. Test Reports: Functional and performance testing, in format acceptable to Engineer and certification of functional and performance test for each piece of equipment or system specified.
3. Certifications of Calibration: Testing equipment.
4. Record Drawings: Accurate and current markups of electrical record drawings.

B. Informational Submittals:

1. Factory Testing: Provide written notification at least 15 days prior to any factory testing.
2. Facility startup plan and schedule for project describing all procedures and showing all activities described or referenced herein. Submit at least 30 days prior to commencement of facility startup activities.
3. Provide detailed sub-network of Progress Schedule with the following activities identified:

    a. Manufacturer's services.
    b. Installation certifications.
    c. Operator training.
    d. Submission of Operation and Maintenance Manual.
    e. Functional testing.
    f. Performance testing.
    g. Operational testing.

4. Provide testing plan with test logs for each item of equipment and each system when specified. Include testing of alarms, control circuits, capacities, speeds, flows, pressures, sound levels, and other parameters.
5. Provide summary of shutdown requirements for existing systems which are necessary to complete start-up of new equipment and systems.
6. Revise and update start-up plan based upon review comments, actual progress, or to accommodate changes in the sequence of activities.

1.3 Contractor FACILITY STARTUP RESPONSIBILITIES

A. General:

1. Perform all Work for functional and performance test specified.
2. Demonstrate proper function of each component and feature of all equipment, systems, and control devices.
3. Complete all Work associated with the unit and related processes before testing, including related manufacturer's representative services.
4. Provide all related operations and maintenance manuals, and spare parts and special tools as specified before testing any unit or system.
5. Furnish qualified manufacturer's representatives when required to assist in testing.
6. Utilize the Equipment Supplier’s Certificate of Installation Form, supplemented as necessary, to document all functional and performance procedures, results, problems, and conclusions.
7. Prepare testing and startup plan and schedule and attend pretest meetings related to test schedule, plan of test, materials, chemicals, and liquids required, facilities' operations interface, and other required Engineer and Owner involvement.
8. Startup Coordinator. Designate and provide one person to be responsible for coordinating and expediting Contractor’s testing and startup duties. The person shall be present during all testing and startup meetings and shall be available at all times during the startup period. It is the Contractor’s responsibility to coordinate all work of vendors and subcontractors including, but not limited to, equipment suppliers and representatives, Process Instrumentation and Control System subcontractor, and electrical subcontractor. The Contractor shall ensure that all required work, testing, and documentation is

completed and submitted in a timely manner to allow for an integrated and organized approach to the startup effort.

9. Convey facility effluent water, as required, for testing.
10. Schedule time for field testing and adjustment of controls. Complete testing, training, and startup within Contract Time.
11. Allow realistic durations in Progress Scheduling for testing, training, and start-up.
12. Test equipment for proper performance at point of manufacture or assembly when specified.
13. When source quality control testing is specified:

    a. Demonstrate equipment meets specified performance requirements.
    b. Provide certified copies of test results.
    c. Do not ship equipment until certified copies have received written acceptance from Engineer. Written acceptance does not constitute final acceptance.
    d. Perform testing as specified in the equipment specification sections.

B. Startup Test Period:

1. As applicable to the equipment furnished, state in writing that all necessary hydraulic structures, piping systems, and valves have been successfully tested; that all necessary equipment systems and subsystems have been checked for proper installation, started, and successfully tested to indicate that they are all operational; that the systems and subsystems are capable of performing their intended functions; and that the facilities are ready for startup and intended operation.
2. Provide all temporary water pumping, piping, and other items as required for testing, unless otherwise indicated.
3. When facility startup has commenced, schedule remaining Work so as not to interfere with or delay the completion of facility startup. Support the startup activities with adequate staff to prevent delays or process upsets. This staff shall include, but not be limited to, major equipment and system manufacturers' representatives, subcontractors, electricians, instrumentation personnel, millwrights, pipefitters, and plumbers.
4. Supply and coordinate specified manufacturer's startup services.
5. Make adjustments, repairs, and corrections necessary to complete startup.

1.4 Owner/Engineer FACILITY STARTUP RESPONSIBILITIES

A. General:

1. Review Contractor's test plan and schedule.
2. Witness testing or review testing documentation.
3. Provide wastewater, power, chemicals, and other items as required for testing, unless otherwise indicated.

B. Startup Test Period:

1. Operate pump station with support of Contractor.
2. Designate and provide one person to be responsible for coordinating and expediting Owner and Engineer’s testing and startup duties.

1.5 CERTIFICATE OF PROPER INSTALLATION

A. At completion of Functional Testing, furnish written report prepared and signed by manufacturer's authorized representative, certifying equipment:

1. Has been properly installed, adjusted, aligned, and lubricated.
2. Is free of any stresses imposed by connecting piping or anchor bolts.
3. Is suitable for satisfactory full-time operation under full load conditions.
4. Controls, protective devices, instrumentation, and control panels furnished as part of the equipment package are properly installed, calibrated, and functioning.
5. Control logic for start-up, shutdown, sequencing, interlocks, and emergency shutdown have been tested and are properly functioning.

B. Furnish written report prepared and signed by the electrical and/or instrumentation Subcontractor certifying:

1. Motor control logic that resides in motor control centers, control panels, and circuit boards furnished by the electrical and/or instrumentation subcontractor has been calibrated and tested and is properly operating.
2. Control logic for equipment start-up, shutdown, sequencing, interlocks and emergency shutdown has been tested and is properly operating.
3. Co-sign the reports along with the manufacturer's representative and subcontractors.

1.6 TRAINING OF OWNER'S PERSONNEL

A. Provide operations and maintenance training for items of mechanical, electrical and instrumentation equipment. Utilize manufacturer's representatives to conduct training sessions.

B. Provide Operation and Maintenance Manual for specific pieces of equipment or systems 1 month prior to training session for that piece of equipment or system. Onsite training requirements are as follows:

Intake Screens – 4 hours
Drum Filters – 4 hours
UV Disinfection Equipment – 4 hours
Liquid Oxygen System – 4 hours
Flow Meter – 2 hours

C. Satisfactorily complete functional testing before beginning operator training.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 SEQUENCE OF FACILITY STARTUP ACTIVITIES

A. Complete all associated structural, mechanical, instrumentation, and electrical installations for system to be tested.

B. Startup Test Period: After successful completion of clean water testing, begin 10-consecutive-day Startup Test Period.

C. Achieve substantial completion of process system or subsystem by correcting or completing any remaining issues as identified by a process substantial completion list provided by the Engineer.

3.2 TESTING PREPARATION

A. General:

1. Schedule and attend pretest meetings related to test schedule, plan of test, materials, chemicals, and liquids required, facilities' operations interface, Engineer and Owner involvement.
2. Provide temporary valves, gauges, piping, test equipment and other materials and equipment required to conduct testing.

B. Cleaning and Checking: Prior to starting functional testing:

1. Calibrate testing equipment for accurate results.
2. Inspect and clean equipment, devices, connected piping, and structures so they are free of foreign material.
3. Lubricate equipment in accordance with manufacturer's instructions.
4. Turn rotating equipment by hand and check motor-driven equipment for correct rotation.
5. Open and close valves by hand and operate other devices to check for binding, interference, or improper functioning.
6. Check power supply to electric-powered equipment for correct voltage.
7. Adjust clearances and torques.
8. Complete piping system pressure testing and cleaning as specified in Division 15.
9. Obtain completion of applicable portions of Equipment Supplier’s Certificate of Installation.

C. Mechanical Systems: As specified in the individual equipment specification sections:

1. Remove rust preventatives and oils applied to protect equipment during construction.
2. Remove temporary supports, bracing, or other foreign objects installed to prevent damage during shipment, storage, and erection.
3. Check rotating machinery for correct direction of rotation and for freedom of moving parts before connecting driver.
4. Perform cold alignment and hot alignment to manufacturer's tolerances.

5. Inspect hand and motorized valves for proper adjustment. Tighten packing glands to insure no leakage, but permit valve stems to rotate without galling. Verify valve seats are positioned for proper flow direction.
6. Tighten leaking flanges or replace flange gasket. Inspect screwed joints for leakage.
7. Install gratings, safety chains, handrails, shaft guards, and sidewalks prior to operational testing.

D. Electrical Systems: As specified in Division 16 and the individual equipment specification sections.

1. Perform insulation resistance tests on wiring except 120 volt lighting, wiring, and control wiring inside electrical panels.
2. Perform continuity tests on grounding systems.
3. Test and set switchgear and circuit breaker relays for proper operation.
4. Check motors for actual full load amperage draw. Compare to nameplate value.

E. Instrumentation Systems: As specified in Division 17 and the individual equipment specification sections:

1. Bench or field calibrate instruments and make required adjustments and control point settings.
2. Energize transmitting and control signal systems, verify proper operation, ranges and settings.

F. Ready-to-test determination will be made by Engineer based at least on the following:

1. Notification by Contractor of equipment and system readiness for testing.
2. Acceptable testing plan.
3. Acceptable Operation and Maintenance Manuals.
4. Receipt of Equipment Supplier’s Certificate of Installation, if specified.
5. Adequate completion of Work adjacent to, or interfacing with, equipment to be tested.
6. Availability and acceptability of manufacturer's representative, when specified, to assist in testing of respective equipment, and satisfactory fulfillment of other specified manufacturers' responsibilities.
7. Equipment and electrical tagging complete.
8. All spare parts and special tools delivered to Owner.

3.3 FUNCTIONAL TESTING

A. After completion of Testing Preparation, begin testing at a time mutually agreed upon by the Owner, Engineer, and Contractor.

B. Engineer will be present during test. Notify in writing Owner, Engineer, and manufacturer’s representative(s) at least 10 days prior to scheduled date of functional tests.

C. Functionally test mechanical and electrical equipment, and instrumentation and controls systems for proper operation after general start-up and testing tasks have been completed.

D. Demonstrate proper rotation, alignment, speed, flow, pressure, vibration, sound level, adjustments, and calibration. Perform initial checks in the presence of and with the assistance of the manufacturer's representative.

E. Demonstrate proper operation of each instrument loop function including alarms, local and remote controls, instrumentation and other equipment functions. Generate signals with test equipment to simulate operating conditions in each control mode.

F. Conduct continuous 8-hour test under full load conditions. Replace parts that operate improperly.

G. Conduct functional tests as specified for each equipment item or system. Demonstrate correct function of all operational features and control functions.

H. If, in Engineer’s opinion, functional test results do not meet requirements specified, the systems will be considered as nonconforming.

I. The Startup Period testing shall not commence until the equipment or system meets the specified functional tests.

3.4 STARTUP TEST PERIOD

A. After successful completion of Functional Testing and submission of Test Reports identified below commence Startup Test Period. Startup of the entire facility shall be considered complete when, in the opinion of the Engineer, the facility or designated unit process has operated in the manner intended for 10 continuous days. A significant interruption will require the startup then in progress to be stopped and restarted after corrections are made.

B. Test Reports: As applicable to the equipment furnished, certify in writing that:

1. Hydraulic structures, piping systems, and valves have been successfully tested.
2. Equipment systems and subsystems have been checked for proper installation, started, and successfully tested to indicate that they are operational.
3. Systems and subsystems are capable of performing their intended functions.
4. Facilities are ready for intended operation. 5. Instrumentation and control systems, including all alarm systems, are completely tested, calibrated, and are fully functional.

C. Schedule and lead planning meetings and arrange for attendants by key major equipment manufacturer representatives as required by the Contract Documents.

3.5 CONTINUOUS OPERATIONS

A. Owner will accept equipment and systems as substantially complete and ready for continuous operation only after successful facility startup is completed and documented, and reports submitted, and manufacturers' services completed for training of Owner's personnel excluding post startup training.

3.6 SUPPLEMENTS

A. The supplements following “END OF SECTION,” are part of this Specification.

1. Startup and Performance Evaluation Form.
2. Equipment Supplier’s Certificate of Installation.
3. Electrical, Instrumentation and Control Startup Standard Procedures.

END OF SECTION 01756

SECTION 01756

SUPPLEMENT 1
STARTUP AND PERFORMANCE EVALUATION FORM

OWNER:_____ PROJECT: _____

Unit Process Description: (Include description and equipment number of all equipment and devices):

_____

_____

_____

_____

Startup Procedure (Describe procedure for sequential startup and evaluation, including valves be opened/closed, order of equipment startup, etc.):

_____

_____

_____

_____

Startup Requirements (Water, power, chemicals, etc.): _____

_____

_____

Evaluation Comments: _____

_____

_____

_____

CONTRACTOR Certification that Unit Process is capable of performing its intended function(s), including full automatic operation:

Firm Name: _____

Startup Representative: _____ Date:_____, 20____
(Authorized Signature)

SECTION 01756

SUPPLEMENT 2

EQUIPMENT SUPPLIER'S CERTIFICATE OF INSTALLATION

OWNER_____

PROJECT _____

CONTRACT NO._____

EQUIPMENT SPECIFICATION SECTION_____

EQUIPMENT DESCRIPTION_____

_____Authorized representative of
(Print Name)

_____
(Print Manufacturer's Name)

Hereby CERTIFY that _____
(Print Equipment Name and Model with Serial Number)

_____
installed for the subject project has (have) been installed in a satisfactory manner, has (have) been tested and adjusted, and is (are) ready for final acceptance testing and operation on:

Date:_____

Time:_____

CERTIFIED BY_____
(Signature of Manufacturer's Representative)

Date:_____, 20___

SECTION 02055

SITE DEMOLITION AND SALVAGE

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes all demolition, removal and/or abandonment of existing above and below grade structures and appurtenances as designated on the drawings or as necessary to clear space for new construction and/or to rehabilitate existing construction.

B. The work specified under this section includes but is not limited to the following:

1. Demolition of designated site structures and removal of materials from site.
2. Disconnecting and capping or removal of utilities.
3. Filling or removal of underground tanks and piping.
4. Filling voids in subgrade created as a result of removals or demolition.

C. The existing Intake Pump Station pumps and pump sump pumps shall be salvaged to the Owner.

1.2 SUBMITTALS

A. Submittals shall be in accordance with the requirements of these Contract Documents and shall include the following:

1. When the material and debris resulting from the Contractor's operations are disposed of at locations off the project, the Contractor shall obtain and submit written permission from the Owner of the property upon which the materials and debris is to be placed. Contractor shall provide executed copy of permit to dispose of waste materials from appropriate jurisdictions.
2. An accurate record of actual locations of all existing utilities and subsurface obstructions which are to remain in place shall be submitted to the Owner's Representative prior to final acceptance of the project.
3. Demolition and equipment removal procedures at the site shall be submitted for review and approval by the Owner's Representative. The procedures shall provide for careful removal of materials and equipment and the protection of facilities that are to remain undisturbed.
4. A time schedule for all demolition work. The schedule shall show demolition in relation to new construction, including any temporary facilities. The demolition and procedures schedule shall be submitted in accordance with Section 01300.

1.3 COORDINATION AND CONTROL

A. The Contractor shall:

1. Conform to all Federal, State and local laws and regulations for demolition, safety of adjacent facilities, dust control, runoff control, and disposal.
2. Obtain all required permits and licenses and pay all associated fees including disposal charges.
3. Notify affected utility companies before starting work and comply with their requirements.

B. Contractor shall:

1. Not close or obstruct roadways or fire hydrants without permits.
2. Conform to applicable regulatory procedures when discovering hazardous or contaminated materials.

1.4 JOB CONDITIONS

A. Structures to be demolished shall be discontinued in use and vacated prior to start of demolition work.

B. The Owner assumes no responsibility for actual condition of the facilities or structures to be demolished. Prior to the submittal of bid, the Contractor shall visit the site and inspect all facilities to become familiarized with all existing conditions and utilities and to verify the correctness of the drawings.

C. Conditions existing at time of inspection for bidding purposes will be maintained by Owner in so far as practicable. Variations within structures may occur by Owner's removal and salvage operations prior to start of demolition work.

D. Items of value to Contractor (which are not designated by the Owner to be salvaged and delivered to the Owner) are to be removed from the site by the Contractor. Storage or sale of removed items will not be permitted on site and shall not interfere with any other work specified in the Contract Documents.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL

A. The Contract Drawings identify the major equipment and facilities to be removed. Auxiliary utilities such as water, air, drainage, lubrication oil, electrical wiring, controls, and instrumentation are not necessarily shown. These auxiliary utilities, as well as all equipment and pipe supports and all associated instrumentation devices pertaining to piping or equipment designated to be removed shall be removed.

B. Unless otherwise specified, the Contractor shall demolish and remove below grade construction and concrete slabs on grade to a minimum depth of two (2) feet below proposed subgrade.

C. Unless otherwise shown or specified, excavation resulting from demolition and removal operations shall be backfilled with clean earth or crushed gravel and compacted to ninety five percent (95%) of maximum dry density per AASHTO T-180. Burial of debris shall be prohibited unless otherwise shown or directed.

D. Excavated areas shall be graded to adjacent existing levels and left smooth, clean, free draining and free of debris as approved by the Owner's Representative.

E. Contractor shall conform to all Federal, State and local laws when abandoning wells, septic tanks and fuel tanks.

F. Existing structures and equipment which are damaged in appearance and/or function by performance of demolition work shall be replaced or repaired to Owner's Representative approved condition by the Contractor at no additional cost to the Owner.

3.2 PROTECTION OF EXISTING FACILITIES

A. Contractor shall provide, erect, and maintain temporary barriers and protection as necessary.

B. Existing landscaping materials, appurtenances and structures that are not to be demolished shall be protected from damage. Damage caused by demolition operations shall be replaced or repaired at no additional cost to Owner.

C. Contractor shall provide bracing and shoring as required to prevent movement or settlement of adjacent structures. Bracing and shoring shall be Contractor's design.

D. The location of all utilities shall be marked prior to demolition. Contractor shall protect and maintain in safe and operable condition the utilities to remain, and prevent interruption of existing utility service except when authorized in writing by authorities having jurisdiction. Provide temporary services during interruptions to existing utilities as acceptable to governing authorities.

E. Contractor shall clean adjacent structures and improvements of dust, dirt, and debris caused by demolition operations. Return adjacent areas to conditions existing prior to the start of the work.

F. During demolition, Contractor shall conform to all Federal, State and local laws and regulations for erosion and pollution control.

3.3 CONDUIT AND WIRING

A. All disconnected unused wiring shall be removed from the conduits back to their source and any remaining unused conduit shall be capped at a convenient location.

3.4 STRUCTURES

A. Unless otherwise noted on the drawings, existing manholes and similar structures designated to be removed shall be completely removed unless otherwise noted on the drawings.

B. Structures designated to be abandoned shall be removed to an elevation of at least four (4) feet below ground surface or two (2) feet below the finished subgrade, whichever is greater. The remaining void shall be filled with granular backfill material compacted to ninety five percent (95%) of maximum dry density per AASHTO T180.

C. Care shall be used in demolishing structural elements that are continuous with structural elements remaining in service. Unless otherwise permitted by the Owner's Representative, concrete and masonry shall be cut through entirely with a masonry or concrete saw before removing the unwanted portions.

D. Methods and equipment used in demolition work shall be chosen so the structural integrity and watertightness of both newly constructed and existing structures remain unimpaired by the performance of the demolition work.

E. Portions of underground structures that are in the way of new piping, and structures shall be removed from the area of conflict to a distance not less than twelve (12) inches from any closest point on the new construction.

F. Extreme care shall be used when removing existing concrete from around reinforcing steel that must be used for securing new concrete. If the reinforcing steel is damaged, the Contractor shall remove additional existing concrete until sufficient existing reinforcing steel is exposed to provide adequate embedment length in the new concrete, as approved by the Owner's Representative.

G. The Contractor shall replace, at no cost to the Owner, materials lost or damaged by negligence or by the use of improper methods.

3.5 EQUIPMENT REMOVAL

A. All equipment, valves, piping, fittings and miscellaneous steel structures that are removed shall become the property of the Contractor unless otherwise designated by the Owner.

3.6 DISPOSAL OF DEBRIS

A. Contractor shall not allow debris and/or excess material to accumulate. All debris shall be hauled away from the site as soon as removed.

B. All debris resulting from demolition operations (i.e. broken concrete, masonry, pipe, miscellaneous metal, trees and brush, etc., as well as mechanical and electrical equipment not designated by the City for salvage) shall be trucked from the work site by the Contractor and disposed of at spoil sites in a legal manner, in full compliance with all Federal, State and local laws and regulations.

C. The Contractor shall police the hauling of debris to ensure that all spillage from trucks is promptly and completely removed and cleaned up.

D. During and upon completion of the demolition and salvage operations, the Contractor shall promptly remove unused tools and equipment, surplus materials, rubbish, debris, and dust and shall leave work areas in a clean condition.

E. The Contractor shall not sweep, grade, or flush surplus materials, rubbish, or debris into storm drains, channels, lakes, or streams.

3.7 MAINTENANCE OF OWNER'S OPERATIONS

A. Demolition shall be scheduled and performed in strict conformance with these Specifications and in a manner which results in no interruption of Owner's normal operations beyond that provided for and approved by the Owner. The date and time of commencing the separate items of demolition work shall be submitted to the Owner's Representative for review, and no demolition work shall commence until the Owner's Representative's approval of date and time is given.

B. All equipment, labor and material costs which are made necessary by the requirements of the Contractor's sequence of operations shall be borne by the Contractor.

3.8 USE OF EXPLOSIVES

A. The use of explosives for the work of removal of structures and obstructions is prohibited.

END OF SECTION 02055

SECTION 02221

EARTHWORK

PART 1 - GENERAL

1.1 SUMMARY

A. The work covered in this section consists of structural excavation and backfill and testing necessary to construct this project as shown on the Drawings or as specified. No borrow sources or disposal sites have been designated for this project unless indicated otherwise in the general provisions.

1.2 SUBMITTALS

A. Submittals are required on all materials. The submittals shall be made at least 5 working days prior to the time the material is required for use.

1.3 REFERENCE STANDARDS

A. American Society for Testing and Material (ASTM).

B. Standard Specifications for Construction, 2015, prepared by the California State Department of Transportation.

1.4 PROTECTION OF EXISTING FACILITIES

A. Protection of the public, adjacent facilities, contractor’s personnel is the responsibility of the Contractor. Where open cuts are used the excavation slopes shall meet applicable OSHA requirements. Additionally, temporary slopes shall be no steeper than 1 vertical to 1.5 horizontal and permanent slopes shall be no steeper than 1 vertical to 2 horizontal. Cover exposed slopes if erosion threatens.

PART 2 - PRODUCTS

2.1 STRUCTURAL FILL

A. Fill for structural embankments may be made of any material from site excavation, excepting mud, silt and clays too wet to compact, organic soils, organic debris, stone and pieces of inorganic waste whose greatest dimension does not allow complete compaction of the material. No stone over 3-inches in any dimension shall be allowed in the embankment. No stone with broken or sharp faces shall be allowed in the embankment. Layered materials shall be processed so as to achieve a blending of dissimilar materials in the fill. In cases where the quality or

quantity of material on the site is not sufficient to form the embankment, imported borrow material shall be furnished by the Contractor. The material shall be capable of being compacted by conventional methods without weaving and heaving to a maximum dry density of 95 percent as determined by ASTM D 698.

B. Excess unusable material shall be removed and disposed of offsite.

C. Imported borrow material used for embankment fill shall be material meeting the requirements of Paragraph A in addition to the following: a minimum of 10% of the material shall pass the No. 40 sieve and a minimum of 50% of the material shall be larger than the No. 40 sieve. Pit "reject" material meeting these requirements is acceptable.

D. Engineer reserves the right to control the areas excavated and the placing of embankment materials to ensure the most satisfactory construction.

E. Excavation Material. The Contractor shall make his own deductions and conclusions as to the nature of the materials to be excavated and the difficulties that may arise from subsurface conditions.

2.2 CRUSHED BASE ROCK

A. Material shall be 3/4 –inch Class 2 Aggregate Base in accordance with Section 26 of the Caltrans Standard Specifications.

2.3 STABILIZATION ROCK

A. Stabilization rock shall consist of ±1 to 4-inch minus well-graded crushed, angular gravel or rock with no more than ±15% passing the #40 U.S. Sieve.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clearing and grubbing: Remove trees, shrubs, brush, topsoil and organic soils exposed in excavations within the limits of the fill placement. Properly protect trees and shrubs which are not to be cut, from damage. Remove stumps entirely. Grub out roots and matted roots to at least 18 inches below the existing surface; grub all surface vegetation and roots from beneath the building or fill area for a distance of five feet beyond the building perimeter, and beneath paving or fill area. Dispose of brush, refuse, stumps, roots, and unmerchantable timber off site. All clearing to be done mechanically; no spraying shall be allowed. Topsoil, suitable for landscaping operations, may be stockpiled for future use at a location approved by the Engineer.

B. Stripping in embankment, paved or gravel surfaced areas or beneath structures shall consist of removing near surface plants, root matter, top soil and other organics.

C. Low-lying areas shall be drained prior to placing fill.

D. Refuse from the clearing and grubbing operations shall be removed from the site within 10 days of the clearing and grubbing operations, or as directed by the Engineer. Disposal shall be the responsibility of the Contractor and shall be in accordance with applicable ordinances and environmental requirements.

E. The Contractor shall protect moisture sensitive material to be used as fill or to serve as a base for fill or foundations. The Contractor shall replace materials made unsuitable by moisture with imported borrow material at no cost to the Owner.

F. Protection of adjacent work must be accomplished. Properly slope cuts to provide stability. Temporary cuts should be no steeper than one vertical to one horizontal. Permanent slopes should be no steeper than one vertical to two horizontal. Cover exposed slopes if erosion or raveling threatens.

G. Stockpiling of Excavated Materials. The Contractor may not have sufficient area on site to stockpile excavated material that will be required for fill or topsoil later in the project. If additional stockpile area required to complete the Project on schedule, the Contractor will arrange off site stockpile areas. No additional payments will be made for stockpiling excavated materials off site. Stripping and stockpiling of reusable materials shall be carefully segregated into well defined stockpiles.

3.2 PREPARATION OF SUBGRADE

A. After stripping and excavating to final grades, but before any new fill is installed, all building, pavement and fill areas shall be inspected by the Engineer. If the material is loose, wet or does not meet the requirements for placement of the fill material the surface shall be scarified to a depth of at least eight inches. The scarified soil should be aerated as necessary and then compacted to at least 95% relative compaction (ASTM D 698). Soft or wet areas that cannot be effectively dried and compacted shall have all unsuitable material removed, replaced with fill material in accordance with these specifications.

3.3 EMBANKMENT CONSTRUCTION

A. Grub areas of roots, buried vegetable matter and debris in accordance with paragraph 3.1.

B. Pump standing water from low areas to receive embankment construction.

C. Sprinkle and aerate fill materials as required.

D. Embankment Construction

1. Constructed to the lines, grades and cross-section shown on the plans.

2. Build by mechanical excavating and hauling equipment.

3. Compacted in horizontal layers not to exceed ten (10) inches.

4. Regardless of method used, fill shall be carried approximately level across entire to be filled.

5. Fill shall be brought out to required slope width.

6. Use of loose material to widen fill areas will not be permitted.

7. Areas found to be inadequate width at any time shall be removed and replaced to proper width.

8. Slopes of fill areas shall be bladed and dressed to cross-sections shown on plans.

3.4 COMPACTION

A. Contractor shall provide compaction equipment as required to do the compaction specified herein.

B. Fill shall be compacted for their full depth, length and width to at least 95% of ASTM D 698.

C. Tests for density of compacted material shall be made by the Contractor as specified in 3.7. This frequency may be increased at the option of the engineer if tests fail. Deficiencies shall be corrected by the Contractor at the Contractors expense.

D. Testing shall be done at expense of Contractor.

E. No additional compensation will be made for evacuating standing water from embankment areas prior to fill placement, for evacuating water from the bottom of any structures during and after embankment liner or fill placement, or for the hauling and disposing of waste material or wasting unsuitable material.

3.5 EXCAVATION BELOW GRADE

A. Excavation Material. The Contractor shall make his own deductions and conclusions as to the nature of the materials to be excavated and the difficulties that may arise from subsurface conditions

B. Excavate at least 12-inches below the base of structure to provide for base stabilization. Place and compact a clean, free-draining, angular crushed base rock. Compact with light hand-operated equipment to reduce disturbance of the subgrade. Compact all fill to a minimum of 95% of maximum dry density per ASTM D698.

C. Unless otherwise specified, any appropriate method of excavation within the work limits shown may be employed which, in the opinion of the Contractor, is considered best, and meets applicable safety standards. The Contractor shall take whatever precautions are necessary to maintain the undisturbed state of the natural soils at and below the bottom of the excavation.

D. Where, in the opinion of the Engineer, the undisturbed condition of the natural soils below the excavation grades indicated or specified is inadequate to meet the specified compaction or maximum dry density, the Contractor shall overexcavate to adequate supporting soils and refill the excavated space to the proper elevation in accordance with the procedure specified for backfill. If the excavation exceeds by more than 1 foot the elevations shown on the drawings or

identified in the soils investigation, then the excess will be paid for as extra work in accordance with the general conditions.

E. Should the excavation be carried below the lines and grades indicated on the drawings or specified herein because of the Contractor's operations, the Contractor shall refill such excavated space to the proper elevation as directed by the Engineer. Should foundation materials be disturbed or loosened because of the Contractor's operations, they shall be removed and the space refilled as directed at no additional cost to the Owner.

3.6 DISPOSAL OF EXCAVATED MATERIAL

A. Disposal shall comply with all Local, State and Federal requirements.

3.7 TESTING

A. The Contractor shall test for compaction in accordance with Caltrans CTM 231.

B. Testing frequency

1. For areas less than 1,000 square yards, perform a minimum of three density tests. This includes three tests of the aggregate base below all individual structures including buildings, tanks, slabs, manholes and vaults.

2. For areas greater than 1,000 square yards, select a minimum of five nonbiased test sites. No test may represent more than 2,000 square yards.

C. In the event that the original tests do not comply with the requirements of the specifications, additional compaction shall be performed or the fill shall be replaced with fill that does comply.

D. Material not meeting the compaction requirements shall be made to meet the requirements prior to any additional fill placed in the area not meeting the requirements.

END OF SECTION 02220

SECTION 02222

EXCAVATING, BACKFILLING AND COMPACTING FOR UTILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. The work covered in this section includes but is not limited to site inspection, utility location, unclassified excavation, dewatering, shoring, bedding, backfilling, compacting, grading, cleaning and testing of utility trenches for pipes and structures.

1.2 LABOR AND SAFETY STANDARDS

A. All work to be done in accordance with these specifications and the requirements of Cal/OSHA.

1.3 REFERENCE STANDARDS

A. American Society for Testing and Material (ASTM).

B. Standard Specifications for Construction, 2015, prepared by the California State Department of Transportation.

1.4 SUBMITTALS

A. Before excavation, Contractor shall submit dewatering plans. The dewatering plan shall in accordance with specified erosion control requirements, and state and federal requirements. The dewatering plan shall also include provisions for desilting prior to release.

B. Submit material gradation and proctor test results of proposed fill materials prior to their use on site.

1.5 PROJECT CONDITIONS

A. Protection: Protect the opened trench and open pipe end against the intrusion of water and soil when stopping work for the day.

B. Notify all affected utilities at least 48 hours in advance of actual excavation.

C. Field locate all existing utilities prior to beginning construction.

PART 2 - PRODUCTS

2.1 CRUSHED BASE ROCK

Material shall be 3/4 –inch Class 2 Aggregate Base in accordance with Section 26 of the Standard Specifications. The material shall be capable of being compacted by conventional methods without undue weaving and heaving to a maximum dry density of 95 percent as determined by ASTM D 698.

2.2 STRUCTURAL FILL

A. Native or imported material meeting the requirements of paragraph 2.1 of SECTION 02221 - EARTHWORK.

2.3 NATIVE BACKFILL MATERIAL

A. Native backfill may consist of native excavated material excepting mud, silt and clays too wet to compact, organic soils, organic debris, stone and pieces of inorganic waste whose greatest dimension does not allow complete compaction of the material. No stone over 3 inches in any dimension shall be allowed. No stone with broken or sharp faces shall be allowed in the backfill where placed against pipes, structures, near the surface or other vulnerable objects.

2.4 FOUNDATION STABILIZATION

A. Stabilization rock shall consist of ±1 to 4-inch minus well-graded crushed, angular gravel or rock with no more than ±15% passing the #40 U.S. Sieve.

PART 3 - EXECUTION

3.1 SITE INSPECTION AND UTILITY LOCATION

A. The Contractor shall inspect the site before starting work. The documents shall be examined and checked with the field layout to correct any and all discrepancies which may exist.

1. The general location of all known underground utilities and other property likely to be encountered in excavation has been shown on the plans. This data has been compiled from the best available sources but is to be used for informational purposes only and accuracy is not guaranteed. The Contractor shall be responsible for contacting and working with the Owner of the particular utility or property involved to determine its exact location during construction. The Owner of the utility shall repair all damage to existing facilities at the Contractors expense. Adequate provisions shall be made for maintaining the flow of existing drains and water courses encountered during construction.
2. All costs to rectify conflicts due to failure to verify possible conflicts, shall be the Contractor's responsibility.

3.2 EXCAVATION AND TRENCHING

A. The Contractor shall do all excavation of whatever substance is encountered to the lines and grades required. Where unexpected objects, such as stumps, railroad ties, buried pavement, and the like, are encountered in the trench excavation, they shall be removed and disposed of by the Contractor. In cases where they can be removed by the same equipment or method at hand for excavation, and where it is unnecessary to employ special equipment, install shoring or bracing, or to increase the trench width or depth more than 2 feet for any one object, then in that event the removal of such obstructions shall be considered as an incidental part of the Contractor's work and no additional payment will be made therefore. Except where specifically approved by the Engineer, no more than 100 feet of open trench shall be excavated in advance of laying of pipe.

1. Excavation dimensions and trench sections: The bottom of the trench shall be carried to the lines and grades required with proper allowance for thickness of pipe, manhole, or structure, floor and bedding used. Trench walls shall be vertical from the trench bottom to at least 6 inches above the top of the pipe. Trench bottom width shall be as shown on the drawings. In all cases, trench must be of sufficient width to permit proper jointing of the pipe and backfilling and compacting of material along the sides of the pipe. Trench width at the surface of the ground shall be kept to the minimum amount necessary to install the pipe in a safe manner using boxes, shoring, sheeting or other means that may be necessary. Excavation for manholes and other structures shall provide a minimum of 12 inches between their surfaces and the sides of the excavation.

2. Except where removal of unsuitable material is authorized by the Engineer, trench excavation beyond the limits authorized in plans and specifications and any additional costs associated with the excess excavation shall be at the Contractor's expense. Additional costs may include but are not limited to additional and/or higher quality bedding, heavier pipe, additional backfill, and additional surface restoration costs.

B. Excavation support system shall be designed, fabricated, installed, maintained, and removed in such a manner as to protect workers, the required excavation section, existing property, structures, utilities, pavements, and the like, and to maintain the undisturbed state of soils adjacent to excavation and at and below the excavation bottom. Support systems shall also be adequate to support static and dynamic loads incident to structures, traffic and construction activity adjacent and proximate to the work. If the Contractor elects he may use a combination of shoring, tunneling, boring, sliding trench shields or other methods of accomplishing the work provided the method meets with the approval of all applicable local, state and federal safety codes.

C. The Contractor shall be solely responsible to determine the nature and extent of excavation support required in any and all portions of the project, and any damage resulting from inadequate excavation support shall be restored at the expense of the Contractor.

D. That portion of the excavation support system extending below the springline of rigid pipe, or below the crown elevation of flexible pipe, shall be left in place unless satisfactory means of recompacted bedding or side support, disturbed by support system removal, can be demonstrated. If a movable box is used in lieu of cribbing or sheeting, and the bottom cannot be kept above the springline of rigid pipe or the crown elevation of flexible pipe, the bedding or side support shall be carefully recompacted behind the movable box, prior to placing backfill.

E. Temporary storage of excavated materials: All excavated material shall be piled in an orderly manner at a sufficient distance (per state and federal requirements) from the trench to prevent overloading, sliding into the trench, or other occurrences which could endanger the excavation. Material shall be placed in such a manner as will cause minimum inconvenience to public travel, will provide unrestricted access to fire hydrants, water meters, and the like, and will not impede the flow in natural and man-made drainage courses and/or structures.

3.3 DEWATERING

A. The Contractor shall furnish, install and operate all necessary machinery appliances and equipment to keep excavations free from water during construction, and shall dewater and dispose of the water so as not to cause injury to public or private property or to cause a nuisance or a menace to the public. Contractor shall at all times have on hand sufficient pumping equipment and machinery in good working condition for all ordinary emergencies including power outage, and shall have available at all times competent personnel for the operation of the pumping equipment. The dewatering system shall not be shut down between shifts, on holidays, or weekends, or during work stoppages without written permission from the Engineer.

B. The Contractor shall be responsible for all costs of the temporary service.

C. The control of ground water shall be such that softening of the bottom of excavations, or formation of "quick" conditions or "boils" during excavation shall be prevented. Dewatering systems shall be designed and operated so as to prevent removal of the natural soils.

D. During excavating, construction of structures, installation of pipelines, placing of structure and trench backfill and the placing and setting of concrete, excavations shall be kept free of water. The Contractor shall control surface runoff so as to prevent entry to, and collection of, water in excavations.

E. The static water level shall be drawn down a minimum of two feet below the bottom of the excavation so as to maintain the undisturbed state of the foundation soils and allow the placement of any fill or backfill to the required density. The dewatering system shall be installed and operated so that the groundwater level outside the excavation is not reduced to the extent that would damage or endanger adjacent structures or property.

F. Before dewatering is started, the Contractor shall submit for review by the Engineer for the method, installation and details of the dewatering and desilting system he proposes to use. This submittal is for record purposes only and shall not be construed as a detailed analysis for adequacy of the dewatering system, nor shall it be construed as relieving the Contractor of his overall liability and responsibility for the work. If the submitted plan does not control the groundwater as required herein the Contractor shall make all necessary modifications to control groundwater as required. All costs associated with the modifications to the dewatering system to comply with the requirements shall be borne by the Contractor.

G. The release of groundwater to its static level shall be performed in such a manner as to maintain the undisturbed state of the natural foundation soils, prevent disturbance of compacted backfill and prevent flotation or movement of structures and pipelines.

H. The Contractor shall construct and maintain subgrade ditches and temporary and permanent pipes required during the construction period as necessary to provide drainage of the site to

permit continuous progress of, or to prevent damage to, his work or the work of others. Grading operations shall be conducted in a manner which will prevent surface or groundwaters from carrying silt into the ditch system. Temporary settling lagoons shall be constructed to collect runoff and settle out silt particles before the water is allowed to enter the ditch system. All costs involved in the control of site drainage during construction shall be included in and incidental to the cost of the project.

I. Desilting: Water from dewatering operations shall be desilted before discharging to surface waters outside of the construction area. The Contractor shall not discharge water from the excavation directly to a receiving stream. The size of the desilting facility will be adequate to allow discharge of the water to the receiving stream in such a way and of a quality as to not violate any laws or regulations. The Contractor shall be responsible for maintaining the desilting facility so that continuous adequate operation is assured. The Contractor shall obtain review of his method from the Engineer before proceeding with any dewatering. In addition, approval is required as to the exact location for any contemplated pump discharge areas.

3.4 UNSUITABLE MATERIAL REMOVAL AND REPLACEMENT

A. Unsuitable materials include but are not limited to peat, soils with high organic content, and other soft, loose, saturated, and/or disturbed soils. Removal of unsuitable material below the trench bottom shall not be authorized without prior approval of the Engineer.

B. When unsuitable material is encountered at or below the trench bottom, it shall be excavated to a depth specified by the Engineer and backfilled with stabilization material. The material shall be placed in lifts of 8 inches maximum thickness. Each layer shall be fully compacted prior to placement of subsequent layers. The Engineer reserves the right to specify an alternate trench section in lieu of the over-excavation procedure described above.

C. Unsuitable material shall be disposed of by the Contractor within 5 working days of the time of excavation, except in or adjacent to roadways or other improved areas where it shall be disposed of within 24 hours of excavation.

3.5 BEDDING

A. Bedding material shall consist of crushed base rock.

B. Bedding material shall be placed after the bottom of the trench or excavation has been excavated to the proper depth and grade and the bottom is brought to a reasonably flat surface and dewatered. Bedding under manholes and pipe shall be placed to uniformly support the entire bottom of the manhole or pipe.

C. During bedding operations, all necessary measures shall be taken to prevent damage to the pipe and to maintain the pipe within the line and grade tolerances specified in the Caltrans Standard Specifications. Bedding shall be placed in loose lifts of 6-inch maximum depth and compacted to at least 95% of the maximum dry density as determined by ASTM D698. Each layer shall be fully compacted before subsequent layers are placed. Bedding shall be placed, compacted, and shaped to conform to the barrel of the pipe, with allowance for bells and other appurtenances, to ensure firm and continuous support for the entire length of pipe. Additional bedding required

because of unauthorized excavation outside the specified limits shall be provided at the Contractor's expenses.

D. Bedding shall be handled and placed in the trench or excavation in such a manner as to prevent cave-in of trench or excavation walls or contamination with excavated material. Bedding that becomes contaminated by these or similar occurrences such that it contains prohibited substances or does not meet gradation requirements, shall be removed, disposed of, and replaced by the Contractor at his own expense.

3.6 PIPE ZONE BACKFILL

A. Pipe zone backfill material shall be either structural fill or crushed base rock.

B. Pipe zone backfill shall be placed after the pipe has been installed, alignment and grade checked and the inside checked for possible obstructions. Place the pipe zone backfill carefully to prevent damage to the pipe. Ensure the pipe zone backfill is in contact with the entire periphery of the pipe.

C. Pipe zone backfill shall be placed in loose lifts with a maximum thickness of 6 inches and compacted to at least 95% of the dry density as determined by ASTM D 698. Side fill shall be brought up evenly on both sides of the pipe to prevent lateral movement. Each lift shall be fully compacted before subsequent fill is placed

3.7 TRENCH BACKFILL

A. Trench backfill materials

1. Within 10 feet of structures and in areas subject to vehicular traffic: material shall be structural fill or crushed base rock compacted to at least 95% of the dry density as determined by ASTM D 698.

2. Unimproved areas not subject to vehicular traffic: material shall be native backfill material or structural fill compacted to at least 90% of the dry density as determined by ASTM D 698.

B. Trench backfill shall be placed in loose lifts of 10 inches maximum thickness and compacted as specified.

C. All backfill and compaction operations shall be completed in the same day as excavation.

3.8 FINAL TRIMMING, CLEANUP, AND REPAIR

A. Final trimming, cleanup, and repair shall include but is not limited to the following: grading, cleaning, disposal of excess excavated material including rock and pavement, and repair of utilities, structures, culverts, pavements, and private property damaged or disturbed by the Contractor during construction or associated activities.

B. All irregularities shall be made smooth, washouts shall be filled, slopes made uniform, slightly rounded at top and bot-tom, and the entire area of the fill compacted and completed to the required lines, grades, and cross sections. Erosion control devices shall be installed as specified.

C. The Contractor shall clean up as the work progresses, and shall maintain his operations in a neat and orderly manner. Surplus excavated material, stumps, trees, brush, excavated rock, unsuitable material and other debris shall be disposed of promptly. Roadway surfaces shall be thoroughly cleaned.

D. Water service, sewer lines, sanitary service laterals and culverts which are unearthed, undermined, or damaged as a result of the Contractor's operations shall be repaired or, if necessary, replaced by the Contractor at his own expense. The Contractor shall notify the Engineer of each water or sewer line and its location. The Contractor shall repair all damage and complete the repair immediately if leakage of water or sewage is occurring. Upon completion of the repair, the Engineer shall be notified and shall inspect the repair prior to backfilling. Reconnection to an existing water main or service shall be made only at times that the Engineer is present, unless otherwise specified.

E. Unless specified otherwise, all trimming, cleanup, and re-pair shall be accomplished within 10 working days from the time that the trench was initially excavated.

F. If the Contractor fails to comply with these requirements within 24 hours after receiving written notice from the Engineer, others will be engaged to do such work and the total expense involved shall be deducted from the Contractor's payment.

3.9 TESTING

A. The Contractor shall furnish and pay for density tests showing compliance with the requirements of the specifications and drawings.

B. Density tests shall be performed for every 300 feet of trench. One of every three tests shall be below half trench depth. Tests shall be performed locations selected by the Owner’s site representative. See Section 01400, Quality Control, for additional testing requirements.

C. In the event the original tests do not comply with the requirements of the specifications, additional compaction shall be performed or the fill shall be replaced with fill that will comply. Additional tests for the repaired areas shall be paid for by the Contractor, for either the fill or the tests. This process shall be repeated until the compaction complies with the specifications.

END OF SECTION 02222

SECTION 02270

EROSION CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. The work included in this section consists of construction of temporary erosion control measures as specified and as shown on the Drawings.

1.2 SUBMITTALS

A. The Contractor shall submit manufacturer's data on all products to the Engineer prior to ordering materials.

PART 2 - PRODUCTS

2.1 SILT FENCE

A. The temporary silt fence system shall be the "Envirofence" silt fence system manufactured by Mirafi, Inc., or equal.

2.2 WATTLES

A. Compost sock shall be FilterSoxx, manufactured by Filtrexx International LLC, or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

A. All erosion control products and materials will be installed and maintained in accordance with Section 21 of the Caltrans Standard Specifications, the manufacturer's recommendations and as shown on the plans.

B. All sediment barriers shall remain in place until completion of the project, at which time they shall be removed by the Contractor.

END OF SECTION 02270

SECTION 02510

SURFACE RESTORATION

PART 1 - GENERAL

1.1 SUMMARY

A. The work covered by the section consists of surface restoration for utility and structure excavation.

1.2 REFERENCE STANDARDS

A. American Society for Testing and Material (ASTM).

B. Standard Specifications for Construction, 2015, prepared by the California State Department of Transportation.

1.3 SUBMITTALS

A. Submit material gradation and proctor test results of proposed aggregates prior to their use on site.

PART 2 - PRODUCTS

2.1 AGGREGATE SURFACE COURSE

A. Material shall be 3/4 –inch Class 2 Aggregate Base in accordance with Section 26 of the Standard Specifications.

2.2 SEED

A. Disturbed areas shall be hydroseeded in accordance with Section 21 of the Standard Specifications.

PART 3 - INSTALLATION

3.1 CRUSHED ROCK RESTORATION

A. All graveled roadways, graveled shoulders, graveled driveways, areas shown on the Drawings, or as required by the Engineer shall be restored using crushed rock as shown on the Drawings.

1. Surfacing shall have a compacted depth as shown on the Drawings. Compaction shall be to 95% of ASTM D 698.
2. Material shall be placed on undisturbed subgrade.
3. The finished surface shall be smooth and level with the surrounding surfacing.
4. Settlement of 1/2-inch or greater in graveled areas within one year of completion will require repair and regrading as directed by the Engineer at the Contractor's expense.

3.2 SOIL STERILIZATION

A. Soil sterilization shall be provided under all surface areas.

B. Soil sterilant shall be applied on all compacted subgrades just prior to placing the import gravel base material.

C. The sterilant shall be a borate chlorate type containing not less than 25% sodium chlorate. It shall be mixed thoroughly with water at the rate of 1-1/2 pounds of sterilant per gallon of water. The sterilant shall be applied evenly at the rate of 0.2 gallons per square yard. The Contractor shall take whatever precautions are necessary to prevent contamination of adjacent soil areas with sterilant and for the protection of personnel. Certification shall be furnished if requested to the Engineer, showing the purchase receipt and rate of application of the material.

3.3 HYDRO SEEDING

A. Disturbed areas shall be hydroseeded in accordance with Section 21 of the Standard Specifications.

3.4 TESTING

A. Compaction testing of rock surfacing shall be done every 300 square yards of surface area, or fraction thereof.

B. All testing reports shall be furnished and certified by a certified testing laboratory; see Section 01400 or the General Provisions.

END OF SECTION 02510

SECTION 02605

WETWELLS AND VAULTS

PART 1 - GENERAL

1.1 SUMMARY

A. The work covered by this section consists of precast concrete vaults and wet wells.

1.2 REFERENCE STANDARDS

A. ASTM C478 - Standard Specification for Precast Reinforced Concrete Wetwell Sections

B. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Wetwells

1.3 SUBMITTALS

A. Submit manufacturer's descriptive literature for vaults, wetwells, covers and grates and recommended method of installation.

B. Fabrication Drawings: Submit fabrication drawings for wet wells, wetwells and vaults that illustrate details including wall thickness, reinforcement and location of all openings.

1.4 DELIVERY, STORAGE AND HANDLING

A. Delivery and storage: Inspect materials delivered to the site for damage; unload and store with the minimum of handling.

B. Handling: Handle wetwells and other accessories in such manner as to ensure delivery to the trench in sound undamaged condition.

PART 2 - PRODUCTS

2.1 WET WELL HATCH

A. Wetwell hatch shall be 300 lb per square foot rated.

B. Hatch shall be double leaf aluminum, hinged as shown on the drawings. Unless otherwise specified, all hardware shall be stainless steel. The top slab at the hatch shall be formed such that the concrete supporting the hatch frame extends to the inside face of the frame on all sides.

C. The hatch shall have an angle frame with an anchor flange around the perimeter. The hatch leaf shall be ¼-inch aluminum diamond pattern plate reinforced with aluminum stiffeners completely around the perimeter.

1. Hatches shall be lift assist equipped with a stainless steel hold open arm. Door lock shall open in the 90 degree position. Each hold open arm shall be fastened to the frame with a ½" grade 316 SST bolt.
2. Hinges shall be of grade 316 SST, each with a grade 316 SST pin. Hinges shall be bolted to the angle frame and diamond plate with grade 316 SST bolts and lock nuts.
3. Each hatch shall be supplied with a SST slam lock with the keyway protected by a threaded removable plug. The plug shall be flush with the top of the ¼" diamond plate. The slam lock shall be fastened with grade 316 SST bolts and washers.
4. Hatch shall be equipped with a SST lift handle. Lift handles shall be flush with the ¼" diamond plate.
5. Hatch shall be provided with integral safety grate.

    a. Integral safety grate shall provide fall through protection per OSHA standard 1910.23 and controlled confine space entry per OSHA standard 1910.146. The design must assure that the fall through protection is in place before the doors can be closed, thereby protecting the next operator.
    b. The safety grate shall be made of 6061-T6 aluminum with a minimum ultimate strength of 38,000 psi and a minimum yield strength of 35,000 psi per ASTM. B221.
    c. Grating shall be designed to withstand a minimum live load of 300 lbs/sf. Deflection shall not exceed 1/150th of the span.
    d. Each grate shall be provided with a hinging system which will lock the grate in the 90° position once opened. Each grate shall have an opening arm, with a red vinyl grip handle, which will allow opening of the grate, while providing the grate as a barrier between the operator and the pit. The opening arm shall also be equipped with a controlled confined space entry lock. The grating system will allow anyone to make visual inspection without entering the confined space.
    e. Grate shall be painted with OSHA type safety orange paint.

D. Hatch shall be Model EC-6HD, manufactured by Syracuse Castings, or equal.

2.2 PRECAST CONCRETE WETWELLS

A. Concrete wetwells shall be as dimensioned on the Drawings and conform to the following.

1. ASTM C478.
2. High-density, precast, reinforced concrete sections.
3. Watertight joints incorporating rubber gasket in addition to butyl rubber sealant, such as Kent Seal, between precast sections in accordance with ASTM C443. Joints shall be grouted on the inside of manhole.
4. Grade ring joints and all other wetwell joints made with mortar shall be constructed using an approved commercial concrete bonding agent applied to all cured concrete surfaces being mortared. No joints or risers shall be mortared without bonding agents.
5. Adapters

a. Regardless of the pipe or wetwell manufacturer's recommendations, adapters for connecting PVC pipe to existing and new wetwells shall be approved commercial adapters manufactured specifically for the intended use. Adapter shall be Kor-N-Seal, or equal.
b. Adapters requiring the use of grout for installation shall be anchored and finished using an approved nonshrink grout.
c. All grout to be placed in contact with cured concrete shall be placed with the use of an approved commercial concrete bonding.

6. Miscellaneous Hardware

a. All hardware within the wetwell, including anchor bolts, shall be 316 stainless steel.

2.3 PRECAST CONCRETE VAULTS

A. Design Loading: Design loading shall be 300 psf.

B. Hatch arrangement shall be single, double, or triple leaf, hinged as shown on the drawings. Hatch shall ¼" diamond plate aluminum with lift assist and lockable latch. All hardware shall be stainless steel. The top slab at the hatch shall be formed such that the concrete supporting the hatch frame extends to the inside face of the frame on all sides.

C. Vault floor: Contractor shall pour a concrete floor in the bottom of the vault after the vault has been set. Concrete floor is to slope to the vault drain as shown on the drawings. Provide floor drain as shown on the Drawings.

D. Seal joints with asphalt mastic, Kent Seal, Ram-Nek, K.T. Snyder Co. Mastic sealant to be placed on the two shoulders of the groove. Areas that mastic is placed on to be clean and free of debris prior to placement.

E. Concrete

1. Aggregate: All aggregates, fine and coarse, other than lightweight aggregate shall conform to specifications outlined by ASTM C 33. Lightweight aggregates, fine and coarse, shall conform to the specifications outlined by ASTM deleterious substances causing reactivity with oxidized hydrogen sulfide. Both types of aggregates shall be graded in a manner so as to produce a homogeneous concrete mix. All materials are to be accurately weighed at a central batching facility for mixing.
2. Cement: All cement shall be portland cement conforming to ASTM C 150, Type I/II. Cement content shall be sufficient to produce a minimum compressive strength of 4,500 PSI, or other design strengths required.
3. Reinforcing Steel: All bars shall be intermediate or hard grade billet steel conforming to ASTM A615 or A706. Welded wire mesh is to conform with ASTM A497. Bars other than 1/4" round or smaller shall be deformed in accordance with ASTM A305.

2.4 CONCRETE

A. Concrete shall be 4,000 psi, ¾" maximum aggregate size and meet all requirements of Standard Specifications Section 02001.

2.5 NON-SHRINK GROUT

A. Non-shrink grout shall be Sika 212, Euco N-S, Five-Star, or equal non-metallic cementitious commercial grout exhibiting zero shrinkage per ASTM C-827 and CRD-C-621. Grout shall not be amended with cement or sand, and shall not be reconditioned with water after initial mixing. Unused grout shall be discarded after 20 minutes and shall not be used.

2.6 CONCRETE BONDING AGENT

A. Concrete bonding agent for sealing between existing concrete and newly poured concrete shall be epoxy resin adhesive. Epoxy shall be Sikadur 32, Hi-Mod as manufactured by Sika or equal.

B. Concrete bonding agents for sealing between existing PVC and newly poured concrete shall be an epoxy resin adhesive and a polyurethane based non-sag elastomeric sealant. The epoxy shall be Sikadur 32, Hi-Mod and the sealant shall be Sikaflex 1A as manufactured by Sika, or equal.

PART 3 - EXECUTION

3.1 EXCAVATION, BACKFILL AND BEDDING

A. Except as otherwise specified in this Section, excavation, backfill and bedding shall be in accordance with Section 02221, Structural Excavation and Backfill.

B. Vaults to be placed on a minimum of 12-inches compacted select fill per Section 02221. The select fill shall be graded level and compacted prior to placing the structure.

C. Backfill to be crushed rock per Section 02221.

3.2 WETWELL AND VAULT PENETRATIONS

A. Connections to wetwells shall be as specified below, in the Standard Specifications and as shown on the Drawings.

1. Openings for penetrations for force mains, vault drains, and other required connections shall be pre-cast into structure; field constructed penetrations shall not be allowed. Such pipe penetrations shall be sealed with mechanical seals such as link seal type seals. For pipe sizes less than 4-inches, seal with epoxy sealant.
2. All gravity sewer pipe connections to existing and new wetwells shall be approved commercial adapters manufactured specifically for the intended use. Adapter shall be Kor-N-Seal, or equal.

3.3 TESTING AND INSPECTION

A. Wet Well Leak Test: Perform hydrostatic leak test per ASTM C497: Plug all inlets and outlets and fill wet well with water to level with the rim at the start of the test. Leakage in each wetwell shall not exceed 0.3 gallon per hour per foot of head above the invert. Determine leakage by filling to rim using a calibrated container. Wet well may be filled 24 hours prior to the time of testing to allow normal absorption into walls.

B. Testing of wetwells shall be per Standard Specifications 470.70.

3.4 FINISHING AND CLEANUP

A. Finishing and cleanup shall be as the work progresses, or as directed by the Engineer. All excess material shall be removed. Any damaged concrete shall be restored to the satisfaction of the Engineer. All dirt and debris that accumulates from the Contractor's operations shall be removed from wet wells and vaults.

END OF SECTION 02605

SECTION 02834
RIPRAP BANK STABILIZATION

1. GENERAL

1.01 DESCRIPTION OF WORK

A. The work shall consist of the supply and placement of rip-rap protection and native material on the river bank as shown on the Drawings. Work includes protection of willow cuttings on protected slopes placed by MPWMD staff.

1.02 REFERENCE STANDARDS

A. American Society for Testing and Material (ASTM).

B. Standard Specifications for Construction, 2015, prepared by the California State Department of Transportation.

1.03 SUBMITTALS

A. Contractor to provide submittals for rip rap and granular filter in accordance with Section 01300 Submittal to include rip rap gradation Certificate of Compliance.

2. PRODUCTS

2.01 RIPRAP

A. Rock gradation shall be in accordance with Standard Specifications 72-2.02B for each class of rip rap identified on the Drawings. Class 1T rock shall be placed by Method A. Class 1/4T rock shall be placed by Method B. The stone for riprap shall be hard, sound and durable. It shall be free from segregation, seams, cracks and other defects. Riprap shall be free of rock fines, soil, or other extraneous material.

B. The grading of the riprap shall be inspected by the Owners representative by visual inspection of the load before it is placed, or, if so ordered by the Engineer, by dumping individual loads on a flat surface and sorting and measuring the individual rocks contained in the load.

2.02 FILTER MATERIAL

A. Gradation for filter material shall be as follows:

Sieve Size	Percent Passing
3-inch	90-100
3/4-inch	20-90

3. EXECUTION

3.01 WILLOW PLANTINGS

A. Prior to placement of rip-rap on the bank, MPWMD staff shall place willow cuttings at approximately five (5)-foot center to center. Willow cuttings shall be supplied by the District. Rip-rap shall not be installed on the bank until willow placement has been completed.

3.01 RIPRAP PLACEMENT

A. Rock placement shall be in accordance with Standard Specifications 72-2.02B. Class 1T rock shall be placed by Method A. Class 1/4T rock shall be placed by Method B. Riprap layer thickness shall conform to the Drawings. The larger size stones composing the riprap material shall be placed first and roughly arranged in close contact. The spaces between the larger stones shall then be filled with smaller stone of suitable size. The material may be machine-placed with sufficient hand work to accomplish requirements of this specification.

3.02 NATIVE MATERIAL PLACEMENT

A. The Contractor shall cover the slopes protected with rip-rap with native river bottom material (sand, gravel, and cobbles). The layer of material on top of the rip-rap shall have a minimum thickness of six (6) inches (please note that the rip-rap layer will likely consist of 20% to 30% voids, a portion of which will be filled in during placement of native material). The Contractor shall take due care not to damage or destroy plantings during this operation.

B. If material is pushed (e.g., by bulldozer) into place to cover the willow cuttings, the Owners Representative shall inspect selected areas where native fill is placed over willow cuttings. If the Owners Representative determines that the willow cuttings may not survive to regenerate as a result of material placement methods, the Contractor shall plant additional cuttings in the and cover the cuttings by dropping material onto the slope with a loader, backhoe, excavator, or similar equipment. Material shall not be pushed into place if reinstallation is required.

END OF SECTION

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes.

1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash, slag cement, other pozzolans, and silica fume; materials subject to compliance with requirements.

B. W/C Ratio: The ratio by weight of water to cementitious materials.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1. Indicate amounts of mixing water to be withheld for later addition at Project site.

C. Steel Reinforcement Shop Drawings: Placing Drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.

D. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.

1. Location of construction joints is subject to approval of the Engineer.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For installer and manufacturer.

B. Welding certificates.

C. Material Certificates: For each of the following, signed by manufacturers:

1. Cementitious materials.
2. Admixtures.
3. Form materials and form-release agents.
4. Steel reinforcement and accessories.
5. Waterstops.
6. Curing compounds.
7. Vapor retarders.
8. Semirigid joint filler.
9. Repair materials.

D. Material Test Reports: For the following, from a qualified testing agency:

1. Aggregates**:** Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.

E. Formwork Shop Drawings: Prepared by or under the supervision of a qualified professional engineer, detailing fabrication, assembly, and support of formwork.

1. Shoring and Reshoring: Indicate proposed schedule and sequence of stripping formwork, shoring removal, and reshoring installation and removal.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs on Project personnel qualified as ACI-certified Flatwork Technician and Finisher and a supervisor who is an ACI-certified Concrete Flatwork Technician.

B. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.4/D 1.4M.

1.7 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on concrete mixtures.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage.

B. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

1.9 FIELD CONDITIONS

A. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When average high and low temperature is expected to fall below 40 deg F for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

B. Hot-Weather Placement: Comply with ACI 301 and ACI 305.1, and as follows:

1. Maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:

1. ACI 301.
2. ACI 117.

2.2 FORM-FACING MATERIALS

A. Smooth-Formed Finished Concrete: Form-facing panels that provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.

1. Plywood, metal, or other approved panel materials.

B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.

C. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that produce surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.

D. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.

E. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch, minimum.

F. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.

G. Form-Release Agent: Commercially formulated form-release agent that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.

1. Formulate form-release agent with rust inhibitor for steel form-facing materials.

H. Form Ties: Factory-fabricated, removable or snap-off glass-fiber-reinforced plastic or metal form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.

1. Furnish units that leave no corrodible metal closer than 1 inch to the plane of exposed concrete surface.
2. Furnish ties that, when removed, leave holes no larger than 1 inch in diameter in concrete surface.
3. Furnish ties with integral water-barrier plates.

2.3 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

2.4 REINFORCEMENT ACCESSORIES

A. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:

1. For concrete surfaces exposed to view, where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.

2.5 CONCRETE MATERIALS

A. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.

B. Cementitious Materials:

1. Portland Cement: ASTM C 150/C 150M, Type I/II, gray.
2. Fly Ash: ASTM C 618, Class F.
3. Slag Cement: ASTM C 989/C 989M, Grade 100 or 120.
4. Silica Fume: ASTM C 1240, amorphous silica.

C. Normal-Weight Aggregates: ASTM C 33/C 33M, Class 1N coarse aggregate or better, graded. Provide aggregates from a single source with documented service record data of at least 10 years' satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials.

1. Maximum Coarse-Aggregate Size: 1-1/2 inches nominal.
2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

D. Air-Entraining Admixture: ASTM C 260/C 260M.

E. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

F. Water: ASTM C 94/C 94M and potable.

2.6 WATERSTOPS

A. Flexible PVC Waterstops: CE CRD-C 572, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.

1. Sika Greenstreak or approved equal.
2. Profile: Ribbed with center bulb.
3. Dimensions: 4 inches by 3/16 inch thick; nontapered.

B. Self-Expanding Rubber Strip Waterstops: Manufactured rectangular or trapezoidal strip, bentonite-free hydrophilic polymer-modified chloroprene rubber, for adhesive bonding to concrete, 3/8 by 3/4 inch.

1. Sika Hydrotite or approved equal.

2.7 VAPOR RETARDERS

A. Sheet Vapor Retarder: Polyethylene sheet, ASTM D 4397, not less than 10 mils thick.

2.8 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. when dry.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

1. Dayton Superior Clear Cure VOC J7WB or approved equal.

2.9 RELATED MATERIALS

A. Semirigid Joint Filler: Two-component, semirigid, 100 percent solids, according to ASTM D 2240.

2.10 REPAIR MATERIALS

A. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/4 inch and that can be filled in over a scarified surface to match adjacent floor elevations.

1. Cement Binder: ASTM C 150/C 150M, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by topping manufacturer.
4. Compressive Strength: Not less than 5000 psi at 28 days when tested according to ASTM C 109/C 109M.

2.11 CONCRETE MIXTURES, GENERAL

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.

1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.

B. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.

C. Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water-reducing, high-range water-reducing or plasticizing admixture in concrete, as required, for placement and workability.
2. Use water-reducing and -retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
3. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a w/c ratio below 0.50.

2.12 CONCRETE MIXTURES FOR BUILDING ELEMENTS

A. Normal-weight concrete.

1. Minimum Compressive Strength: 4500 psi at 28 days.
2. Maximum W/C Ratio: 0.45.
3. Minimum Cementitious Materials Content: 560 lb/cu. yd. for 3/4-inch nominal maximum aggregate size.
4. Minimum Cementitious Materials Content: 535 lb/cu. yd. for 1-inch nominal maximum aggregate size.
5. Minimum Cementitious Materials Content: 515 lb/cu. yd. for 1-1/2-inch nominal maximum aggregate size.
6. Air Content: 4.5 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch nominal maximum aggregate size.
7. Air Content: 5 percent, plus or minus 1.5 percent at point of delivery for 1-inch or 3/4-inch nominal maximum aggregate size.

2.13 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.14 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M, and furnish batch ticket information.

1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For mixer capacity of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
2. For mixer capacity larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd.

3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixture time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.1 FORMWORK INSTALLATION

A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.

B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.

C. Limit concrete surface irregularities, designated by ACI 347 as abrupt or gradual, as follows:

1. Class A, 1/8 inch for smooth-formed finished surfaces.
2. Class B, 1/4 inch for rough-formed finished surfaces.

D. Construct forms tight enough to prevent loss of concrete mortar.

E. Construct forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast-concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.

1. Install keyways, reglets, recesses, and the like, for easy removal.
2. Do not use rust-stained steel form-facing material.

F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

G. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

H. Chamfer exterior corners and edges of permanently exposed concrete.

I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

L. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.2 EMBEDDED ITEM INSTALLATION

A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

1. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC 303.

3.3 REMOVING AND REUSING FORMS

A. General: Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete. Concrete has to be hard enough to not be damaged by form-removal operations, and curing and protection operations need to be maintained.

1. Leave formwork for beam soffits, joists, slabs, and other structural elements that support weight of concrete in place until concrete has achieved its 28-day design compressive strength.
2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

B. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material are not acceptable for exposed surfaces. Apply new form-release agent.

C. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by Engineer.

3.4 SHORING AND RESHORING INSTALLATION

A. Comply with ACI 318 and ACI 301 for design, installation, and removal of shoring and reshoring.

B. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

3.5 VAPOR-RETARDER INSTALLATION

A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder according to ASTM E 1643 and manufacturer's written instructions.

1. Lap joints 6 inches and seal with manufacturer's recommended tape.

3.6 STEEL REINFORCEMENT INSTALLATION

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that reduce bond to concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.

1. Weld reinforcing bars according to AWS D1.4/D 1.4M, where indicated.

D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

3.7 JOINTS

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Engineer.

1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
2. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
3. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
4. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.

C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to 1 inch as follows:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.
2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch-wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

3.8 WATERSTOP INSTALLATION

A. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field fabricate joints in waterstops according to manufacturer's written instructions.

B. Self-Expanding Strip Waterstops: Install in construction joints and at other locations indicated, according to manufacturer's written instructions, adhesive bonding, mechanically fastening, and firmly pressing into place. Install in longest lengths practicable.

3.9 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections are completed.

B. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301.

1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

C. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete is placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.

1. Deposit concrete in horizontal layers of depth not to exceed formwork design pressures and in a manner to avoid inclined construction joints.
2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

D. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.

1. Consolidate concrete during placement operations, so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
2. Maintain reinforcement in position on chairs during concrete placement.
3. Screed slab surfaces with a straightedge and strike off to correct elevations.
4. Slope surfaces uniformly to drains where required.
5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

3.10 FINISHING FORMED SURFACES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces not exposed to public view.

B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces exposed to public view.

C. Rubbed Finish: Apply the following to smooth-formed-finished as-cast concrete:

1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.

D. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.11 FINISHING FLOORS AND SLABS

A. General: Comply with ACI 302.1R recommendations for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

B. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power-driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture.

1. Apply float finish to all floor and slab surfaces.

3.12 MISCELLANEOUS CONCRETE ITEM INSTALLATION

A. Equipment Bases and Foundations:

1. Coordinate sizes and locations of concrete bases with actual equipment provided.

3.13 CONCRETE PROTECTING AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 305.1 for hot-weather protection during curing.

B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for remainder of curing period.

D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.

E. Cure concrete according to ACI 308.1, by one or a combination of the following methods:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

    a. Water.
    b. Continuous water-fog spray.
    c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period, using cover material and waterproof tape.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

    a. Removal: After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer.

3.14 JOINT FILLING

A. Prepare, clean, and install joint filler according to manufacturer's written instructions.

1. Defer joint filling until concrete has aged at least one month(s). Do not fill joints until construction traffic has permanently ceased.

B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joints clean and dry.

C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

3.15 CONCRETE SURFACE REPAIRS

A. Defective Concrete: Repair and patch defective areas when approved by Engineer. Remove and replace concrete that cannot be repaired and patched to Engineer's approval.

B. Patching Mortar: Mix dry-pack patching mortar, consisting of 1 part portland cement to 2-1/2 parts fine aggregate passing a No. 16 sieve, using only enough water for handling and placing.

C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.

1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch in any dimension to solid concrete. Limit cut depth to 3/4 inch. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.
2. Repair defects on surfaces exposed to view by blending white portland cement and standard portland cement so that, when dry, patching mortar matches surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by Engineer.

D. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.

1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
2. After concrete has cured at least 14 days, correct high areas by grinding.
3. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.
4. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
5. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean,

square cuts and expose steel reinforcement with at least a 3/4-inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original concrete, except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.

6. Repair random cracks and single holes 1 inch or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

E. Perform structural repairs of concrete, subject to Engineer's approval, using epoxy adhesive and patching mortar.

F. Repair materials and installation not specified above may be used, subject to Engineer's approval.

3.16 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a special inspector and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

END OF SECTION 03300

SECTION 05120

STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Structural steel.
2. Grout.

B. Related Requirements:

1. Section 13341 "Metal Building Systems" for structural steel.

1.3 DEFINITIONS

A. Structural Steel: Elements of the structural frame indicated on Drawings and as described in AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

1.4 COORDINATION

A. Coordinate installation of anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication of structural-steel components.

1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
2. Include embedment Drawings.
3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.

4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical, high-strength bolted connections.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For fabricator.

B. Welding certificates.

C. Mill test reports for structural steel, including chemical and physical properties.

D. Product Test Reports: For the following:

1. Bolts, nuts, and washers including mechanical properties and chemical analysis.
2. Nonshrink grout.

1.7 QUALITY ASSURANCE

A. Fabricator Qualifications: A qualified fabricator that is registered and approved to perform the work without special inspections in accordance with the California Building Code Section 1704.2.5.1.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Comply with applicable provisions of the following specifications and documents:

1. AISC 303.
2. AISC 360.
3. RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.

1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.

B. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.

1. Fasteners may be repackaged provided Owner's testing and inspecting agency observes repackaging and seals containers.
2. Clean and relubricate bolts and nuts that become dry or rusty before use.
3. Comply with manufacturers' written recommendations for cleaning and lubricating ASTM F 1852 fasteners and for retesting fasteners after lubrication.

PART 2 - PRODUCTS

2.1 STRUCTURAL-STEEL MATERIALS

A. W-Shapes: ASTM A 992/A 992M or ASTM A 572/A 572M, Grade 50.

B. Channels, Angles, M, S-Shapes: ASTM A 36/A 36M.

C. Plate and Bar: ASTM A 36/A 36M.

D. Cold-Formed Hollow Structural Sections: ASTM A 500/A 500M, Grade B, structural tubing.

E. Steel Pipe: ASTM A 53/A 53M, Type E or Type S, Grade B.

F. Welding Electrodes: Comply with AWS requirements.

2.2 BOLTS, CONNECTORS, AND ANCHORS

A. High-Strength Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy-hex steel structural bolts; ASTM A 563, Grade DH heavy-hex carbon-steel nuts; and ASTM F 436, Type 1, hardened carbon-steel washers.

1. Finish: Hot-dip zinc coating.

B. Unheaded Anchor Rods and Threaded Rods: ASTM F 1554, Grade 55, weldable.

1. Configuration: Straight.
2. Nuts: ASTM A 563 heavy-hex carbon steel.
3. Plate Washers: ASTM A 36/A 36M carbon steel.
4. Washers: ASTM F 436, Type 1, hardened carbon steel.
5. Finish: Hot-dip zinc coating, ASTM A 153/A 153M, Class C.

C. Headed Anchor Rods: ASTM F 1554, Grade 55, weldable, straight.

1. Nuts: ASTM A 563 heavy-hex carbon steel.
2. Plate Washers: ASTM A 36/A 36M carbon steel.
3. Washers: ASTM F 436, Type 1, hardened carbon steel.
4. Finish: Hot-dip zinc coating, ASTM A 153/A 153M, Class C.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107/C 1107M, factory-packaged, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.4 FABRICATION

A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC 303, "Code of Standard Practice for Steel Buildings and Bridges," and to AISC 360.

1. Camber structural-steel members where indicated.
2. Fabricate beams with rolling camber up.
3. Identify high-strength structural steel according to ASTM A 6/A 6M and maintain markings until structural steel has been erected.
4. Mark and match-mark materials for field assembly.

B. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.

1. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1/D1.1M.

C. Bolt Holes: Cut, drill, or punch standard bolt holes perpendicular to metal surfaces.

D. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.

E. Holes: Provide holes required for securing other work to structural steel and for other work to pass through steel members.

1. Cut, drill, or punch holes perpendicular to steel surfaces. Do not thermally cut bolt holes or enlarge holes by burning.
2. Baseplate Holes: Cut, drill, mechanically thermal cut, or punch holes perpendicular to steel surfaces.
3. Weld threaded nuts to framing and other specialty items indicated to receive other work.

2.5 SHOP CONNECTIONS

A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.

1. Joint Type: Snug tightened.

B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

2.6 GALVANIZING

A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A 123/A 123M.

1. Fill vent and drain holes that are exposed in the finished Work unless they function as weep holes, by plugging with zinc solder and filing off smooth.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify, with certified steel erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.

1. Prepare a certified survey of existing conditions. Include bearing surfaces, anchor rods, bearing plates, and other embedments showing dimensions, locations, angles, and elevations.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.

3.3 ERECTION

A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.

B. Baseplates, Bearing Plates, and Leveling Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.

1. Set plates for structural members on wedges, shims, or setting nuts as required.
2. Weld plate washers to top of baseplate.
3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
4. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.

C. Maintain erection tolerances of structural steel within AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

D. Align and adjust various members that form part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that are in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.

1. Level and plumb individual members of structure.

E. Splice members only where indicated.

F. Do not use thermal cutting during erection.

G. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.

3.4 FIELD CONNECTIONS

A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.

1. Joint Type: Snug tightened.

B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

1. Comply with AISC 303 and AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.
2. Remove backing bars or runoff tabs where indicated, back gouge, and grind steel smooth.

3.5 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform Special Inspections.

3.6 REPAIRS AND PROTECTION

A. Galvanized Surfaces: Clean areas where galvanizing is damaged or missing and repair galvanizing to comply with ASTM A 780/A 780M.

END OF SECTION 05120

SECTION 05511

METAL GRATING STAIRS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Industrial Class stairs with steel-grating treads.
2. Steel railings attached to metal stairs.

1.3 COORDINATION

A. Coordinate installation of anchorages for metal stairs.

1. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry.
2. Deliver such items to Project site in time for installation.

1.4 ACTION SUBMITTALS

A. Product Data: For metal grating stairs and the following:

1. Gratings.

B. Shop Drawings:

1. Include plans, elevations, sections, details, and attachment to other work.
2. Indicate sizes of metal sections, thickness of metals, profiles, holes, and field joints.
3. Include plan at each level.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store materials to permit easy access for inspection and identification.

1. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers.
2. Protect steel members and packaged materials from corrosion and deterioration.
3. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures.

a. Repair or replace damaged materials or structures as directed.

PART 2 - PRODUCTS

2.1 METALS

A. Metal Surfaces: Provide materials with smooth, flat surfaces unless otherwise indicated. For components exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

B. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

C. Steel Bars for Grating Treads: ASTM A 36/A 36M or steel strip, ASTM A 1011/A 1011M or ASTM A 1018/A 1018M.

D. Steel Wire Rod for Grating Crossbars: ASTM A 510/A 510M.

E. Steel Pipe for Railings: ASTM A 53/A 53M, Type F or Type S, Grade A, Schedule 80.

F. Cast-Abrasive Nosings: Cast iron, with an integral abrasive, as-cast finish consisting of aluminum oxide, silicon carbide, or a combination of both.

2.2 FASTENERS

A. Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A; with hex nuts, ASTM A 563; and, where indicated, flat washers.

2.3 MISCELLANEOUS MATERIALS

A. Welding Electrodes: Comply with AWS requirements.

B. Galvanizing Repair Paint: High-zinc-dust-content paint complying with ASTM A 780/A 780M and compatible with paints specified to be used over it.

C. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107/C 1107M, factory-packaged, nonmetallic aggregate grout; recommended by manufacturer for exterior use; noncorrosive and nonstaining; mixed with water to consistency suitable for application and a 30-minute working time.

2.4 FABRICATION, GENERAL

A. Provide complete stair assemblies, including metal framing, hangers, railings, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure.

1. Join components by welding unless otherwise indicated.
2. Use connections that maintain structural value of joined pieces.

B. Assemble stairs and railings in shop to greatest extent possible.

1. Disassemble units only as necessary for shipping and handling limitations.
2. Clearly mark units for reassembly and coordinated installation.

C. Cut, drill, and punch metals cleanly and accurately.

1. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated.
2. Remove sharp or rough areas on exposed surfaces.

D. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

E. Form exposed work with accurate angles and surfaces and straight edges.

F. Weld connections to comply with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Weld exposed corners and seams continuously unless otherwise indicated.
5. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Finish # 3 - Partially dressed weld with spatter removed.

2.5 FABRICATION OF STEEL-FRAMED STAIRS

A. NAAMM Stair Standard: Comply with NAAMM AMP 510, "Metal Stairs Manual," for Industrial Class, unless more stringent requirements are indicated.

B. Stair Framing:

1. Fabricate stringers of steel channels.

    a. Stringer Size: As indicated on Drawings.
    b. Provide closures for exposed ends of channel stringers.
    c. Finish: Galvanized.

C. Metal Bar-Grating Stairs: Form treads to configurations shown from metal bar grating; fabricate to comply with NAAMM MBG 531, "Metal Bar Grating Manual."

1. Fabricate treads from welded steel grating with 1-1/4-by-3/16-inch bearing bars at 1-3/16 inch o.c. and crossbars at 4 inches o.c.

    a. Surface: Plain.
    b. Finish: Galvanized.

2. Fabricate grating treads with cast-abrasive nosing and with steel angle or steel plate carrier at each end for stringer connections.

    a. Secure treads to stringers with bolts.

D. Risers: Open.

2.6 FABRICATION OF STAIR RAILINGS

A. Fabricate railings to comply with requirements indicated for dimensions, details, finish, and member sizes, including wall thickness of member, post spacings, and anchorage.

B. Welded Connections: Fabricate railings with welded connections.

1. Fabricate connections that are exposed to weather in a manner that excludes water.

    a. Provide weep holes where water may accumulate internally.

2. Cope components at connections to provide close fit, or use fittings designed for this purpose.
3. Weld all around at connections, including at fittings.
4. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
5. Obtain fusion without undercut or overlap.
6. Remove flux immediately.
7. Finish welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Finish #3 - Partially dressed weld with spatter removed as shown in NAAMM AMP 521.

C. Form changes in direction of railings as follows:

1. By bending or by inserting prefabricated elbow fittings.

D. For changes in direction made by bending, use jigs to produce uniform curvature for each repetitive configuration required.

1. Maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.

E. Close exposed ends of railing members with prefabricated end fittings.

F. Connect posts to stair framing by direct welding unless otherwise indicated.

2.7 FINISHES

A. Finish metal stairs after assembly.

B. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A 153/A 153M for steel and iron hardware and with ASTM A 123/A 123M for other steel and iron products.

1. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify elevations of floors, bearing surfaces and locations of bearing plates, and other embedments for compliance with requirements.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLING METAL STAIRS

A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal stairs to in-place construction.

B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free of rack.

C. Install metal stairs by welding stair framing to steel structure or to weld plates cast into concrete unless otherwise indicated.

1. Grouted Baseplates: Clean concrete and masonry bearing surfaces of bond-reducing materials, and roughen to improve bond to surfaces.

a. Clean bottom surface of baseplates.
b. Set steel-stair baseplates on wedges, shims, or leveling nuts.
c. After stairs have been positioned and aligned, tighten anchor bolts.
d. Do not remove wedges or shims, but if protruding, cut off flush with edge of bearing plate before packing with grout.
e. Promptly pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

1) Neatly finish exposed surfaces; protect grout and allow to cure.
2) Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.

D. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

E. Fit exposed connections accurately together to form hairline joints.

1. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations.
2. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
3. Comply with requirements for welding in "Fabrication, General" Article.

3.3 INSTALLING RAILINGS

A. Adjust railing systems before anchoring to ensure matching alignment at abutting joints with tight, hairline joints.

1. Space posts at spacing indicated.
2. Plumb posts in each direction, within a tolerance of 1/16 inch in 3 feet.
3. Align rails so variations from level for horizontal members and variations from parallel with rake of stairs for sloping members do not exceed 1/4 inch in 12 feet.
4. Secure posts and rail ends to building construction as follows:

a. Anchor posts to steel by welding to steel supporting members.

3.4 REPAIR

A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780/A 780M.

END OF SECTION 05511

SECTION 05521

PIPE RAILINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Steel pipe railings.

1.3 COORDINATION

A. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

B. Do not support railings temporarily by any means that do not satisfy structural performance requirements.

1.4 ACTION SUBMITTALS

A. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

1.8 FIELD CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 METALS, GENERAL

A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.

2.2 STEEL

A. Pipe: ASTM A 53/A 53M, Type F or Type S, Grade A, Schedule 80.

B. Plates, Shapes, and Bars: ASTM A 36/A 36M.

2.3 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Etching Cleaner for Galvanized Metal: Complying with MPI#25.

C. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

2.4 FABRICATION

A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage.

B. Shop assemble railings to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.

C. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

D. Form work true to line and level with accurate angles and surfaces.

E. Fabricate connections that are exposed to weather in a manner that excludes water. Provide weep holes where water may accumulate.

F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.

G. Connections: Fabricate railings with welded connections unless otherwise indicated.

H. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove flux immediately.
4. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces.

I. Form Changes in Direction as Follows:

1. By bending or by inserting prefabricated elbow fittings.

J. For changes in direction made by bending, use jigs to produce uniform curvature for each repetitive configuration required. Maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.

K. Close exposed ends of railing members with prefabricated end fittings.

L. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch or less.

2.5 STEEL FINISHES

A. Galvanized Railings:

1. Hot-dip galvanize steel railings, including hardware, after fabrication.
2. Comply with ASTM A 123/A 123M for hot-dip galvanized railings.
3. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Fit exposed connections together to form tight, hairline joints.

B. Perform cutting, drilling, and fitting required for installing railings. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.

1. Do not weld, cut, or abrade surfaces of railing components that are coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
2. Set posts plumb within a tolerance of 1/16-inch in 3 feet.
3. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12.

C. Adjust railings before anchoring to ensure matching alignment at abutting joints.

3.2 RAILING CONNECTIONS

A. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article whether welding is performed in the shop or in the field.

3.3 ADJUSTING AND CLEANING

A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas, and repair galvanizing to comply with ASTM A 780/A 780M.

3.4 PROTECTION

A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.

END OF SECTION 05521

SECTION 05531

BAR GRATINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes metal bar gratings.

B. Related Requirements:

1. Section 05120 "Structural Steel Framing" for structural-steel framing system components.
2. Section 05511 "Metal Grating Stairs" for grating treads and landings of steel-framed stairs.
3. Section 05521 "Pipe and Tube Railings" for metal pipe and tube handrails and railings.

1.3 COORDINATION

A. Coordinate installation of anchorages for gratings, grating frames, and supports. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Clips and anchorage devices for gratings.

B. Shop Drawings: Include plans, sections, details, and attachments to other work.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.7 FIELD CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with gratings by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Grating Pacific, Inc. or approved equal.

2.2 METAL BAR GRATINGS

A. Metal Bar Grating Standards: Comply with NAAMM MBG 531, "Metal Bar Grating Manual."

B. Welded Steel Grating:

1. Grating Mark W-19-4 (1-1/2 x 3/16) STEEL: 1-1/2-by-3/16-inch bearing bars at 1-3/16 inches o.c., and crossbars at 4 inches o.c.
2. Traffic Surface: Plain.
3. Steel Finish: Hot-dip galvanized with a coating weight of not less than 1.8 oz./sq. ft. of coated surface.

2.3 FERROUS METALS

A. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

B. Steel Bars for Bar Gratings: ASTM A 36/A 36M or steel strip, ASTM A 1011/A 1011M or ASTM A 1018/A 1018M.

C. Wire Rod for Bar Grating Crossbars: ASTM A 510.

2.4 FASTENERS

A. General: Unless otherwise indicated, provide zinc-plated fasteners with coating complying with ASTM B 633 or ASTM F 1941, Class Fe/Zn 5. Select fasteners for type, grade, and class required.

2.5 MISCELLANEOUS MATERIALS

A. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

2.6 FABRICATION

A. Shop Assembly: Fabricate grating sections in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

B. Cut, drill, and punch material cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

C. Form from materials of size, thickness, and shapes indicated.

D. Fit exposed connections accurately together to form hairline joints.

E. Welding: Comply with AWS recommendations and the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.

F. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space the anchoring devices to secure gratings rigidly in place.

G. Fabricate cutouts in grating sections for penetrations indicated. Arrange cutouts to permit grating removal without disturbing items penetrating gratings.

1. Edge-band openings in grating that interrupt four or more bearing bars with bars of same size and material as bearing bars.

H. Do not notch bearing bars at supports to maintain elevation.

2.7 STEEL FINISHES

A. Finish gratings after assembly.

B. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A 153/A 153M for steel and iron hardware and with ASTM A 123/A 123M for other steel and iron products.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing gratings to in-place construction. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.

B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing gratings. Set units accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.

C. Provide temporary bracing or anchors in formwork for items that are to be built into concrete or masonry.

D. Fit exposed connections accurately together to form hairline joints.

1. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade the surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

E. Field Welding: Comply with AWS recommendations and the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.

3.2 INSTALLING METAL BAR GRATINGS

A. General: Install gratings to comply with recommendations of referenced metal bar grating standards that apply to grating types and bar sizes indicated, including installation clearances and standard anchoring details.

B. Attach nonremovable units to supporting members by welding where both materials are same; otherwise, fasten by bolting as indicated above.

3.3 ADJUSTING AND CLEANING

A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780/A 780M.

END OF SECTION 05531

SECTION 08332

OVERHEAD COILING DOORS

1.1 PERFORMANCE REQUIREMENTS

A. Operability under specified wind load is required.

B. Air-infiltration limit for exterior doors.

C. Windborne-debris impact-resistance performance.

D. Seismic Performance: ASCE/SEI 7.

1.2 DOOR ASSEMBLY

A. Service Door: Door curtain of painted Aluminum.

B. Operation Cycles: 50,000.

C. Design Wind Load: 110 MPH ultimate design wind speed.

D. Hood: Aluminum to match door.

E. Electric Door Operator: Heavy duty, with emergency manual chain operation.

1. Obstruction-detection device.
2. Other Equipment: Audible and visual signals.

1.3 MAINTENANCE SERVICE

A. Initial Maintenance Service: Three months.

1.4 DEMONSTRATION

A. Factory-authorized representative to train Owner's personnel.

END OF SECTION 08332

SECTION 11226 – LOW HEAD OXYGENATOR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the Low Head Oxygenator to be used for oxygenating of the process reuse water.

1.3 DEFINITIONS

A. The following are industry abbreviations:

1. LHO: Low Head Oxygenator
2. gpm: Gallons per minute

1.4 SYSTEM PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of oxygenating the required process flow of 1,350 gpm.

1.5 SUBMITTALS

A. Submittals shall comply with the requirements of the Construction Contract Clauses, Division 1 Section “Submittals” and the individual sections specifying the work.

B. Product Data: Provide product data for each item in PART 2 – PRODUCTS. Indicate dimensions, capacities, performance characteristics, finishes for materials, and installation instructions for each type of product indicated.

C. Shop Drawings: Detail piping and equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Schematic flow diagrams showing piping and equipment.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Maintenance Data: For systems to include in maintenance manuals specified in Division 1.

F. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

G. Project Record Documents: Record actual locations of piping and equipment. Revise shop drawings to reflect actual installation.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in manufacturing Low Head Oxygenators similar to that indicated for this project and with a record of successful in-service performance at this flow rate or greater. Minimum experience of at least 5 installations with an installed service record of 5 years or greater is required.

B. Installer Qualifications: Engage personnel experienced in equipment installations similar to that required by this project who are acceptable to the Low Head Oxygenator manufacturer.

C. Provide listing/approval stamp, label, or other marking on the Low Head Oxygenators made to specified standards.

1.7 MATERIAL RESTRICTIONS

A. The Contractor shall not install any material containing cadmium, brass, bronze, copper, zinc, or their alloys, which could come in contact with fish rearing water. These heavy metal materials have been shown to be toxic to fish.

B. All pump, valve, piping, wetted components, etc. that may come in contact with water shall be a material specified and approved by the Owner.

PART 2 - PRODUCTS

2.1 LOW HEAD OXYGENATORS

A. The Low Head Oxygenator shall be an aluminum or stainless steel unit custom manufactured to the specifications in this section and as detailed in the drawing set. Alternatively, the CO2 Stripper can be a custom FRP vessel manufactured according to the specification for FRP vessels in this 13215, PART 2 – PRODUCTS, 2.1 FRP VESSELS.

1. ACCEPTABLE MANUFACTURERS

a) Reiff Manufacturing – Contact: (509) 525-1081
b) Water Management Technologies – Contact: (225) 755-0026
c) Pentair Aquatic Eco-systems, Inc. – Contact: (407) 992-5515
d) Red Ewald, Inc. – Contact: (800) 242-3524

2. MANUFACTURER

a) Any changes to the Contract Documents required to suit the Manufacturer shall be made at no cost to the Owner. Any changes in the design shall be submitted to the Owner for approval.

B. GENERAL REQUIREMENTS

1. Identification

a) Name – Low Head Oxygenator

b) Equipment Number – LHO-1

c) Quantity – 1

2. Operating Conditions

a) Fluid Service – Freshwater

b) Duty – Continuous

c) Fluid Temperature (ºF) – 32 to 77

3. Performance Requirements: See the drawing set for detail dimensions, flange sizes and orientation, and other required accessory dimensions. Major dimensions are as follows:

a) Flow capacity (gpm) – 1,350

b)	Length (ft)	–	4.5
c)	Width (ft)	–	4.5
d)	Height (ft)	–	4.5
e)	Number of internal baffles	–	7
f)	Perforated Plate length (ft)	–	4.5
g)	Perforated Plate width (ft)	–	4.5
h)	Fall height (inch)	–	18
i)	Submerged height (inch)	–	36
j)	Operating water level over the Perforated Plate for the design flows (inch)	–	6
k)	Maximum water level over Perforated Plate before overflow (inch)	–	12
l)	Inlets	–	4.5-ft wide by 1.5-ft tall flanged Transition Channels (bolt holes drilled in the field)

C. LOW HEAD OXYGENATOR REQUIREMENTS

1. Description of Operation

LHO-1 shall be installed within its respective LHO Sump (LHOS-1). The LHO shall receive process water via its connecting transition channels. Only one channel shall be in use at a time. The LHO will oxygenate the process water before it is delivered to the Rearing Channel/Tanks. In operation the LHO will receive oxygen gas via a gas inlet port and transfer the oxygen to the water falling through the unit. Oxygenated water will flow out of the bottom of the unit and into the LHO Sump. The offgas from the LHO shall flow out the gas outlet port via an adjustable pipe that may be slightly submerged in the water surrounding the LHO.

2. Construction

a) The LHO shall be constructed of 5052 marine grade aluminum or 304/304L stainless steel, 0.125 inch minimum thickness.

b) The LHO shall have 7 internal baffle walls (8 chambers) with oxygen transfer holes between baffles.

c) The LHO shall be amply supported with cradle arms that will rest on the top of the LHO Sump. The cradle arms shall be integral to the LHO.

d) The Perforated Plate shall be constructed in two sections with two handles attached on the top of each plate section for easy removal from the LHO. The handles shall be stainless steel.

e) The number and size of holes in the Perforated Plate shall be determined by the Manufacturer to achieve 6 inches of water flooded over the plate during operation over the range of flows for each LHO as specified:

1) LHO-1: Flowrates up to 1,350 gpm

f) The LHO shall be shipped complete with all required oxygen inlet fittings (0.25-inch barb) and offgas venting tubes ready for installation.

D. NUTS, BOLTS WASHERS

1. Nuts, bolts, washers and threaded rod shall be 304/304L stainless steel. Hanger and pipe supports shall be 304/304L stainless steel.

E. SPARE PARTS

1. No spare parts are required.

PART 3 - EXECUTION

3.1 EXAMINATION

A. All parts of the Low Head Oxygenator and Transition Channels shall be properly designed and built for stresses that may occur during fabrication, shipping, installation, and intermittent or continuous operation. Workmanship shall be of high industrial standards in all respects.

B. The Low Head Oxygenator shall come with a Manufacturer’s warranty covering both parts and labor for a period of at least two years.

3.2 INSTALLATION

A. Install Low Head Oxygenator in accordance with Manufacturer’s instructions.

1. The flanged connection between the LHO and the Transition Channels shall have the bolt holes drilled in the field to ensure a matching connection.

2. The LHO cradle arms shall be secured to the top of the LHO Sump 3-inch flange after the LHO Head Tank has been installed, the LHO/Transition Channel connections have been made, and clearances and dimensions have been verified.

3.3 FIELD QUALITY CONTROL

A. Inspect Low Head Oxygenator as follows:

1. Do not enclose, cover, or put Low Head Oxygenator into operation until they are inspected and approved by the Owner.

2. During installation, notify the Owner at least 24 hours before inspection must be made. Perform tests specified below in presence of the Owner.

B. Test Low Head Oxygenator as follows:

1. Test Low Head Oxygenator for leaks, defects and compliance with performance requirements. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of Low Head Oxygenator tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.

3. Repair leaks and defects with new materials and retest Low Head Oxygenator or portion thereof until satisfactory results are obtained.

3.4 CLEANING

A. Clean and disinfect Low Head Oxygenator as follows:

1. Purge new Low Head Oxygenator and parts of existing water piping that have been altered, extended, or repaired before using.

2. Remove dirt and debris as work progresses.

3.5 COMMISSIONING

A. Field Testing

1. Upon completion of the installation, the Low Head Oxygenator shall be tested for satisfactory operation. All equipment shall be adjusted and checked for alignment, clearances, supports, and adherence to safety standards, until found satisfactory. This work will be performed by the Contractor.

END OF SECTION

SECTION 11330

INTAKE SCREEN ASSEMBLIES

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers the work and materials necessary for the design, fabrication, delivery, installation, startup, and operation training for the intake screens and related controls. The specific design and fabrication details for the screens and cleaning systems shall be the responsibility of the screen manufacturer. Screen assemblies shall be coordinated with the respective river intake design as shown in the Contract Drawings.

B. The equipment furnished shall be fabricated, assembled, erected, and placed in proper operating conditions in conformity with approved detail drawings, specifications, engineering data, and recommendations of the equipment manufacturer.

C. The drawings do not show the final design of the intake screens and mounting to the structural slabs, but show the limiting dimensions and general arrangement.

1.2 SUPPLIER

A. The screen and controls shall be designed and furnished by a single supplier with demonstrated experience with similar systems: Intake Screens, Inc., Sacramento, CA or approved equal.

1.3 REFERENCES

A. The following publications form a part of this specification to the extent referenced.

1. American Society for Testing and Materials (ASTM):

   a. ASTM A 36 – Standard Specification for Carbon Structural Steel.
   b. ASTM A 123 – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   c. ASTM A 153 – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   d. ASTM A 193 – Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   e. ASTM A 276 – Specifications for Stainless Steel Bars and Shapes.
   f. ASTM A 320 – Specifications for Stainless Steel Nuts and Bolts for Low Temperature Service.

2. American Welding Society:

a. AWS D1.1 – Structural Welding Code – Steel.
b. AWS D1.6 – Structural Welding Code – Stainless Steel.

3. National Electrical Code (NEC).
4. National Electrical Manufacturer's Association (NEMA).
5. Underwriters Laboratories (UL).

1.4 SUBMITTALS

A. Submit the following:

1. Product data, make, model of manufactured components. Include capacities, materials, physical dimensions for screens, control systems, hydraulic system, and brushes.

2. Design computations for the following:

a. Weights and center of gravity of the intake screens.
b. Analysis showing the hydraulic power system for the intake screen will deliver the required power to the screen brush mechanism to meet the manufacturer's recommendations.

3. Shop Drawings:

a. General arrangement drawings of the intake screen.
b. Control Wiring diagrams.
c. General arrangement and schematic drawings of the hydraulic system.

4. Construction materials, including MSDS sheets on the hydraulic oil.
5. List of special tools and spare parts to be furnished.
6. Welder certifications using stainless steel, and carbon steel as appropriate.

1.5 OPERATION AND MAINTENANCE DATA MANUALS

A. Prepare instruction manuals describing the operation, servicing and maintenance requirements of all mechanical equipment provided, and complete parts lists.

B. Information contained in the Manual: Catalog data on the particular item and not the complete "line" of the manufacturer. Index all contents listed in an orderly presentation. Provide indexed chapters to contain the following (not a complete list).

1. Test charts and test records.
2. Installation certificates.
3. Operation and maintenance data for all specified equipment.
4. Guarantee and warranties.
5. Instructions for lubricating each piece of equipment installed. Instructions shall state type of lubricant, where and how frequently lubrication is required. Lubrication and lubricants especially shall be detailed separately for all equipment and presented for ready reference.
6. Supplementary drawings for servicing and maintenance points.

C. Binding: Secure material with post-type, 3-hole binder with cloth-covered heavy-duty cardboard cover. Imprint front cover with the name of the project, the Owner, the year of completion, the words “EQUIPMENT OPERATING AND MAINTENANCE DATA" and the names of the Owner.

D. Number of Copies: Submit one preliminary copy for approval by 75% project completion. Deliver three (3) final bound copies to the Owner after incorporating review comments, for final approval and delivery to the Owner by the date of Substantial Completion.

1.6 DELIVERY, STORAGE AND HANDLING OF EQUIPMENT AND MATERIALS

A. Insofar as is practical, the equipment specified herein shall be factory assembled. The parts and assemblies that are, of necessity, shipped unassembled shall be packaged and tagged in a manner that will protect the equipment from damage and facilitate the final assembly in the field. Generally, machined and unpainted parts shall be protected from damage by the elements of weather with the application of a strippable protective coating.

1.7 DESCRIPTION

A. This section covers intake screen assemblies:

1. Intake screen units shall include the following:

   a. Cone shaped intake screen stainless steel wedge-wire (1.75 mm wide) construction, with 1.75 mm wide openings.
   b. Screen area—26.8 sf per screen, 50% open area
   c. Cleaning brushes for the outside of the screen cone that are activated automatically or manually by a hydraulic power unit.
   d. Controls, hydraulic system, and monitoring systems related to the brush cleaning system. The controls to include all components for a complete working system.
   e. Hydraulic hoses including all fittings, hose carriers, and hose protection system between the control panel and the screens.
   f. Cabinets for the controls and hydraulic system
   g. Testing.
   h. Special tools and spare parts.

B. The equipment furnished shall be fabricated, assembled, erected, and placed in proper operating conditions in conformity with approved detail drawings, specifications, engineering data, and recommendations of the equipment manufacturer.

PART 2 - PRODUCTS

2.1 INTAKE SCREENS

A. General:

1. Intake screens shall be fabricated for mounting on concrete slabs, and shall include lifting eyes, and bi-directional brush cleaning system. The screens shall have an internal suction manifold/baffle system to evenly distribute the intake flow over the screen surface area.
2. Design flow rate per screen is 3.3 cubic feet per second, with an approach velocity of less than 0.125 feet per second.

B. Intake Screen Mounting Requirements: Intake screens shall be fabricated for mounting on concrete slabs using hold down clamps secured by two large bolts.

2.2 INTAKE SCREEN CONTROLS

A. The intake screen control panel and Hydraulic Power Unit shall be contained inside an enclosure rated for exterior protection against dust and rain, NEMA 3R rated or approved equal. The control electronics and PLC shall be mounted in a NEMA 4 rated enclosure within this larger cabinet.

B. The controls shall include a PLC with touch screen controls, main disconnect switch, motor starter, interface with circuit breakers, transformers, alarms, and other devices as required. The main disconnect switch shall be capable of being locked in the open position. Motor controller disconnect shall be capable of being locked in the open position. The touchscreen panel shall include screen system status, control settings, and alarm status. The intake screen control panel hardware shall be a packaged system by the screen manufacturer with dry contact alarm outputs.

C. All indicating lights shall be LED, push-to-test type. Lights for 120VAC application shall be transformer type. Indicating lights shall be Allen Bradley 800T or approved equal.

D. All control relays shall have lighted indication when the coil is energized.

E. Electrical controls shall contain both manual and automatic controls for screen cleaning. A timer shall be provided to cycle the screens at adjustable intervals from continuous to once daily, with local manual start/stop override. Electrical controls shall be located inside the central control structure in a smaller NEMA 4 enclosure.

F. The control system shall contain protections for overload, short circuit, lightning, transient surges, and high voltages. Transmitters located outdoors shall be provided with surge protectors; Rosemount Model 470A, Taylor 1020FP, or equal.

2.3 PERFORMANCE STANDARDS

A. The Screens shall have a sealing surface between the screen base and the concrete surface. When the screen is installed, there should not be any gap openings larger than a nominal screen opening.

B. Each system shall be designed for a user adjustable cleaning operation from once per day to continuous.

C. The warranty period for the intake screen assemblies, including the control panel and hydraulic power unit, shall be 1 year from the date of substantial completion.

2.4 MATERIALS

A. Materials shall conform to the following:

1. Fish screen unit components, shall be fabricated from ASTM A 276, Type 304 stainless steel.
2. Stainless steel bolting materials shall conform to ASTM A 193.

2.5 SPARE PARTS

A. Spare parts shall be interchangeable with, and shall be made of the same material as, the corresponding part to be replaced. Provide the following spare parts:

1. One (1) set of replacement exterior brushes for each screen installed.
2. Five (5) gallons of hydraulic oil.
3. Five (5) fuses of each size and type used.

B. Spare parts shall be crated and boxed. Each item shall be tagged and identified for its intended use and location. Each box shall be labeled with the contract number, the intended location, and a list of the contents. The boxes shall be protected from weather including moisture and excessive heat until delivery. The boxes shall be delivered to a location as directed.

PART 3 - EXECUTION

3.1 FABRICATION AND WORKMANSHIP

A. Metalwork shall be free from warp, twists, dents, buckle and other defects. Installation shall be neat, plumb, square, straight and in alignment. Provisions shall be made for expansion throughout to avoid damage. Surfaces shall be cleaned and left free from stains, marks, burrs, or other defects.

B. Welding on the intake screen units shall be in accordance with AWS D1.6 for stainless steel.

3.2 QUALITY ASSURANCE

A. Welders and welding operators shall be qualified in accordance with AWS D1.6 and D1.1 as appropriate. Procedure qualification tests shall be performed on samples of steel that matches the steel to be used in this section.

3.3 FIELD TESTING – DEMONSTRATION

A. The manufacturer shall provide up to 8 hours of on-site field testing and demonstration of the system for the Owner. The Contractor shall provide 5 days advance notice of the testing and demonstration to the Owner's Representative. The testing and demonstration shall be performed in the presence of the Owner's Representative. Operation and maintenance manuals shall be provided prior to the testing and demonstration.

B. The screen cleaning system shall be operated normally for 24 hours to verify that the system functions as specified.

C. On completion of testing, the fish screen unit shall be positioned and placed in operation.

END OF SECTION 11330

SECTION 11376

ULTRAVIOLET (UV) IRRADIATION UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the Ultraviolet Irradiation Units (UV-1) for disinfection of fish culture water within the recirculating aquaculture systems. The scope of supply shall include all equipment and appurtenances for one complete and operational low pressure, high intensity ultraviolet disinfection systems. The systems shall be complete with vessel, UV lamps, power distribution, system control, UV detection system, as indicated and specified herein.

1.3 DEFINITIONS

A. The following are industry abbreviations for Ultraviolet Disinfection Water Treatment:

1. UV: Ultraviolet
2. EOL: End of Lamp Life
3. LCD: Liquid Crystal Display
4. gpm: Gallons per minute

1.4 SYSTEM PERFORMANCE REQUIREMENTS

A. RAS System – Provide components and installation capable of treating the following design points:
1. 1,350 gpm to a dosage level of 30,000 µWsec/cm², EOL, at a water UV transmissivity of 85 percent.
2. 900 gpm to a dosage level of 30,000 µWsec/cm², EOL, at a water UV transmissivity of 70 percent

B. The dose calculation shall be based on the UV intensity output at a wavelength of 253.7 nm, with the lamp output after 9,000 hours of operation (end of life). Dose calculation shall be in accordance with the point source summation method as described in the US EPA Design Manual (EPA/625/1-86-021).

1.5 SUBMITTALS

A. Submittals shall comply with the requirements of the Construction Contract Clauses, Division 1 Section "Submittals" and the individual sections specifying the work.

B. Product Data: Provide product data for each item in Part 2 - Products. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation instructions for each type of product indicated.

C. Shop Drawings: Detail piping and equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Schematic flow diagrams showing piping and equipment.
2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
3. Provide drawing indicating monitor locations.
4. The manufacturer’s submittal shall state the power consumption per lamp (including ballast loss) and the system peak power consumption (including ballast loss), for both new lamps and the end of lamp life.
5. The submittal shall clearly state head loss through the UV unit with all restrictions.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Maintenance Data: For systems to include in maintenance manuals specified in Division

F. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

G. Project Record Documents: Record actual locations of piping and equipment. Revise shop drawings to reflect actual installation.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in manufacturing of UV water treatment equipment and systems similar to those indicated and specified for this project and with a record of successful in-service performance.

B. Installer Qualifications: Engage personnel experienced in advanced water treatment equipment installations similar to that required by this project who are acceptable to the UV treatment equipment manufacturer.

C. Provide listing/approval stamp, label, or other marking on the UV Water Treatment Equipment and related controls indicating that it is made to specified standards.

1.7 MATERIAL RESTRICTIONS

A. The Contractor shall not install any material containing cadmium, brass, bronze, copper, zinc, or their alloys, which could come in contact with fish rearing water. These heavy metal materials have been shown to be toxic to fish.

B. All pump, valve, piping, wetted components, etc. that may come in contact with water shall be a material specified and approved by the Owner.

PART 2 - PRODUCTS

2.1 RAS SYSTEM UV IRRADIATION UNIT (UV-1)

A. The Water UV Irradiation Unit shall be manufactured by Pentair Aquatic Eco-systems, Model Safeguard SLP6071208A21, or approved equal.

1. Acceptable Manufacturers

a) Aquafine Corporation – Contact: (519) 457-2701 ext. 2516
b) Pentair Aquatic Eco-systems. - Contact: (877) 347-4788

2. Manufacturer

a) Any changes to the Contract Documents required to suit the Manufacturer shall be made at no cost to the Owner. Any changes in the design shall be submitted to the Owner for approval.

B. RAS SYSTEM UV IRRADIATION UNIT GENERAL REQUIREMENTS

1. Identification

a)	UV System Name	–	RAS System UV Irradiation Unit
b)	Equipment Number	–	UV-1
c)	Quantity	–	1

2. Operating Conditions

a)	Duty	–	Continuous
b)	Fluid service	–	Fresh water
c)	Transmissivity Assumption	–	85 percent baseline
d)	Fluid temperature (degrees F)	–	32 to 77

3. Key Component Dimensions/Properties

a)	Vessel Construction	–	PVC SCH 80
a)	Inlet	–	8” diameter ANSI 150 lbs. FF flange
b)	Outlet	–	8” diameter ANSI 150 lbs. FF

			flange
c)	Vessel Length (inch)	–	90
d)	Vessel Diameter (inch)	–	12
e)	Number of Lamps	–	7 total, 320 Watt Amalgam Lamps

C. UV IRRADIATION UNIT PERFORMANCE REQUIREMENTS

1. Description of Operation:

Recirculated water in the quantity of 1350 gpm is passed through the UV unit after having been pre-filtered for solids. The UV unit shall be equipped with a UV intensity sensor.

2. Performance Requirements

a)	Design flow capacity (USgpm)	–	1350
b)	Minimum UV Dosage EOL in Germicidal Range	–	30,000 μWsec/cm^2
c)	Maximum Operating Pressure (psi)	–	75
d)	Power Requirements	–	15 A, 240 V, 1 phase, 60 Hz
e)	Control Panel	–	PLC-based main control system – Displays individual lamp status, lamp running time, UV intensity, and water temperature – NEMA 4X construction – 30.0-inch x 24.1-inch x 12.6-inch (H x W x D)
f)	Control Panel Alarm Output	–	Relay, Modbus via RS-485

2.2 GENERAL SYSTEM CONSTRUCTION

A. All metal components in contact with the water shall be Type 316 stainless steel. Aluminum wetted materials shall not be used.

B. All wiring exposed to UV light shall be Teflon coated.

2.3 UV LAMPS

A. Lamps shall be low-pressure amalgam, high intensity type.

B. All lamps within the UV unit shall be completely identical (type, length, diameter, power, output etc.).

C. Lamp life shall be guaranteed at 12,000 operating hours on a pro-rata basis.

D. UV lamps shall not require a long cool down period prior to re-start should the power to the UV system fail or be interrupted for a short period of time. Systems or lamps that require long cooling periods, (e.g., 10–30 minutes) before re-start are not acceptable.

E. The lamps shall be capable of operating in a “No Flow“ condition for a minimum period of 60 minutes without causing any damage to the lamps.

F. The lamp output shall not fluctuate more than 3 percent due to water temperature variations between 33–100ºF.

G. The operating skin temperature of the UV lamp shall not exceed 130ºC in order to minimize the possibility of quartz fouling.

H. The UV manufacturer shall provide Certification of lamp output measured in Watts of UV output at a wavelength of 254 nm.

2.5 UV LAMP ASSEMBLIES

A. Each UV lamp assembly shall consist of a UV lamp, enclosed in an individual quartz sleeve, with the open end appropriately sealed using an O-ring sealed quartz end plug.

B. Lamps shall be removable with the quartz sleeve remaining in place.

C. The UV lamp sleeve shall be a single piece of clear fused quartz circular tubing, open at one end.

D. It shall be rated for a minimum UV transmittance (254 nm) of 92%, which shall not be subject to degradation over the life of the system.

2.6 UV MONITORING SYSTEM

A. A UV sensor shall continuously sense the UV intensity produced in the UV unit.

B. The sensor shall measure only the germicidal portion of the light emitted by the UV lamps as measured at 254 nm; it shall have sensitivity at 254 nm of greater than 95%. Sensors whose sensitivity to other wavelengths amounts to more than 5% of the total sensitivity shall not be allowed.

C. The UV intensity sensor shall be field calibrated.

2.7 ELECTRICAL REQUIREMENTS

A. The electrical system shall be designed to provide:

1. Maximum reliability of the UV disinfection system.
2. Plug and socket quick disconnect facilities enabling non-technical personnel to carry out lamp replacement, etc. without the need for any tools or specialist isolation procedures.

B. All heat sensitive components shall be adequately cooled with dry air utilizing forced or natural ventilation.

C. Systems or designs that subject sensitive electrical or electronic components to excess humidity or poor air quality for cooling are not acceptable.

D. Systems that lack positive mechanical heat transfer such as fans (or air conditioning) for the sensitive electronic components are not acceptable.

E. The enclosure for the UV power supply and PLC shall be NEMA 4X.

2.8 SYSTEM POWER SUPPLY AND PLC

A. The system power supply shall be a separate enclosure to house the system PLC, operator interface, control and instrumentation equipment and plant interface termination points.

B. Electrical power supply to the power supply shall be a single 240 volts / 60 Hz / 1 phase 3 wire with ground, supply.

C. The system power supply shall have an internal single point of isolation and house any power distribution circuits, transformers or power supplies for the UV system requirements.

D. The UV unit main control shall be performed by a PLC.

1. The PLC shall be a standard proprietary unit with no specialist hardware or firmware modifications.
2. Full application software will be generated using the PLC manufacturer’s Proprietary software package.

E. The operator interface for the system will be a commercially available unit with LCD screen and fully compatible with the PLC.

1. The unit shall provide a graphics interface and utilize menu driven screens to allow UV system control, status monitoring, and alarm handling.

F. The operator interface will provide access to all status and control functions for operations personnel.

G. The PLC shall include a communications port for import and export of all UV plant data from / to the main works PLC and or SCADA system via RS-485 Modbus.

H. Low UV intensity alarms shall be provided to detect possible water quality problems or fouling of the system. Alarm set point shall be field adjustable.

I. Individual lamp status shall be monitored by the PLC and provide status information on the operator interface showing:

1. Re-settable lamp run-time hour meter to indicate the total number of hours each lamp has been on.
2. Status Indicator to display the lamp status as on/off and total number of hours the individual lamp has been on.

J. The PLC shall monitor main power indicator status to indicate that the unit has main input voltage.

K. The PLC shall provide a main power on/off disconnect switch.

L. The PLC shall monitor the water temperature in the lamp. The temperature monitor shall have a set point alarm circuit that is used to protect the system from overheating during a no flow situation.

2.9 CONTROL AND INSTRUMENTATION

A. All instrumentation used in the UV Irradiation Unit control or monitoring shall be individually fuse or circuit breaker protected to minimize the effects of any single point of failure.

B. All instrumentation shall be designed for use in the application for which the UV unit is using it.

C. All instrumentation shall be installed as per manufacturer instructions.

D. All instrumentation used for on line process measurement shall be located in the medium it is measuring and not rely on transfer of medium to external reservoirs or chambers where changes in characteristics being measured could occur.

1. This shall apply specifically to Transmittance measurement for the influent and shall preclude any straining or filtering which would clearly effect the characteristics of the medium being measured.

2.10 NUTS, BOLTS WASHERS AND HANGERS

A. Nuts, bolts, washers and threaded rod shall be 316 stainless steel. Hanger and pipe supports shall be 316 stainless steel.

2.11 SPARE PARTS

A. The following spare parts and safety equipment shall be provided as a minimum:

1. RAS System Spares:

a) 1 complete set of UV Lamps (7 lamps total).
b) 1 complete set of additional Lamp Sleeves.
c) 1 complete set of additional Lamp Sealing Rings.
d) 1 replacement UV intensity sensors

PART 3 - EXECUTION

3.1 EXAMINATION

A. All parts of the UV Irradiation Unit shall be properly designed and built for stresses that may occur during fabrication, shipping, installation, and intermittent or continuous operation. Workmanship shall be of high industrial standard in all respects.

B. The UV Irradiation Unit shall come with a Manufacturer's warranty covering both parts and labor for a period of at least one year.

3.2 INSTALLATION

A. The UV Irradiation Unit or official representative shall be available for assistance in the interpretation of installation instructions during installation.

B. The UV Irradiation Unit or official representative shall complete the commissioning of the UV Irradiation Unit after installation is complete.

3.3 COMMISIONING

A. Upon completion of the installation, the UV Irradiation Unit Manufacturer or official representative shall make a site visit to perform commissioning services. Commissioning shall include:

1. Test UV Irradiation Unit for satisfactory operation without excessive noise, vibration, overheating, etc. All equipment shall be adjusted and checked for alignment, clearances, supports, and adherence to safety standards, until found satisfactory. Manufacturer shall repair or modify equipment with factory defaults at their expense.

2. Test UV Irradiation Unit for leaks, defects and compliance with performance requirements. Repair leaks and defects with new materials and retest UV Irradiation Unit or portion thereof until satisfactory results are obtained.

3. Prepare reports for tests and required corrective action. If testing is performed in segments, submit separate report for each test.

B. Provide 4 hours of on-site training to hatchery staff. Training shall include operation, maintenance, and programming as required. Training shall occur after operating and maintenance manuals have been approved by the Owner.

END OF SECTION

SECTION 11393

PROCESS FILTRATION EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope of Work: This division covers the furnishing and installation of self-cleaning rotary drum filter systems as herein specified and as shown on the drawings.

B. Job Site Conditions: The drawings show the various piping and systems schematically, and do not attempt to show exact details of all piping or all offsets that may be required. Proper judgment must be exercised in carrying out the work to secure the best possible headroom and space conditions throughout, to secure neat arrangement of piping, valves, fixtures, and hangers to overcome local difficulties and interference of structural conditions wherever encountered.

1.2 DEFINITIONS AND STANDARDS

A. The work "provide," as used in these specifications, means "furnish and install."

B. The following are industry abbreviations:

1. gpm: Gallons per minute
2. TEFC: Totally Enclosed Fan Cooled
3. HP: Horsepower
4. UHMW PE: Ultra-High Molecular Weight Polyethylene

C. References: The editions referenced herein of Federal Specifications (Fed. Spec.) and of the other standards and specifications published by the following organizations apply to the work only to the extent specified by the reference.

1.	ANSI	American National Standards Institute
2.	AISC	American Institute of Steel Construction
3.	ASME	American Society of Mechanical Owners
4.	ASTM	American Society of Testing Materials
5.	AWWA	American Water Works Association
6.	AWS	American Welding Society
7.	CISPI	Cast Iron Soil Pipe Institute
8.	FM	Factory Mutual Owning Corporation
9.	NBS	National Bureau of Standards
10.	NEC	National Electrical Code
11.	NEMA	National Electrical Manufacturers Association
12.	NFPA	National Fire Protection Association
13.	OSHA	Occupational Safety and Health Administration
14.	SMACNA	Sheet Metal and Air Conditioning Contractors National Association, Inc.
15.	UBC	Uniform Building Code

16. UL Underwriters Laboratories, Inc.

1.3 CODES, PERMITS AND INSPECTIONS

A. Codes: Work shall be installed in conformity with county and state of California codes and ordinances, and state and federal codes and regulations where they apply. Standards and sizes which meet or exceed preceding requirements shall be installed as drawn or specified. Nothing in the specifications shall be construed to permit deviation from the requirements of governing codes.

B. Underwriters' Approval: Where Underwriters Laboratories, Inc., standards exist, all items of electrical equipment shall carry Underwriters Laboratories, Inc. label either for the entire unit or for the electrical portion of the equipment. If standards do not exist, equipment must be field certified to comply with UL.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in manufacturing Rotating Drum Microscreen Filter equipment systems similar to that indicated for this project and with a record of successful in-service performance at this flow rate or greater. Minimum experience of at least 5 installations with an installed service record of 5 years or greater is required.

B. Installer Qualifications: Engage personnel experienced in equipment installations similar to that required by this project who are acceptable to the Rotating Drum Microscreen Filter equipment manufacturers.

C. Provide listing/approval stamp, label, or other marking on the Rotating Drum Microscreen Filter made to specified standards.

D. Labor and Material: The Contractor shall take all measurements, verify all drawings and be responsible for the proper installation in the available space of the equipment specified and shown on the drawings.

E. Drawings and Specifications: The drawings and specifications shall be taken together. Provide work specified and not indicated or work indicated and not specified as though mentioned in both.

1.5 WARRANTY

A. The Rotating Drum Microscreen Filters shall come with a Manufacturer’s warranty covering both parts and labor for a period of at least one year following substantial completion.

1.6 MATERIAL RESTRICTIONS

A. The Contractor shall not install any material containing cadmium, brass, bronze, copper, zinc, or their alloys, which could come in contact with fish rearing water. These heavy metal materials have been shown to be toxic to fish

1.7 SUBMITTALS, APPROVALS AND REVIEWS

A. Submittals shall comply with the requirements of Division 1. Provide complete product data for this section in its entirety. Incomplete or piecemeal submittals will be returned unreviewed.

B. Product Data: Provide product data for each item in Part 2 – PRODUCTS. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation instructions for each type of product indicated.

C. Shop Drawings: Detail piping and equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Schematic flow diagrams showing piping and equipment.
2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
3. Provide drawing indicating control panel locations.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.8 OPERATION AND MAINTENANCE DATA MANUALS

A. Prepare instruction manuals describing the operation, servicing and maintenance requirements of all mechanical equipment provided, and complete parts lists.

B. Information contained in the Manual: Catalog data on the particular item and not the complete "line" of the manufacturer. Index all contents listed in an orderly presentation. Provide the following indexed chapters:

1. Valve identification chart; that correlates data with the tag numbers given on the shop drawings.
2. Test charts and test records.
3. Pressure vessel certificates.
4. Operation and maintenance data for all specified equipment.
5. Guarantee and warranties.
6. Pump and equipment installation certificates.
7. Instructions for lubricating each piece of equipment installed. Instructions shall state type of lubricant, where and how frequently lubrication is required. Lubrication and lubricants especially shall be detailed separately for all equipment and presented for ready reference.
8. Supplementary drawings for servicing and maintenance points.

C. Binding: Secure material with post-type, 3-hole binder with cloth-covered heavy-duty cardboard cover. Imprint front cover with the name of the project, the Owner, the year of completion, the words “EQUIPMENT OPERATING AND MAINTENANCE DATA" and the names of the Owner.

D. Number of Copies: Submit one preliminary copy for approval by 75% project completion. Deliver three (3) final bound copies to the Owner after incorporating review comments, for final approval and delivery to the Owner by the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 DRUM FILTERS

A. General

1. The drum filters consist of the drive-line, filter elements, drum structure, weather cover, spray bar, sludge trough, support bearings, liquid level controls, wing walls, and high pressure rinse system.

2. The Rotating Drum Microscreen Filter shall be a Hydrotech Model HDF 1604 with backwash pump, or approved equal

3. Acceptable Manufacturers
   a. Hydrotech – Distributor Contact: Pranger Enterprises, (260) 587-9309
   b. NP Innovation – Contact: Water Management Technologies, (225) 755-0026

B. Performance Requirements

1. Furnish two drum filter units, complete with separate control panels and instrumentation. Each unit shall be rated as follows

   a. Rated flow: 1350 gpm
   b. Design TSS: 25 mg/L
   c. Screen size: 40 microns
   d. Minimum Screen Area: 77.5 square feet

2. Operating Conditions

   a) Fluid Service – Freshwater

   b) Fluid Temperature (degrees F) – 33–77

   c) Screen Operation – Continuous screening; continuous or intermittent drum rotation and back-wash on demand

   d) Installation Type – Self-contained tank with cover, piped intake and discharge

3. Description of Operation

   a. Standard operation of the microscreen filter is as follows: Untreated process water enters the interior of the rotating drum and disperses radially through the microscreen panels on the drum surface, to the outside of the drum. The screened water is to flow out of the filter through an effluent level control weir that is used to maintain the water level surrounding the drum at a minimum of 40% submergence. For initial clean screen operation, the influent (inside the drum) water levels should be very close to the set effluent water level.

b. As particulate matter is screened from the flow and collects on the screen panels, the headloss across the microscreen filter increases until a "High Level" set point is reached. When this set point is reached, the control system on the microscreen filter will initiate drum rotation, via the motor on the microscreen filter, open the normally closed solenoid on the backwash supply header, and begin operation of the high-pressure backwash pump.

c. Clean water is supplied by the high-pressure backwash pump to the spray header located adjacent to the drum. The flow from this spray header washes off the inner surface of the screen panels into a backwash trough located inside the drum, near the top.

d. As the microscreen filter is backwashed, the headloss through the microscreen filter is reduced, thus reducing the water level in the influent channel. The backwash continues until the user-adjustable time interval has elapsed and the "Normal Level" set point is reached in the influent channel. Once both of these control conditions has been reached, the backwash solenoid is closed, high-pressure backwash pump operation is stopped, and drum rotation is to automatically stop. The filter then continues normal operation until the next backwash cycle begins.

C. Construction Requirements

1. Driveline: The helical worm gearbox shall be coupled to the drum filter drive shaft with riveted roller chain and sprockets. The chain shall run in a continuous oil bath for extended life and corrosion resistance.

2. Filter Element: The filter cloth shall be polyester, bonded to polyethylene grids measuring .8” x .8” x .4”. Each filter element is secured to the drum frame by one filter strap. An individual filter element shall be easily removed without removal or disengagement of additional filter elements. The filter elements shall be sealed to the drum structure utilizing EDPM type gasket material to provide watertight closure. Minimum screen area shall be 77.5 square feet.

3. Drum: The drum and support structure shall be Type 304 Stainless Steel, welded one-piece construction with custom fabricated watertight inlet channel. Four support blades shall support each filter element. The end ring at the inlet side of the drum structure serves as the roller bearing track. The drum shall be supported on a three point bearing system. The drum shaft shall be constructed of AISI 316SS and bolted to the drum structure. The open end of the drum shall be supported by two single idler wheels.

4. Spray Bar: The drum filter shall have one common spray bar providing 5 nozzles per filter element width to provide overlapping coverage. A quick release type nozzle shall be used to allow for easy cleaning. The quick release nozzle shall be made of a nylon cap and stainless steel spray tip.

5. Sludge Trough: The trough is capable of capturing solids from top dead center to 75º in clockwise direction from the inlet end view. Lateral arms attached to the drum frame support the sludge trough, permitting the drum to rotate unobstructed. Under normal operation, with a clean drum screen, the water level inside the drum will be 1-foot below the sludge trough rim elevation.

6. High Pressure Rinse System: The system shall consist of a motor starter/overload relay, and vertical multi-stage booster pump. Appropriate lengths of 1/2" flexible non-metallic conduit with watertight connectors shall be provided for connection from the liquid level control to the booster pump and solenoid valve. The motor starter/overload relay shall be incorporated into the liquid level control panel to provide control in conjunction with the drum filter operation. Pump motor shall be 1.5 hp, 240 V, 3 ph, 60 Hz, submersible well pump with sleeve to force water past motor to pump suction. Provide a second liquid level control switch to run drive motor continuously if minimum-low water level outside drum is reached.

7. Drive Motor: 1/3 hp, 240 V, 3 ph, 60 Hz, TEFC, VFD Control.

8. Drum Filter assembly shall have removable cover for weather protection.

D. Controls and Instrumentation

1. Each microscreen drum filter shall be furnished with a Local Control Panel which houses all electrical components. The enclosure shall be Allied Moulded NEMA 4X fiberglass enclosures, or equal. Each local control panel shall be equipped with the following:

   a. Three position selector switch (hand-off-auto)
   b. VFD for drum motor, AB Power Flex 4m or equal.
   c. Contactor and motor protector for pump
   d. Quick clamp terminal blocks
   e. Central PLC – AB Micrologix 1500 or equal
   f. 75 VA/120 VAC Control Voltage Transformer
   g. Run-time meter

2. The three-way "Hand- Off -Auto" selector switch shall simultaneously control the backwash solenoid, the high-pressure backwash pump, and the drum drive motor. The microscreen filter operates according to the following logic:

   a. "Hand" Setting: Operator selection of the "Hand" mode will result in continual rotation of the drum and backwashing of the screen panels via continual operation of the drum drive motor, the high-pressure backwash pump, and the opening of the backwash solenoid.
   b. "Off" Setting: The "Off" mode does not allow the backwash solenoid to open, the high-pressure backwash pump to operate, or the drum drive motor to operate.
   c. "Auto" Setting: Operator selection of the "Auto" mode will result in intermittent backwashing (drive motor operation) based upon an input signal sent to the local control panel from the inlet channel level sensor. Backwashing is to commence when the water level in the filter reaches a "high level" float switch. In the "Auto" mode, the backwash system will be deactivated when the water level reaches a low level switch and when a preset time delay interval (operator adjustable from 2 to 60 seconds), expires.

3. Variable Frequency Drive (VFD) Controller: The VFD controller shall control the drum drive motor to ramp-up the drum rotation from standing to full rotational speed upon initiation of drum rotation. The VFD will also ramp-down the drum rotation from full rotational speed to a stop upon cessation of the automatic backwash sequence or through

manual “Hand” and “Off” signals from the local control panel. Rotational speed ramp-up and ramp-down should occur over an approximately 10–15 second time period.

4. Level Sensors: Four 316SS mechanical float switches, 2 Auto and 2 Alarm Level shall be furnished for each drum filter unit and wired to the respective local control panel. Level sensor shall be magnetic float switch type. Level sensor model shall be determined by the Manufacturer but shall be guaranteed for a minimum service of 3 years. Elevation of level sensor shall be field adjustable.

5. The Manufacturer shall supply appropriate lengths of ½” flexible non-metallic conduit with watertight connectors for connection from the liquid level control to the gear box and float switches.

E. Spare Parts: The following spare parts shall be provided for each drum screen unit:

1. One complete set of spare 40 micron screen panels complete with associated stainless steel fasteners.
2. One complete set of backwash nozzle assemblies

F. Start up and Training: Contractor to have factory authorized representative on site for 16 hours to verify installation of equipment and perform initial start-up and trouble-shooting. A second site visit for Owner training shall be conducted 1-2 months after system startup.

PART 3 - EXECUTION

3.1 GENERAL

A. This section covers general installation of the process water treatment systems specified. Specific installation requirements for the equipment are to be as specified herein, or per the manufacturer’s instructions if installation requirements are not specified herein. Contractor shall establish quantities, verify space requirements, dimensions and possible interferences with other trades

3.2 CUTTING AND PATCHING

A. Contractor's responsibility shall include, but not be limited to the following:

1. Accurately locate all such openings and coordinate work with the General Contractor in order to properly complete this work within the General Contractor's time schedule.
2. Furnish the necessary drawings to the trades whose materials must be cut or fitted.
3. Furnish sleeves, inserts, anchor bolts and similar items set into concrete or masonry or the work of other trades, and be responsible for the exact location of all such items.
4. Do all drilling and cutting of holes in steel and fiberglass decks required for sleeves and supports. All additional openings required through existing slabs or walls shall be drilled with a diamond core drill and in no case shall any structural member be cut without approval of Structural Owner.

3.3 INSTALLATION OF EQUIPMENT

A. The Contractor shall install equipment in strict accordance to the manufacturer's written instruction, as required for complete workable systems.

B. The Rotating Drum Microscreen Filter Manufacturer or official representative shall be available for assistance in the interpretation of installation instructions during installation.

C. The Rotating Drum Microscreen Filter Manufacturer or official representative shall complete the commissioning of the Rotating Drum Microscreen Filter after installation is complete

3.4 SYSTEM START-UP OPERATIONS

A. Upon completion of the installation, the Rotating Drum Microscreen Filter Manufacturer or official representative shall make a site visit to perform commissioning services. Obtain approval of schedule and coordinate operational testing with equipment suppliers, Owner's Representative and Owner. Commissioning shall include:

1. Test Rotating Drum Microscreen Filters for satisfactory operation at design flows without excessive noise, vibration, overheating, etc. All equipment shall be adjusted and checked for alignment, clearances, supports, and adherence to safety standards, until found satisfactory. Manufacturer shall repair or modify equipment with factory defaults at their expense.

2. Test Rotating Drum Microscreen Filters for leaks, defects and compliance with performance requirements in both "manual" and "automatic" modes. Repair leaks and defects with new materials and retest Rotating Drum Microscreen Filter or portion thereof until satisfactory results are obtained.

3. Prepare reports for tests and required corrective action. If testing is performed in segments, submit separate report for each test.

B. All testing shall be made in the presence of the Owner's representative. The Contractor shall have available during the entire start-up period a supervisor, an electrician, and a plumber to make any adjustments or corrections required to start or continue to operation of the system.

C. Provide 4 hours of on-site training to hatchery staff. Training shall include operation, maintenance, and programming as required. Training shall occur after operating and maintenance manuals have been approved by the Owner.

3.5 PROJECT CLOSE-OUT REQUIREMENTS

A. General Requirement: Completion of each of the following items are conditional to acceptance of the work by the Owner:

1. Guarantee: Submit guarantee of materials and workmanship.
2. System Start-up Operations: Provide materials and labor for system start-up operations.

3. O&M Data: Submit Operating and Maintenance Data Manual. Include complete product data, manufacturer’s maintenance instructions, start-up and trouble shooting procedures. Manual shall be in standard 3-ring binder with divider sheets for major sections.
4. Record Drawings: Submit Record Drawings ("As-Builts") to the Owner.
5. Clean up: Comply with requirements for cleaning equipment and premises.
6. Detachable Parts: Deliver to the Owner's Representative with receipt requested all special tools required for proper operation and maintenance of the equipment, portable/detachable parts, keys or other devices provided.
7. Provide all spare parts.

END OF SECTION 11393

SECTION 13215 – FRP VESSELS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the Fiber Reinforced Plastic vessels for the Treatment System Pump Sump, Carbon Dioxide Stripper, and Low Head Oxygenator Sump.

1.3 DEFINITIONS

A. The following are industry abbreviations:

1. FRP: Fiber reinforced plastic
2. gpm: Gallons per minute

1.4 SYSTEM PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of performance requirements stated in PART 2 – PRODUCTS, unless otherwise indicated.

1.5 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

1. Provide submittals as required in PART 2 – PRODUCTS, 2.1 FRP VESSELS, D. MANUFACTURER FURNISHED DRAWINGS AND INFORMATION, for each item in PART 2 – PRODUCTS.

B. Product Data: Provide product data for each item in PART 2 – PRODUCTS. Indicate dimensions, capacities, performance characteristics, finishes for materials, and installation instructions for each type of product indicated.

C. Shop Drawings: Detail piping and equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Schematic flow diagrams showing piping and equipment.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Maintenance Data: For systems to include in maintenance manuals specified in Division 1.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in custom FRP vessel manufacture similar to that indicated for this project and with a record of successful in-service performance in similar applications. Minimum experience of at least 10 installations with an installed service record of 5 years or greater is required.

B. Installer Qualifications: Engage personnel experienced in FRP vessel installations similar to that required by this project who are acceptable to the FRP vessel manufacturers.

C. Provide listing/approval stamp, label, or other marking on the FRP vessels indicating that they are made to specified standards.

1.7 MATERIAL RESTRICTIONS

A. The Contractor shall not install any material containing cadmium, brass, bronze, copper, zinc, or their alloys, which could come in contact with fish rearing water. These heavy metal materials have been shown to be toxic to fish.

B. All pump, valve, piping, wetted components, etc. that may come in contact with water shall be a material specified and approved by the Owner.

PART 2 - PRODUCTS

2.1 FRP VESSELS

A. GENERAL

1. Industry Standards: Equipment shall meet the requirements of ASTM D-3299 for filament wound tanks and ASTM D-4097 for custom contact molded equipment and the current applicable portions of ASME RTP-l.

2. Applicable Documents: This specification together with the attached drawings, plus any referenced codes or standards, constitutes a complete set of requirements for the equipment. Should a conflict occur between any of the applicable documents, the discrepancy should be brought to the attention of the Owner.

3. Miscellaneous Details: All equipment shall be furnished complete, including all accessories as shown on provided drawings, unless otherwise indicated.

4. Nameplates: Vessels built to these specifications shall have the following information imprinted on the stainless steel nameplate:

a) Name of Manufacturer
b) Capacity in Gallons
c) Chemical Environment
d) Manufacturer Serial Number
e) Year built
f) Name & Equipment Number
g) Purchase Order Number
h) Maximum Specific Gravity
i) Design Pressure & Temperature
j) Resin

B. MATERIALS OF CONSTRUCTION

1. Resin

a) All material shall conform to the specified purchasing specifications. The resin, unless otherwise specified shall be as produced by Reichhold, Dow, Ashland or approved equal. The same resin shall be used throughout the laminate unless otherwise specified.

b) The resin used shall not contain fillers, unless specified. When specified up to 2% by weight thixotropic agent, Cab-O-Sil, or equal, may be used for viscosity control in the paraffinated top coat on vertical surfaces, provided it will not interfere with visual inspection. No dyes or pigments will be used unless otherwise specified.

c) Unless otherwise agreed upon by the Manufacturer and the Owner, the cure system used for the resin shall be in accordance with the resin manufacturer's current recommendations. Proper curing of the resin is

the FRP vessel Manufacturer's responsibility. All products fabricated to this specification shall be cured to at least 90% of the minimum Barcol Hardness specified by the resin manufacturer. This requirement applies to both interior and exterior surfaces. (Note: The use of paraffin in the resin or the use of synthetic veil may lower the Barcols below the resin manufacturer's specifications, this is acceptable.)

d) A separately cured, un-reinforced gel coat shall not be used.

e) No chemical-resistant surface, interior or exterior, shall be acetone sensitive. Where application of polyester film to prevent air inhibition of these surfaces is impractical, a wax containing resin coating, formulated to the resin manufacturer's most recent recommendations must be used. The minimum thickness of the polyester film shall be 0.004 inch.

2. Reinforcement

a) Chemical surfacing mat (veil) shall be Type "C" (chemical) glass, with a silane finish and a binder compatible with the lay-up resin or a synthetic veil (Nexus), 10–16 mils thick.

b) Chopped strand mat shall be Type E (electrical borosilicate) glass, 1 1/2 oz per sq. ft., with a silane finish and a styrene-soluble reactive binder.

c) Continuous roving used in chopper gun for spray-up shall be Type E.

d) Woven roving shall be Type E glass, nominal 24 oz./sq. yd., 4 by 5 weave, with a silane-type finish.

e) Continuous roving used for filament winding shall be Type E.

3. Laminate Construction for Filament-Wound Vessels

a) Inner Surface shall be 0.010 to 0.020 inches (250 to 500 microns) thick reinforcement surfacing veil (type of veil as indicated on the quotation and/or drawing). The amount of reinforcement required to prevent cracking in the resin-rich surface shall be as determined by the FRP vessel Manufacturer.

b) Corrosion resistant liner to be provided utilizing the specific resin system and a minimum of 105 mils of chopped strand mat, mechanically applied.

c) Tank Structural laminate is to be fabricated utilizing the chopped hoop filament winding procedure, incorporating continuous filament winding glass interwoven with chopped strand grass and the specified resins system throughout.

C. DESIGN

1. General: It is the object of this standard, the associated drawings and specifications to afford the Manufacturer as much design latitude as possible, consistent with the basic requirements. Therefore, it is intended that the Manufacturer will have ample opportunity to utilize his particular "know-how" in the design and details of equipment fabrication in order to produce equipment which will be adequate for the intended purpose and at a minimum cost.

2. Design of Details: Details are often indicated without being fully designed. This permits the equipment Manufacturer to submit a design for approval, and it is intended that the Manufacturer furnish a design based on the information given which will meet the requirements of the job regarding strength, corrosion resistance and workability.

3. Design Basics

   a) For custom contact molded storage tanks subject to hydrostatic head, the design stress shall be 10% of the minimum ultimate tensile stress of the selected laminate thickness thereby providing a factor of safety of 10:1 against shell or head rupture.

   b) For filament wound storage tanks subject to hydrostatic head, the design stress shall be determined by the following formula:

      $S_H = (E_T)(Z)$ where:
      S_H = Hoop Stress used for design -psi
      E_T = Hoop Tensile Modulus of the total laminate –psi
      (See Appendix XI of ASTM D-3299)
      Z = Allowable Strain = 0.0010 in/in Max.

   c) For ducts, pipe and equipment other than atmospheric storage tanks, the design basis shall be as specified.

4. Tanks and similar equipment for installation outdoors shall be checked for wind loading. Four or more tie down lugs shall be provided for vertical tanks.

5. Other design requirements shall be considered such as stiffening in top heads, stiffener rings for agitated tanks, lifting lugs, seismic considerations, etc.

D. MANUFACTURER FURNISHED DRAWINGS AND INFORMATION

1. Approval Drawings

   a) Prior to beginning fabrication, the Manufacturer shall submit to the Owner a detailed drawing for approval. These drawings shall include the following:

      1. All information as supplied by the Owner.

      2. Certified dimensions of overall equipment, thickness and attachments.

3. Construction specifications.

4. Maximum temperature.

5. Maximum specific gravity and pressure.

6. Shop testing procedures.

7. Nozzle schedule, including size, mark, thickness and attachments.

8. Details of all nozzles, joints, and reinforcements.

9. Details of all ladders, lifting, tie down, or support lugs.

10. Specifications for all supplies, bolting and gaskets, and accessory items.

11. Equipment weight, empty and filled with water (lbs.)

12. Equipment capacity (gallons).

13. UV absorbers, pigments or applicable gel coats.

14. Customer purchase order number, project number, and equipment number.

15. All material of construction and laminate sequence of construction.

16. Method used for post heat curing, if applicable.

2. Design Calculations: If requested by the Owner, two copies of detailed design calculations shall be submitted for approval prior to beginning fabrication.

3. Approval of the Manufacturer's drawings, procedures and calculations shall not relieve the Manufacturer of the responsibility for the proper and efficient design of the equipment.

4. The Manufacturer's bill of materials, if requested, will list all component materials which are intended for use in fabrication of the quoted order. This included resins, catalysts, and promoters, UV absorbers, thixotropic and parting agents, etc., and all reinforcing materials. The list shall include the component manufacturer's name, trade name, and identifications marks.

E. FABRICATION REQUIREMENTS

1. General

a) The Manufacturer shall not sublet any component assembly without first obtaining written permission from the Owner.

b) The pigment color shall be selected by the Owner. The contractor shall submit color samples for approval. The pigment shall be dispersed in resin used for the finish coat of the laminate.

2. Shell and Head Requirements – Storage Tanks and Equipment

a) The minimum wall thickness shall be 0.1875 inch regardless of operating conditions.

b) On storage tanks equipped with agitators, the shell shall be reinforced with external circumferential reinforcing ribs in order to provide suitable rigidity.

c) Open-top, vertical tanks shall be constructed with a horizontal flange or reinforcing ring at the top of the tank shell of sufficient rigidity to maintain the shape of the tank.

d) Where top heads of vertical tanks are required to support operating personnel, auxiliary equipment or snow loads, stiffener rods, thickening of heads or other means shall be used to provide structural rigidity.

e) Top heads of all vertical tanks and equipment shall be ASME flanged and dished, unless otherwise specified.

f) Unless otherwise specified, all vertical tanks shall be of flat- bottomed construction, continuously supported on a flat concrete pad, or equivalent.

g) The knuckle radius of all flat-bottom tanks shall be 3.5 inch minimum.

h) Body flanges, when specified, shall be flat and true to a tolerance of plus or minus 0.03125 inch. If machining is required, the machined surface shall be faced with veil. Finished machined flange thickness shall not be less than that specified.

3. Equipment and Tank Connections

a) Unless otherwise specified, all connections on equipment and tanks shall be 150# F.F. flanges.

b) Manways on storage tanks and equipment shall be 24 inch inside diameter minimum.

c) All flanges shall be fabricated via the "hand lay-up" method. Press molded flanges are not permitted.

d) Flange drilling on pipe connections shall be in accordance with ANSI B-16.5 for 150 psi pressure class.

e) All nozzles 4 inch and smaller shall be reinforced with conical gussets. Plate gussets may be substituted upon customer request.

f) Bolt holes in flanged nozzles are to straddle the vessel's main centerline. Tolerance in bolt hole locations and in diameter of the bolt circle shall be plus or minus ¼ inch.

g) On all flanged joints, 0.125 inch minimum thickness full-faced elastomeric gaskets having a Shore A Durometer hardness of 60±5 shall be provided.

F. CLEANING

1. Prior to inspection, all dirt and extraneous materials shall be removed from the equipment interior. The Manufacturer shall remove all surface markings prior to the inspection.

G. INSPECTION, TESTS, AND ACCEPTANCE

1. The Owner shall be permitted access to the applicable plant area at all times during fabrication and shall be notified one week prior to the estimated date of tests and/or inspection(s). Final inspection and approval by the Owner shall be obtained prior to shipment unless waived in writing. A clearance for shipment shall not relieve the Manufacturer of responsibility as to performance guarantee, quality of material and workmanship, and dimensional conformity with the drawings.

2. Shop Inspections

a) A visual inspection of the laminate shall be made by the manufacturer. Laminate defects and the permissible limits shall be in accordance with the following table:

Defect	Process Surface	Non-Process Surface
Blisters	None	Max ¼ inch diameter, 0.0625 inch high
Burned Areas	None	None
Chips	None	Max ¼ inch with Max thickness 20% of wall
Cracks	None	None
Crazing	None	Slight
Dry Spots	None	Max 2 sq. in./sq. ft.
Entrapped Air	None at Surface	0.125 inch diameter max; no more than 3% laminate, 0.0625 inch

		diameter of area, max 10/sq. in.
Exposed Glass	None	None
Exposed Cut Edges	None	None
Foreign Matter	None	None if it effects the properties of the laminate
Pits	Max 0.125 inch by 0.03125 inch deep, max 10/sq. ft.	Max 0.125 inch diameter by 0.0625 inch deep
Scratches	None (Coated)	None (Coated)
Surface Porosity	None	None
Wrinkles	Max deviation 20%	Max deviation 20%
Sharp Discontinuity	None	None

3. The shop inspection of the equipment shall include the following:

   a) Check for compliance with drawing dimensions and adherence to construction standards.

   b) An acetone wipe test to verify surface cure. No surface tackiness is permitted.

   c) All Barcol readings shall be a minimum of 90% of the resin manufacturer's recommendations. Note: Nexus surfacing veil may drop the Barcol reading an additional 10 points.

   d) Nozzle cutouts shall be tagged and stored for five (5) years minimum. Physical property tests may be run if deemed necessary by the Owner in advance. The Owner is responsible for all costs of said tests.

   e) When specified, a hydrotest of at least 24 hours duration to check for leaks.

H. SHIPPING

1. Transportation, off-loading, and installation shall be in accordance with the Manufacturer’s guidelines.

2.2 TREATMENT SYSTEM PUMP SUMP (PS-1)

A. The Treatment System Pump Sump shall be a custom FRP vessel manufactured according to the specification for FRP vessels in this section, PART 2 – PRODUCTS, 2.1 FRP VESSELS.

1. Acceptable Manufacturers

a) Reiff Manufacturing – Contact: (509) 525-1081
b) Water Management Technologies – Contact: (225) 755-0026
c) Pentair Aquatic Eco-systems, Inc. – Contact: (407) 992-5515
d) Red Ewald, Inc. – Contact: (800) 242-3524

2. Manufacturer

a) Any changes to the Contract Documents required to suit the Manufacturer shall be made at no cost to the Owner. Any changes in the design shall be submitted to the Owner for approval.

B. TREATMENT SYSTEM PUMP SUMP GENERAL REQUIREMENTS

1. Identification

a)	Equipment Name	–	Treatment System Pump Sump
b)	Equipment Number	–	PS-1
c)	Quantity	–	1

2. Operating Conditions

a)	Duty	–	Continuous
b)	Fluid service	–	Freshwater
c)	Fluid temperature (degrees F)	–	32 to 77
d)	Maximum Water Level (inches)	–	5.5

3. Key Component Dimensions: See the drawing set for detail dimensions, port orientation, and other required accessory dimensions. Major dimensions are as follows:

a)	Diameter (ft)	–	11
b)	Height (ft)	–	6.5
c)	Top Opening Diameter (ft)	–	11

d)	Inlet Port from Microscreen Filter	–	Two 16-inch diameter PVC SCH40 pipe stubs – Tangential inlet orientation
e)	Inlet Port from Bypass	–	N/A
f)	Overflow Standpipe Port	–	12-inch diameter 150 lbs. ANSI FF FRP flange
g)	Pump Suction Ports	–	Two 10-inch diameter PVC SCH40 socket couplings – Interior and exterior of ports to have PVC SCH40 socket couplings

4. Treatment System Pump Sump Sidewall Box Dimensions: See the drawing set for detail dimensions, orientation, and other required accessory dimensions. Major dimensions are as follows:

a)	Length (inch)	–	1.75
b)	Width (inch)	–	1.75
c)	Depth (inch)	–	3.2
d)	Outlet	–	Box to have one 12-inch diameter PVC SCH40 standpipe and socket coupling outlet

C. TREATMENT SYSTEM PUMP SUMP PERFORMANCE REQUIREMENTS

1. Description of Operation

a) In normal operation the Treatment System Pump Sump shall receive up to 1,350 gpm of water from either or a combination of the RAS or the Raw Water, Rotating Drum Microscreen Filter (DF-1, DF-2) via the 16-inch pipe inlets. Water shall be pumped from the Pump Sump by its respective Water Pumps (P-1, P-2). The water level in the Pump Sump shall primarily be set with the overflow standpipe within the sump.

D. TREATMENT SYSTEM PUMP SUMP CONSTRUCTION REQUIREMENTS

1. The Treatment System Pump Sump shall be manufactured according to the specification for FRP vessels in this section, PART 2 – PRODUCTS, 2.1 FRP VESSELS.

2. The Treatment System Pump Sump shall be engineered by the Manufacturer to account for fluid service and loading conditions described in this section and in the drawing set.

3. Inside Overflow Standpipe Details for the Treatment System Pump Sump:

a) The Inside Overflow Standpipe shall be included with the Treatment System Pump Sump.

b) The Inside Overflow Standpipe shall be a two-stage design with a 4-inch diameter first stage and a 12-inch diameter second stage.

c) The Inside Overflow Standpipe shall be constructed of PVC SCH40 piping.

E. NUTS, BOLTS, WASHERS AND HANGERS

1. Nuts, bolts, washers and threaded rod shall be 316 stainless steel. Hanger and pipe supports shall be 316 stainless steel.

F. SPARE PARTS

1. None required.

2.3 CO2 STRIPPER (CS-1)

A. The CO2 Stripper shall be a custom FRP vessel manufactured according to the specification for FRP vessels in this section, PART 2 – PRODUCTS, 2.1 FRP VESSELS.

1. Acceptable Manufacturers

a) Reiff Manufacturing – Contact: (509) 525-1081
b) Water Management Technologies – Contact: (225) 755-0026
c) Pentair Aquatic Eco-systems, Inc. – Contact: (407) 992-5515
d) Red Ewald, Inc. – Contact: (800) 242-3524

2. Manufacturer

a) Any changes to the Contract Documents required to suit the Manufacturer shall be made at no cost to the Owner. Any changes in the design shall be submitted to the Owner for approval.

B. CO2 STRIPPER GENERAL REQUIREMENTS

1. The CO2 Stripper shall have a skirt for vessel support.

2. The CO2 Stripper shall be connected to the Low Head Oxygenator (LHO-1) by a connecting flange and transition channel.

3. Identification

a) Equipment Name – CO2 Stripper

b) Equipment Number – CS-1

c) Quantity – 1

4. Operating Conditions

a) Duty – Continuous

b) Fluid service – Freshwater

c) Fluid temperature (degrees F) – 32–77

d) Maximum Water Level (inches) – n/a

5. Dimensions: See the drawing set for detail dimensions, flange sizes and orientation, and other required accessory dimensions. Major dimensions are as follows:

a) Diameter (ft) – 6.5

b) Height (ft) – 13.75

C. CO2 STRIPPER PERFORMANCE REQUIREMENTS

1. Description of Operation:

a) In normal operation, the CO2 Stripper shall receive up to 1,350 gpm of treated process water or clean river water via its respective inlet structure.

b) Process water enters the CO2 Stripper at the top through the nozzle plate and flows down through the plastic media within the vessel. Process water flows out of CO2 Stripper through a flanged opening into the Low Head Oxygenator unit (LHO-1) via a transition channel.

c) An inline fan (F-1; Fantech FKD 14XL) will draw ambient air, through the CO2 Stripper (counter-current to the cascading water) and demister box, and out of the CO2 Stripper. The fan shall provide a constant airflow of 1,350 SCFM through the CO2 Stripper against 1.0-inch W.G. static pressure. Fan shall be provided with the CO2 Stripper.

D. CO2 STRIPPER CONSTRUCTION REQUIREMENTS

1. The CO2 Stripper shall have two inlet structures to connect to piping from the river water pump station and the treatment system facility. Inlets shall be 12-inch PVC SCH40 socket couplings.

2. The CO2 stripper shall have a rectangular flanged outlet that is 4.5-ft wide by 1.5-ft deep.

3. CO2 Stripper Internals: The Contractor shall be responsible for supplying and installing the CO2 Stripper Internals.

    a) Nozzle Plate: The Nozzle Plate shall be 6.5-ft in diameter, divided into 4 sections, and constructed of 304/304L stainless steel or FRP with a minimum thickness of 0.1875-inch. Nozzle Plate sections shall each have two handles for easy lifting; handles shall be constructed of the same material as the Nozzle Plate. The plate shall have 156 1.75-inch diameter holes spaced as indicated in the drawings, but that do not conflict with the underlying support beam or ring. 156 XF Crown Nozzles shall be installed into the holes in Nozzle Plate. The XF Crown Nozzles shall have 1-inch diameter orifice inserts. Minimum flooding on the Nozzle Plate shall be at least 4–6-inches at all times during operation. Maximum flooding on the Nozzle Plate shall not exceed 12-inches. XF Crown Nozzle Contact: L.S. Enterprises, 239-543-1258.

    b) Plastic Media: The plastic media inside the CO2 Stripper shall be 2-inch diameter ring-type polypropylene random plastic packing. Plastic media should be 39-inches deep within the CO2 Stripper. Plastic Media Contact: Raschig-USA, Inc., 800-678-0345.

    c) FRP Packing Support Grating: The plastic packing shall be supported within the CO2 Stripper by FRP grating with a minimum thickness of 1-inch. The grating shall have square openings 1.5-inch by 1.5-inch, with an open area of 70%. The grating shall be 6.5-ft diameter, and shall rest on a support lip and support beam. FRP grating packing support contact: McNichols, 877-884-4653.

    d) The CO2 Stripper shall be furnished with an inline fan (F-1). Acceptable fan Manufacturer and Model: Fantech Product FKD 14XL or approved equal.

4. The CO2 Stripper shall have an attached demister box with removable demister media. The demister box shall be 14-inches wide by 12-inches tall by 42-inches long with a removable end plate. The demister box shall support the weight and vibration of the associated inline fan. A 5.25-inch deep by 14-inches wide by 42-inches long section of plastic media inside the Demister Section shall be Brentwood Industries CF80Max Drift Eliminator. The media shall be cut by the plastic media supplier for installation into the Demister Section. CF80Max, Contact: L.S. Enterprises, 239-543-1258.

5. The CO2 Stripper shall have 60° cone-bottom with a skirt for vessel support. The skirt shall have a manway for access to the bottom of the CO2 Stripper, as specified in the drawing set.

6. Shipping

    a) Transportation, off-loading, and installation shall be in accordance with the Manufacturer’s guidelines.

E. NUTS, BOLTS, WASHERS AND HANGERS

1. Nuts, bolts, washers and threaded rod shall be 316 stainless steel. Hanger and pipe supports shall be 316 stainless steel.

F. SPARE PARTS

1. None required.

2.4 LOW HEAD OXYGENATOR SUMP (LHOS-1)

A. The LHO Sump shall be a custom FRP vessel manufactured according to the specification for FRP vessels in this section, PART 2 – PRODUCTS, 2.1 FRP VESSELS.

1. Acceptable Manufacturers

a) Reiff Manufacturing – Contact: (509) 525-1081
b) Water Management Technologies – Contact: (225) 755-0026
c) Pentair Aquatic Eco-systems, Inc. – Contact: (407) 992-5515
d) Red Ewald, Inc. – Contact: (800) 242-3524

2. Manufacturer

a) Any changes to the Contract Documents required to suit the Manufacturer shall be made at no cost to the owner. Any changes in the design shall be submitted to the Contracting Officer or COTR for approval.

B. LHO SUMP GENERAL REQUIREMENTS

1. Identification

a) Equipment Name – LHO Sump

b) Equipment Number – LHOS-1

c) Quantity – 1

2. Operating Conditions

a) Duty – Continuous

b) Fluid service – Freshwater

c) Fluid temperature (degrees F) – 32–77

d) Maximum Water Level (ft) – 5.25

3. Key Component Dimensions: See the drawing set for detail dimensions, flange sizes and orientation, and other required accessory dimensions. Major dimensions are as follows:

a)	Diameter (ft)	–	8.5
b)	Height (ft)	–	5.75
c)	Outlet to Rearing Channel	–	16-inch diameter PVC SCH40 socket coupling
d)	Outlet to Overflow	–	16-inch diameter PVC SCH40 socket coupling
e)	Outlet to Rearing Tanks	–	8-inch diameter PVC SCH40 socket coupling
f)	Slope Bottom	–	Shall have 5º slope to drain
g)	Drain	–	3-inch diameter PVC SCH40 piping

C. LOW HEAD OXYGENATOR SUMP PERFORMANCE REQUIREMENTS

1. Description of Operation

a) In normal operation the LHO Sump shall support its associated Low Head Oxygenator (LHO-1) and receive up to 1,350 gpm of process water flowing through the CO2 Stripper and Low Head Oxygenator or flowing through the Cooling Tower and Low Head Oxygenator. The LHO Sump shall hold water to the level specified in the drawing set to provide the water head pressure required to supply the Rearing Channel and Tanks. The LHO Sump shall maintain the specified constant water level utilizing a sidebox standpipe overflow; the overflow drains to the existing onsite overflow piping.

D. LOW HEAD OXYGENATOR SUMP CONSTRUCTION REQUIREMENTS

1. The LHO Sump shall be manufactured according to the specification for FRP vessels in this section, PART 2 – PRODUCTS, 2.1 FRP VESSELS.

2. The LHO Sump shall be engineered by the Manufacturer to account for fluid service and loading conditions described in this section and in the drawing set.

3. The LHO Sump shall amply support the Low Head Oxygenator (LHO-1).

4. The LHO Sump shall have a 5° slope-bottom with a skirt for vessel support. The skirt shall have an access port to the bottom drain of the LHO Sump.

5. The LHO Sump shall have a 3-inch diameter PVC ball valve and 3-inch diameter PVC SCH 40 piping to connect to the 3-inch diameter flanged bottom drain of the LHO Sump as indicated in the drawings.

E. NUTS, BOLTS, WASHERS AND HANGERS

1. Nuts, bolts, washers and threaded rod shall be 316 stainless steel. Hanger and pipe supports shall be 316 stainless steel.

F. SPARE PARTS

1. None required.

PART 3 - EXECUTION

3.1 GENERAL

A. All FRP vessels shall be properly designed and built for stresses that may occur during fabrication, shipping, installation, and intermittent or continuous operation. Workmanship shall be of high industrial standard in all respects.

B. The FRP vessels shall come with a Manufacturer's warranty covering both parts and labor for a period of at least one year.

3.2 INSTALLATION

A. The FRP vessel Manufacturer shall be available for assistance in the interpretation of installation instructions during installation.

3.3 COMMISIONING

A. Upon completion of the installation, the Contractor shall perform the following commissioning services:

1. Test for leaks and defects in the FRP vessel by performing a hydrostatic test. Hydrostatic testing shall be completed by filling the vessels to their anticipated operating water levels and closing off all outlets. These water levels must be maintained without adding water for a 24-hour period. Repair leaks and defects with new materials and retest until satisfactory results are obtained.

2. Prepare reports for tests and required corrective action. If testing is performed in segments, submit separate report for each test.

END OF SECTION

SECTION 13341

METAL BUILDING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Structural-steel framing.
2. Metal roof panels.
3. Metal wall panels.
4. Metal soffit panels.
5. Thermal insulation.
6. Personnel doors and frames.
7. Accessories.

B. Related Requirements:

1. Section 083323 "Overhead Coiling Doors" for coiling vehicular doors in metal building systems.

1.3 DEFINITIONS

A. Terminology Standard: See MBMA's "Metal Building Systems Manual" for definitions of terms for metal building system construction not otherwise defined in this Section or in standards referenced by this Section.

1.4 COORDINATION

A. Coordinate sizes and locations of concrete foundations and casting of anchor-rod inserts into foundation walls and footings. Anchor rod installation, concrete, reinforcement, and formwork requirements are specified in Section 03300 "Cast-in-Place Concrete."

B. Coordinate metal panel assemblies with rain drainage work, flashing, trim, and construction of supports and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.5 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site**.**

1. Review methods and procedures related to metal building systems including, but not limited to, the following:

    a. Condition of foundations and other preparatory work performed by other trades.
    b. Structural load limitations.
    c. Construction schedule. Verify availability of materials and erector's personnel, equipment, and facilities needed to make progress and avoid delays.
    d. Required tests, inspections, and certifications.
    e. Unfavorable weather and forecasted weather conditions and impact on construction schedule.

2. Review methods and procedures related to metal roof panel assemblies including, but not limited to, the following:

    a. Compliance with requirements for purlin and rafter conditions, including flatness and attachment to structural members.
    b. Structural limitations of purlins and rafters during and after roofing.
    c. Flashings, special roof details, roof drainage, roof penetrations, and condition of other construction that will affect metal roof panels.
    d. Temporary protection requirements for metal roof panel assembly during and after installation.
    e. Roof observation and repair after metal roof panel installation.

3. Review methods and procedures related to metal wall panel assemblies including, but not limited to, the following:

    a. Compliance with requirements for support conditions, including alignment between and attachment to structural members.
    b. Structural limitations of girts and columns during and after wall panel installation.
    c. Flashings, special siding details, wall penetrations, openings, and condition of other construction that will affect metal wall panels.
    d. Temporary protection requirements for metal wall panel assembly during and after installation.
    e. Wall observation and repair after metal wall panel installation.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of metal building system component.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

    a. Metal roof panels.
    b. Metal wall panels.
    c. Metal soffit panels.
    d. Thermal insulation and vapor-retarder facings.

e. Personnel doors and frames.
f. Louvers.

B. Shop Drawings: Indicate components by others. Include full building plan, elevations, sections, details and the following:

1. Anchor-Rod Plans: Submit anchor-rod plans and templates before foundation work begins. Include location, diameter, and minimum required projection of anchor rods required to attach metal building to foundation. Indicate column reactions at each location.
2. Structural-Framing Drawings: Show complete fabrication of primary and secondary framing; include provisions for openings. Indicate welds and bolted connections, distinguishing between shop and field applications. Include transverse cross-sections.
3. Metal Roof and Wall Panel Layout Drawings: Show layouts of panels including methods of support. Include details of edge conditions, joints, panel profiles, corners, anchorages, clip spacing, trim, flashings, closures, and special details. Distinguish between factory- and field-assembled work; show locations of exposed fasteners.

    a. Show roof-mounted items including roof hatches, equipment supports, pipe supports and penetrations, lighting fixtures, and items mounted on roof curbs.
    b. Show wall-mounted items including personnel doors, vehicular doors, louvers, and lighting fixtures.

4. Accessory Drawings: Include details of the following items, at a scale of not less than 1-1/2 inches per 12 inches.

    a. Flashing and trim.

C. Samples for Initial Selection: For units with factory-applied finishes.

D. Door Schedule: For doors and frames. Use same designations indicated on Drawings. Include details of reinforcement.

1. Door Hardware Schedule: Include details of fabrication and assembly of door hardware. Organize schedule into door hardware sets indicating complete designations of every item required for each door or opening.
2. Keying Schedule: Detail Owner's final keying instructions for locks. Include schematic keying diagram and index each key set to unique door designations.

E. Delegated-Design Submittal: For metal building systems.

1. Include analysis data indicating compliance with performance requirements and design data signed and sealed by the qualified professional engineer responsible for their preparation.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For erector and manufacturer.

B. Welding certificates.

C. Letter of Design Certification: Signed and sealed by a qualified professional engineer. Include the following:

1. Name and location of Project.
2. Order number.
3. Name of manufacturer.
4. Name of Contractor.
5. Building dimensions including width, length, height, and roof slope.
6. Indicate compliance with AISC standards for hot-rolled steel and AISI standards for cold-rolled steel, including edition dates of each standard.
7. Governing building code and year of edition.
8. Design Loads: Include dead load, roof live load, collateral loads, roof snow load, deflection, wind loads/speeds and exposure, seismic design category or effective peak velocity-related acceleration/peak acceleration, and auxiliary loads (cranes).
9. Load Combinations: Indicate that loads were applied acting simultaneously with concentrated loads, according to governing building code.
10. Building-Use Category: Indicate category of building use and its effect on load importance factors.

D. Erector Certificates: For qualified erector, from manufacturer.

E. Material Test Reports: For each of the following products:

1. Structural steel including chemical and physical properties.
2. Bolts, nuts, and washers including mechanical properties and chemical analysis.
3. Tension-control, high-strength, bolt-nut-washer assemblies.
4. Shop primers.
5. Nonshrink grout.

F. Source quality-control reports.

G. Field quality-control reports.

H. Surveys: Show final elevations and locations of major members. Indicate discrepancies between actual installation and the Contract Documents. Have surveyor who performed surveys certify their accuracy.

I. Sample Warranties: For special warranties.

1.8 CLOSEOUT SUBMITTALS

A. Maintenance Data: For metal panel finishes and door hardware to include in maintenance manuals.

1.9 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer.

1. Accreditation: Manufacturer's facility accredited according to the International Accreditation Service's AC472, "Accreditation Criteria for Inspection Programs for Manufacturers of Metal Building Systems."
2. Engineering Responsibility: Preparation of comprehensive engineering analysis and Shop Drawings by a professional engineer who is legally qualified to practice in jurisdiction where Project is located.

B. Erector Qualifications: An experienced erector who specializes in erecting and installing work similar in material, design, and extent to that indicated for this Project and who is acceptable to manufacturer.

C. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.3, "Structural Welding Code - Sheet Steel."

D. Land Surveyor Qualifications: A professional land surveyor who practices in jurisdiction where Project is located and who is experienced in providing surveying services of the kind indicated.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver components, sheets, panels, and other manufactured items so as not to be damaged or deformed. Package metal panels for protection during transportation and handling.

B. Unload, store, and erect metal panels in a manner to prevent bending, warping, twisting, and surface damage.

C. Stack metal panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal panels to ensure dryness, with positive slope for drainage of water. Do not store metal panels in contact with other materials that might cause staining, denting, or other surface damage.

1.11 FIELD CONDITIONS

A. Weather Limitations: Proceed with panel installation only when weather conditions permit metal panels to be installed according to manufacturers' written instructions and warranty requirements.

1.12 WARRANTY

A. Special Warranty on Metal Panel Finishes: Manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:

a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.

c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 20 years from date of Substantial Completion.

B. Special Weathertightness Warranty for Standing-Seam Metal Roof Panels: Manufacturer agrees to repair or replace standing-seam metal roof panel assemblies that leak or otherwise fail to remain weathertight within specified warranty period.

1. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Varco-Pruden, Nucor, or approved equal.

B. Source Limitations: Obtain metal building system components, including primary and secondary framing and metal panel assemblies, from single source from single manufacturer.

2.2 SYSTEM DESCRIPTION

A. Provide a complete, integrated set of mutually dependent components and assemblies that form a metal building system capable of withstanding structural and other loads, thermally induced movement, and exposure to weather without failure or infiltration of water into building interior.

B. Primary-Frame Type:

1. Rigid Clear Span: Solid-member, structural-framing system without interior columns.

C. End-Wall Framing: Manufacturer's standard, for buildings not required to be expandable, consisting of primary frame, capable of supporting one-half of a bay design load, and end-wall columns.

D. Secondary-Frame Type: Manufacturer's standard purlins and joists and exterior-framed (bypass) girts.

E. Eave Height: As indicated by nominal height on Drawings.

F. Bay Spacing: As indicated on Drawings.

G. Roof Slope: 1 1/2 inches per 12 inches (1.5:12).

H. Roof System: Manufacturer's standard standing-seam, vertical-rib, metal roof panels.

I. Exterior Wall System: Manufacturer's standard exposed-fastener, tapered-rib, metal wall panels.

2.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design metal building system.

B. Structural Performance: Metal building systems shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to procedures in MBMA's "Metal Building Systems Manual."

1. Design Loads: As indicated on Drawings.
2. Deflection and Drift Limits: Design metal building system assemblies to withstand serviceability design loads without exceeding deflections and drift limits recommended in AISC Steel Design Guide No. 3 "Serviceability Design Considerations for Steel Buildings."

C. Seismic Performance: Metal building system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

E. Structural Performance for Metal Roof and Wall Panels: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E 1592:

1. Wind Loads: As indicated on Drawings.

F. Water Penetration for Metal Roof Panels: No water penetration when tested according to ASTM E 1646 at the following test-pressure difference:

1. Test-Pressure Difference: 2.86 lbf/sq. ft.

G. Water Penetration for Metal Wall Panels: No water penetration when tested according to ASTM E 331 at the following test-pressure difference:

1. Test-Pressure Difference: 2.86 lbf/sq. ft.

H. Wind-Uplift Resistance: Provide metal roof panel assemblies that comply with UL 580 for wind-uplift-resistance for loads indicated on the Drawings.

I. Thermal Performance for Opaque Elements: Provide the following minimum R-values when tested according to ASTM C 1363 or ASTM C 518:

1. Roof:

a. R-Value: 3.

2.4 STRUCTURAL-STEEL FRAMING

A. Structural Steel: Comply with AISC 360, "Specification for Structural Steel Buildings."

B. Bolted Connections: Comply with RCSC's "Specification for Structural Joints Using High-Strength Bolts."

C. Cold-Formed Steel: Comply with AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members" for design requirements and allowable stresses.

D. Primary Framing: Manufacturer's standard primary-framing system, designed to withstand required loads and specified requirements. Primary framing includes transverse and lean-to frames; rafters, rake, and canopy beams; sidewall, intermediate, end-wall, and corner columns; and wind bracing.

1. General: Provide frames with attachment plates, bearing plates, and splice members. Factory drill for field-bolted assembly. Provide frame span and spacing indicated.

    a. Slight variations in span and spacing may be acceptable if necessary to comply with manufacturer's standard, as approved by Engineer.

2. Rigid Clear-Span Frames: I-shaped frame sections fabricated from shop-welded, built-up steel plates or structural-steel shapes. Interior columns are not permitted.
3. Frame Configuration: One-directional, sloped.
4. Exterior Column: Tapered.
5. Rafter: Tapered.

E. End-Wall Framing: Manufacturer's standard primary end-wall framing fabricated for field-bolted assembly to comply with the following:

1. End-Wall and Corner Columns: I-shaped sections fabricated from structural-steel shapes; shop-welded, built-up steel plates; or C-shaped, cold-formed, structural-steel sheet.
2. End-Wall Rafters: C-shaped, cold-formed, structural-steel sheet; or I-shaped sections fabricated from shop-welded, built-up steel plates or structural-steel shapes.

F. Secondary Framing: Manufacturer's standard secondary framing, including purlins, girts, eave struts, flange bracing, base members, gable angles, clips, headers, jambs, and other miscellaneous structural members. Unless otherwise indicated, fabricate framing from either cold-formed, structural-steel sheet or roll-formed, metallic-coated steel sheet, prepainted with coil coating, to comply with the following:

1. Purlins: C- or Z-shaped sections; fabricated from built-up steel plates, steel sheet, or structural-steel shapes; minimum 2-1/2-inch wide flanges.

    a. Depth: As needed to comply with system performance requirements.

2. Girts: C- or Z-shaped sections; fabricated from built-up steel plates, steel sheet, or structural-steel shapes. Form ends of Z-sections with stiffening lips angled 40 to 50 degrees from flange, with minimum 2-1/2-inch wide flanges.

    a. Depth: As indicated on Drawings.

3. Eave Struts: Unequal-flange, C-shaped sections; fabricated from built-up steel plates, steel sheet, or structural-steel shapes; to provide adequate backup for metal panels.
4. Flange Bracing: Minimum 2-by-2-by-1/8-inch structural-steel angles or 1-inch diameter, cold-formed structural tubing to stiffen primary-frame flanges.
5. Sag Bracing: Minimum 1-by-1-by-1/8-inch structural-steel angles.
6. Base or Sill Angles: Manufacturer's standard base angle, minimum 3-by-2-inch, fabricated from zinc-coated (galvanized) steel sheet.
7. Purlin and Girt Clips: Manufacturer's standard clips fabricated from steel sheet. Provide galvanized clips where clips are connected to galvanized framing members.
8. Framing for Openings: Channel shapes; fabricated from cold-formed, structural-steel sheet or structural-steel shapes. Frame head and jamb of door openings and head, jamb, and sill of other openings.
9. Miscellaneous Structural Members: Manufacturer's standard sections fabricated from cold-formed, structural-steel sheet; built-up steel plates; or zinc-coated (galvanized) steel sheet; designed to withstand required loads.

G. Bracing: Provide adjustable wind bracing as follows:

1. Rods: ASTM A 36/A 36M; ASTM A 572/A 572M, Grade 50; or ASTM A 529/A 529M, Grade 50; minimum 1/2-inch diameter steel; threaded full length or threaded a minimum of 6 inches at each end.
2. Cable: ASTM A 475, minimum 1/4-inch diameter, extra-high-strength grade, Class B, zinc-coated, seven-strand steel; with threaded end anchors.
3. Angles: Fabricated from structural-steel shapes to match primary framing, of size required to withstand design loads.
4. Diaphragm Action of Metal Panels: Design metal building to resist wind forces through diaphragm action of metal panels.

H. Anchor Rods: Headed anchor rods as indicated in Anchor Rod Plan for attachment of metal building to foundation.

I. Materials:

1. W-Shapes: ASTM A 992/A 992M; ASTM A 572/A 572M, Grade 50 or 55; or ASTM A 529/A 529M, Grade 50 or 55.
2. Channels, Angles, M-Shapes, and S-Shapes: ASTM A 36/A 36M; ASTM A 572/A 572M, Grade 50 or 55; or ASTM A 529/A 529M, Grade 50 or 55.
3. Plate and Bar: ASTM A 36/A 36M; ASTM A 572/A 572M, Grade 50 or 55; or ASTM A 529/A 529M, Grade 50 or 55.
4. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade B.
5. Cold-Formed Hollow Structural Sections: ASTM A 500, Grade B or C, structural tubing.
6. Structural-Steel Sheet: Hot-rolled, ASTM A 1011/A 1011M, Structural Steel (SS), Grades 30 through 55, or High-Strength Low-Alloy Steel (HSLAS) or High-Strength Low-Alloy Steel with Improved Formability (HSLAS-F), Grades 45 through 70; or cold-rolled, ASTM A 1008/A 1008M, Structural Steel (SS), Grades 25 through 80, or HSLAS, Grades 45 through 70.
7. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, SS, Grades 33 through 80, or HSLAS or HSLAS-F, Grades 50 through 80; with G60 coating designation; mill phosphatized.

8. Metallic-Coated Steel Sheet Prepainted with Coil Coating: Steel sheet, metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.

    a. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, SS, Grades 33 through 80, or HSLAS or HSLAS-F, Grades 50 through 80; with G90 coating designation.
    b. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, SS, Grade 50 or 80; with Class AZ50 coating.

9. Non-High-Strength Bolts, Nuts, and Washers: ASTM A 307, Grade A, carbon-steel, hex-head bolts; ASTM A 563 carbon-steel hex nuts; and ASTM F 844 plain (flat) steel washers.

    a. Finish: Plain.

10. Structural Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy-hex steel structural bolts; ASTM A 563 heavy-hex carbon-steel nuts; and ASTM F 436 hardened carbon-steel washers.

    a. Finish: Plain.

11. High-Strength Bolts, Nuts, and Washers: ASTM A 490, Type 1, heavy-hex steel structural bolts or tension-control, bolt-nut-washer assemblies with spline ends; ASTM A 563 heavy-hex carbon-steel nuts; and ASTM F 436 hardened carbon-steel washers, plain.
12. Tension-Control, High-Strength Bolt-Nut-Washer Assemblies: ASTM F 1852, Type 1, heavy-hex-head steel structural bolts with spline ends.

    a. Finish: Plain.

13. Headed Anchor Rods: ASTM F 1554, Grade 36.

    a. Configuration: Straight.
    b. Nuts: ASTM A 563 hex carbon steel.
    c. Plate Washers: ASTM A 36/A 36M carbon steel.
    d. Washers: ASTM F 436 hardened carbon steel.
    e. Finish: Plain.

J. Finish: Factory primed. Apply specified primer immediately after cleaning and pretreating.

1. Clean and prepare in accordance with SSPC-SP2.
2. Coat with manufacturer's standard primer. Apply primer to primary and secondary framing to a minimum dry film thickness of 1 mil.

    a. Prime secondary framing formed from uncoated steel sheet to a minimum dry film thickness of 0.5 mil on each side.

2.5 METAL ROOF PANELS

A. Standing-Seam, Vertical-Rib, Metal Roof Panels: Formed with vertical ribs at panel edges; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels and engaging opposite edge of adjacent panels.

1. Material: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.024-inch nominal uncoated steel thickness. Prepainted by the coil-coating process to comply with ASTM A 755/A 755M.

    a. Exterior Finish: Two-coat fluoropolymer.
    b. Color: As selected by Engineer from manufacturer's full range.

2. Clips: Two-piece floating to accommodate thermal movement.
3. Joint Type: Panels snapped together or mechanically seamed.
4. Panel Coverage: 16 inches.
5. Panel Height: 2 inches.

B. Finishes:

1. Exposed Coil-Coated Finish:

    a. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

2. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil.

2.6 METAL WALL PANELS

A. Exposed-Fastener, Tapered-Rib, Metal Wall Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced between major ribs; designed to be installed by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps.

1. Material: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.024-inch nominal uncoated steel thickness. Prepainted by the coil-coating process to comply with ASTM A 755/A 755M.

    a. Exterior Finish: Two-coat fluoropolymer.
    b. Color: As selected by Engineer from manufacturer's full range.

2. Major-Rib Spacing: 12 inches o.c.
3. Panel Coverage: 36 inches.

B. Finishes:

1. Exposed Coil-Coated Finish:

    a. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

2. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil.

2.7 METAL SOFFIT PANELS

A. General: Provide factory-formed metal soffit panels designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners in side laps. Include accessories required for weathertight installation.

B. Concealed-Fastener, Flush-Profile, Metal Soffit Panels: Formed with vertical panel edges and a flush surface; with flush joint between panels; with 1-inch wide flange for attaching interior finish; designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners in side laps.

1. Material: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.024-inch nominal uncoated steel thickness. Prepainted by the coil-coating process to comply with ASTM A 755/A 755M.

    a. Exterior Finish: Fluoropolymer.
    b. Color: As selected by Engineer from manufacturer's full range.

2. Panel Coverage: 12 inches.
3. Panel Height: 1 inch.

2.8 THERMAL INSULATION

A. Unfaced Metal Building Insulation: ASTM C 991, Type I, or NAIMA 202, glass-fiber-blanket insulation; 0.5-lb/cu. ft. density; 2-inch wide, continuous, vapor-tight edge tabs; with a flame-spread index of 25 or less.

B. Vapor-Retarder Facing: ASTM C 1136, with permeance not greater than 0.02 perm when tested according to ASTM E 96/E 96M, Desiccant Method.

C. Vapor-Retarder Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.

2.9 PERSONNEL DOORS AND FRAMES

A. Swinging Personnel Doors and Frames: Metal building system manufacturer's standard doors and frames; prepared and reinforced at strike and at hinges to receive factory- and field-applied hardware according to BHMA A156 Series.

1. Steel Doors: 1-3/4 inches thick; fabricated from metallic-coated steel face sheets, 0.036-inch nominal uncoated steel thickness, of seamed, hollow-metal construction; with 0.060-inch nominal uncoated steel thickness, inverted metallic-coated steel channels welded to face sheets at top and bottom of door.

    a. Design: Flush panel.
    b. Core: Polyurethane foam with U-factor rating of at least 0.07 Btu/sq. ft. x h x deg F.

2. Steel Frames: Fabricate 2-inch- wide face frames from zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.060-inch nominal uncoated steel thickness.

    a. Type: Knocked down for field assembly.

3. Fabricate concealed stiffeners, reinforcement, edge channels, and moldings from either cold- or hot-rolled steel sheet.
4. Hardware:

    a. Provide hardware for each door leaf, as follows:

        1) Hinges: BHMA A156.1. Three plain-bearing, standard-weight, full-mortise, stainless-steel or bronze, template-type hinges; 4-1/2 by 4-1/2 inches, with nonremovable pin.
        2) Lockset: BHMA A156.2. Mortise, with lever handle type.
        3) Threshold: BHMA A156.21. Extruded aluminum.
        4) Silencers: Pneumatic rubber; three silencers on strike jambs of single door frames and two silencers on heads of double door frames.
        5) Closer: BHMA A156.4. Surface-applied, standard-duty hydraulic type.
        6) Weather Stripping: Vinyl applied to head and jambs, with vinyl sweep at sill.

5. Anchors and Accessories: Manufacturer's standard units, galvanized according to ASTM A 123/A 123M.
6. Fabrication: Fabricate doors and frames to be rigid; neat in appearance; and free from defects, warp, or buckle. Provide continuous welds on exposed joints; grind, dress, and make welds smooth, flush, and invisible.

B. Materials:

1. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B, suitable for exposed applications.
2. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, CS, Type B; free of scale, pitting, or surface defects; pickled and oiled.
3. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, CS, Type B; with G60 zinc (galvanized) or A60 zinc-iron-alloy (galvannealed) coating designation.

C. Finishes for Personnel Doors and Frames:

1. Prime Finish: Factory-apply manufacturer's standard primer immediately after cleaning and pretreating.

a. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with SDI A250.10 acceptance criteria; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

2. Factory-Applied Paint Finish: Manufacturer's standard, complying with SDI A250.3 for performance and acceptance criteria.

a. Color and Gloss: As selected by Engineer from manufacturer's full range.

2.10 ACCESSORIES

A. General: Provide accessories as standard with metal building system manufacturer and as specified. Fabricate and finish accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes. Comply with indicated profiles and with dimensional and structural requirements.

1. Form exposed sheet metal accessories that are without excessive oil-canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.

B. Roof Panel Accessories: Provide components required for a complete metal roof panel assembly including copings, fasciae, corner units, ridge closures, clips, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal roof panels unless otherwise indicated.

1. Closures: Provide closures at eaves and ridges, fabricated of same material as metal roof panels.
2. Clips: Manufacturer's standard, formed from stainless-steel sheet, designed to withstand negative-load requirements.
3. Cleats: Manufacturer's standard, mechanically seamed cleats formed from stainless-steel sheet or nylon-coated aluminum sheet.
4. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
5. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch thick, flexible closure strips; cut or premolded to match metal roof panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
6. Thermal Spacer Blocks: Where metal panels attach directly to purlins, provide thermal spacer blocks of thickness required to provide 1-inch standoff; fabricated from extruded polystyrene.

C. Wall Panel Accessories: Provide components required for a complete metal wall panel assembly including copings, fasciae, mullions, sills, corner units, clips, sealants, gaskets, fillers, closure

strips, and similar items. Match material and finish of metal wall panels unless otherwise indicated.

1. Closures: Provide closures at eaves and rakes, fabricated of same material as metal wall panels.
2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
3. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch thick, flexible closure strips; cut or premolded to match metal wall panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.

D. Flashing and Trim: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch nominal uncoated steel thickness, prepainted with coil coating; finished to match adjacent metal panels.

1. Provide flashing and trim as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, eaves, rakes, corners, bases, framed openings, ridges, fasciae, and fillers.
2. Opening Trim: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.030-inch nominal uncoated steel thickness, prepainted with coil coating. Trim head and jamb of door openings, and head, jamb, and sill of other openings.

E. Louvers: Size and design indicated; self-framing and self-flashing. Fabricate welded frames from zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.048-inch nominal uncoated steel thickness; finished to match metal wall panels. Form blades from zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.036-inch nominal uncoated steel thickness; folded or beaded at edges, set at an angle that excludes driving rains, and secured to frames by riveting or welding. Fabricate louvers with equal blade spacing to produce uniform appearance.

1. Blades: Adjustable type, with weather-stripped edges, and manually operated by hand crank or pull chain.
2. Bird Screening: Galvanized steel, 1/2-inch square mesh, 0.041-inch wire; with rewirable frames, removable and secured with clips; fabricated of same kind and form of metal and with same finish as louvers.

    a. Mounting: Exterior face of louvers.

3. Vertical Mullions: Provide mullions at spacings recommended by manufacturer, or 72 inches o.c., whichever is less.

F. Pipe Flashing: Premolded, EPDM pipe collar with flexible aluminum ring bonded to base.

G. Materials:

1. Fasteners: Self-tapping screws, bolts, nuts, self-locking rivets and bolts, end-welded studs, and other suitable fasteners designed to withstand design loads. Provide fasteners with heads matching color of materials being fastened by means of plastic caps or factory-applied coating.

a. Fasteners for Metal Roof Panels: Self-drilling or self-tapping, zinc-plated, hex-head carbon-steel screws, with a stainless-steel cap or zinc-aluminum-alloy head and EPDM sealing washer.
b. Fasteners for Metal Wall Panels: Self-drilling or self-tapping, zinc-plated, hex-head carbon-steel screws, with EPDM sealing washers bearing on weather side of metal panels.
c. Fasteners for Flashing and Trim: Blind fasteners or self-drilling screws with hex washer head.
d. Blind Fasteners: High-strength aluminum or stainless-steel rivets

2. Corrosion-Resistant Coating: Cold-applied asphalt mastic, compounded for 15-mil dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.
3. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107/C 1107M, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.
4. Metal Panel Sealants:

a. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene-compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape of manufacturer's standard size.
b. Joint Sealant: ASTM C 920; one part elastomeric polyurethane or polysulfide; of type, grade, class, and use classifications required to seal joints in metal panels and remain weathertight; and as recommended by metal building system manufacturer.

2.11 FABRICATION

A. General: Design components and field connections required for erection to permit easy assembly.

1. Mark each piece and part of the assembly to correspond with previously prepared erection drawings, diagrams, and instruction manuals.
2. Fabricate structural framing to produce clean, smooth cuts and bends. Punch holes of proper size, shape, and location. Members shall be free of cracks, tears, and ruptures.

B. Tolerances: Comply with MBMA's "Metal Building Systems Manual" for fabrication and erection tolerances.

C. Primary Framing: Shop fabricate framing components to indicated size and section, with baseplates, bearing plates, stiffeners, and other items required for erection welded into place. Cut, form, punch, drill, and weld framing for bolted field assembly.

1. Make shop connections by welding or by using high-strength bolts.
2. Join flanges to webs of built-up members by a continuous, submerged arc-welding process.
3. Brace compression flange of primary framing with steel angles or cold-formed structural tubing between frame web and purlin web or girt web, so flange compressive strength is within allowable limits for any combination of loadings.
4. Weld clips to frames for attaching secondary framing if applicable, or punch for bolts.

5. Shop Priming: Prepare surfaces for shop priming according to SSPC-SP 2. Shop prime primary framing with specified primer after fabrication.

D. Secondary Framing: Shop fabricate framing components to indicated size and section by roll forming or break forming, with baseplates, bearing plates, stiffeners, and other plates required for erection welded into place. Cut, form, punch, drill, and weld secondary framing for bolted field connections to primary framing.

1. Make shop connections by welding or by using non-high-strength bolts.
2. Shop Priming: Prepare uncoated surfaces for shop priming according to SSPC-SP 2. Shop prime uncoated secondary framing with specified primer after fabrication.

E. Metal Panels: Fabricate and finish metal panels at the factory to greatest extent possible, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements. Comply with indicated profiles and with dimensional and structural requirements.

1. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of metal panel.

2.12 SOURCE QUALITY CONTROL

A. Special Inspection: Owner will engage a qualified special inspector to perform source quality control inspections and to submit reports.

1. Accredited Manufacturers: Special inspections will not be required if fabrication is performed by an IAS AC472-accredited manufacturer approved by authorities having jurisdiction to perform such Work without special inspection.

a. After fabrication, submit copy of certificate of compliance to authorities having jurisdiction, certifying that Work was performed according to Contract requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with erector present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Before erection proceeds, survey elevations and locations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments to receive structural framing, with erector present, for compliance with requirements and metal building system manufacturer's tolerances.

1. Engage land surveyor to perform surveying.

C. Proceed with erection only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean and prepare surfaces to be painted according to manufacturer's written instructions for each particular substrate condition.

B. Provide temporary shores, guys, braces, and other supports during erection to keep structural framing secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural framing, connections, and bracing are in place unless otherwise indicated.

3.3 ERECTION OF STRUCTURAL FRAMING

A. Erect metal building system according to manufacturer's written instructions and drawings.

B. Do not field cut, drill, or alter structural members without written approval from metal building system manufacturer's professional engineer.

C. Set structural framing accurately in locations and to elevations indicated, according to AISC specifications referenced in this Section. Maintain structural stability of frame during erection.

D. Base and Bearing Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.

1. Set plates for structural members on wedges, shims, or setting nuts as required.
2. Tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
3. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.

E. Align and adjust structural framing before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with framing. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.

1. Level and plumb individual members of structure.
2. Make allowances for difference between temperature at time of erection and mean temperature when structure will be completed and in service.

F. Primary Framing and End Walls: Erect framing level, plumb, rigid, secure, and true to line. Level baseplates to a true even plane with full bearing to supporting structures, set with double-nutted anchor bolts. Use grout to obtain uniform bearing and to maintain a level base-line elevation. Moist-cure grout for not less than seven days after placement.

1. Make field connections using high-strength bolts installed according to RCSC's "Specification for Structural Joints Using High-Strength Bolts" for bolt type and joint type specified.

    a. Joint Type: Snug tightened or pretensioned as required by manufacturer.

G. Secondary Framing: Erect framing level, plumb, rigid, secure, and true to line. Field bolt secondary framing to clips attached to primary framing.

1. Provide rake or gable purlins with tight-fitting closure channels and fasciae.
2. Locate and space wall girts to suit openings such as doors and windows.
3. Provide supplemental framing at entire perimeter of openings, including doors, windows, louvers, ventilators, and other penetrations of roof and walls.

H. Bracing: Install bracing in roof and sidewalls where indicated on erection drawings.

1. Tighten rod and cable bracing to avoid sag.
2. Locate interior end-bay bracing only where indicated.

I. Framing for Openings: Provide shapes of proper design and size to reinforce openings and to carry loads and vibrations imposed, including equipment furnished under mechanical and electrical work. Securely attach to structural framing.

J. Erection Tolerances: Maintain erection tolerances of structural framing within AISC 303.

3.4 METAL PANEL INSTALLATION, GENERAL

A. Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

B. On-Site Fabrication: Subject to compliance with requirements of this Section, metal panels may be fabricated on-site using UL-certified, portable roll-forming equipment if panels are of same profile and warranted by manufacturer to be equal to factory-formed panels. Fabricate according to equipment manufacturer's written instructions and to comply with details shown.

C. Examination: Examine primary and secondary framing to verify that structural-panel support members and anchorages have been installed within alignment tolerances required by manufacturer.

1. Examine roughing-in for components and systems penetrating metal panels, to verify actual locations of penetrations relative to seams before metal panel installation.

D. General: Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Field cut metal panels as required for doors, windows, and other openings. Cut openings as small as possible, neatly to size required, and without damage to adjacent metal panel finishes.

a. Field cutting of metal panels by torch is not permitted unless approved in writing by manufacturer.

2. Install metal panels perpendicular to structural supports unless otherwise indicated.

3. Flash and seal metal panels with weather closures at perimeter of openings and similar elements. Fasten with self-tapping screws.
4. Locate and space fastenings in uniform vertical and horizontal alignment.
5. Locate metal panel splices over structural supports with end laps in alignment.
6. Lap metal flashing over metal panels to allow moisture to run over and off the material.

E. Lap-Seam Metal Panels: Install screw fasteners using power tools with controlled torque adjusted to compress EPDM washers tightly without damage to washers, screw threads, or metal panels. Install screws in predrilled holes.

1. Arrange and nest side-lap joints so prevailing winds blow over, not into, lapped joints. Lap ribbed or fluted sheets one full rib corrugation. Apply metal panels and associated items for neat and weathertight enclosure. Avoid "panel creep" or application not true to line.

F. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with corrosion-resistant coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by metal roof panel manufacturer.

G. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weatherproof performance of metal panel assemblies. Provide types of gaskets, fillers, and sealants indicated; or, if not indicated, provide types recommended by metal panel manufacturer.

1. Seal metal panel end laps with double beads of tape or sealant the full width of panel. Seal side joints where recommended by metal panel manufacturer.

3.5 METAL ROOF PANEL INSTALLATION

A. General: Provide metal roof panels of full length from eave to ridge unless otherwise indicated or restricted by shipping limitations.

1. Install ridge caps as metal roof panel work proceeds.
2. Flash and seal metal roof panels with weather closures at eaves and rakes. Fasten with self-tapping screws.

B. Standing-Seam Metal Roof Panels: Fasten metal roof panels to supports with concealed clips at each standing-seam joint, at location and spacing and with fasteners recommended by manufacturer.

1. Install clips to supports with self-drilling or self-tapping fasteners.
2. Install pressure plates at locations indicated in manufacturer's written installation instructions.
3. Snap Joint: Nest standing seams and fasten together by interlocking and completely engaging factory-applied sealant.
4. Seamed Joint: Crimp standing seams with manufacturer-approved motorized seamer tool so that clip, metal roof panel, and factory-applied sealant are completely engaged.
5. Rigidly fasten eave end of metal roof panels and allow ridge end free movement for thermal expansion and contraction. Predrill panels for fasteners.

6. Provide metal closures at rake edges and each side of ridge caps.

C. Metal Fascia Panels: Align bottom of metal panels and fasten with blind rivets, bolts, or self-drilling or self-tapping screws. Flash and seal metal panels with weather closures where fasciae meet soffits, along lower panel edges, and at perimeter of all openings.

D. Metal Roof Panel Installation Tolerances: Shim and align metal roof panels within installed tolerance of 1/4 inch in 20 feet on slope and location lines and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

3.6 METAL WALL PANEL INSTALLATION

A. General: Install panels perpendicular to girts, extending full height of building, unless otherwise indicated. Anchor metal wall panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Unless otherwise indicated, begin metal panel installation at corners with center of rib lined up with line of framing.
2. Shim or otherwise plumb substrates receiving metal wall panels.
3. When two rows of metal panels are required, lap panels 4 inches minimum.
4. When building height requires two rows of metal panels at gable ends, align lap of gable panels over metal wall panels at eave height.
5. Rigidly fasten base end of metal wall panels and allow eave end free movement for thermal expansion and contraction. Predrill panels.
6. Flash and seal metal wall panels with weather closures at eaves and rakes, and at perimeter of all openings. Fasten with self-tapping screws.
7. Install screw fasteners in predrilled holes.
8. Install flashing and trim as metal wall panel work proceeds.
9. Apply elastomeric sealant continuously between metal base channel (sill angle) and concrete, and elsewhere as indicated on Drawings; if not indicated, as necessary for waterproofing.
10. Align bottom of metal wall panels and fasten with blind rivets, bolts, or self-drilling or self-tapping screws.
11. Provide weatherproof escutcheons for pipe and conduit penetrating exterior walls.

B. Metal Wall Panels: Install metal wall panels on exterior side of girts. Attach metal wall panels to supports with fasteners as recommended by manufacturer.

C. Installation Tolerances: Shim and align metal wall panels within installed tolerance of 1/4 inch in 20 feet, noncumulative; level, plumb, and on location lines; and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

3.7 METAL SOFFIT PANEL INSTALLATION

A. Provide metal soffit panels the full width of soffits. Install panels perpendicular to support framing.

B. Flash and seal metal soffit panels with weather closures where panels meet walls and at perimeter of all openings.

3.8 THERMAL INSULATION INSTALLATION

A. General: Install insulation concurrently with metal panel installation, in thickness indicated to cover entire surface, according to manufacturer's written instructions.

1. Set vapor-retarder-faced units with vapor retarder toward warm side of construction unless otherwise indicated. Do not obstruct ventilation spaces except for firestopping.
2. Tape joints and ruptures in vapor retarder, and seal each continuous area of insulation to the surrounding construction to ensure airtight installation.
3. Install factory-laminated, vapor-retarder-faced blankets straight and true in one-piece lengths, with both sets of facing tabs sealed, to provide a complete vapor retarder.
4. Install blankets straight and true in one-piece lengths. Install vapor retarder over insulation, with both sets of facing tabs sealed, to provide a complete vapor retarder.

B. Blanket Roof Insulation: Comply with the following installation method:

1. Between-Purlin Installation: Extend insulation and vapor retarder between purlins. Carry vapor-retarder-facing tabs up and over purlin, overlapping adjoining facing of next insulation course and maintaining continuity of retarder. Hold in place with bands and crossbands below insulation.
2. Retainer Strips: Install retainer strips at each longitudinal insulation joint, straight and taut, nesting with secondary framing to hold insulation in place.

3.9 DOOR AND FRAME INSTALLATION

A. General: Install doors and frames plumb, rigid, properly aligned, and securely fastened in place according to manufacturers' written instructions. Coordinate installation with wall flashings and other components. Seal perimeter of each door frame with elastomeric sealant used for metal wall panels.

B. Personnel Doors and Frames: Install doors and frames according to NAAMM-HMMA 840. Fit non-fire-rated doors accurately in their respective frames, with the following clearances:

1. Between Doors and Frames at Jambs and Head: 1/8 inch.
2. Between Edges of Pairs of Doors: 1/8 inch.
3. At Door Sills with Threshold: 3/8 inch.
4. At Door Sills without Threshold: 3/4 inch.

C. Door Hardware:

1. Install surface-mounted items after finishes have been completed at heights indicated in DHI's "Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames."
2. Set units level, plumb, and true to line and location. Adjust and reinforce attachment substrates as necessary for proper installation and operation.
3. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors according to industry standards.
4. Set thresholds for exterior doors in full bed of sealant.

3.10 ACCESSORY INSTALLATION

A. General: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.

1. Install components required for a complete metal roof panel assembly, including trim, copings, ridge closures, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.
2. Install components for a complete metal wall panel assembly, including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.
3. Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with corrosion-resistant coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by manufacturer.

B. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.

1. Install exposed flashing and trim that is without excessive oil-canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance.
2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped or bayonet-type expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with mastic sealant (concealed within joints).

C. Louvers: Locate and place louver units level, plumb, and at indicated alignment with adjacent work.

1. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
2. Provide perimeter reveals and openings of uniform width for sealants and joint fillers.
3. Protect galvanized- and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of corrosion-resistant paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
4. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required.

D. Pipe Flashing: Form flashing around pipe penetration and metal roof panels. Fasten and seal to panel as recommended by manufacturer.

3.11 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform field quality control special inspections and to submit reports.

B. Product will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.12 ADJUSTING

A. Doors: After completing installation, test and adjust doors to operate easily, free of warp, twist, or distortion.

B. Door Hardware: Adjust and check each operating item of door hardware and each door to ensure proper operation and function of every unit. Replace units that cannot be adjusted to operate as intended.

C. Adjustable Louvers: After completing installation, including work by other trades, lubricate, test, and adjust units to operate easily, free of warp, twist, or distortion as needed to provide fully functioning units.

1. Adjust louver blades to be weathertight when in closed position.

3.13 CLEANING AND PROTECTION

A. Repair damaged galvanized coatings on galvanized items with galvanized repair paint according to ASTM A 780/A 780M and manufacturer's written instructions.

B. Touchup Painting: After erection, promptly clean, prepare, and prime or reprime field connections, rust spots, and abraded surfaces of prime-painted structural framing, bearing plates, and accessories.

1. Clean and prepare surfaces by SSPC-SP 2, "Hand Tool Cleaning," or by SSPC-SP 3, "Power Tool Cleaning."
2. Apply a compatible primer of same type as shop primer used on adjacent surfaces.

C. Metal Panels: Remove temporary protective coverings and strippable films, if any, as metal panels are installed. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.

1. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

D. Doors and Frames: Immediately after installation, sand rusted or damaged areas of prime coat until smooth and apply touchup of compatible air-drying primer.

1. Immediately before final inspection, remove protective wrappings from doors and frames.

E. Louvers: Clean exposed surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate until final cleaning.

1. Restore louvers damaged during installation and construction period so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

    a. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION 13341

SECTION 13412 – THERMOMETERS AND PRESSURE GAGES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes the following to be used in process water piping systems:

1. Liquid-in-glass thermometers.
2. Thermowells.
3. Dial-type pressure gages.
4. Gage attachments.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Wiring Diagrams: For power, signal, and control wiring.

C. Product certificates.

D. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Flo Fab Inc.
    b. Miljoco Corporation.
    c. Palmer Wahl Instrumentation Group.
    d. Tel-Tru Manufacturing Company.
    e. Trerice, H. O. Co.
    f. Weiss Instruments, Inc.
    g. Winters Instruments - U.S.

2. Standard: ASME B40.200.
3. Case: Cast aluminum; 7-inch nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.

7. Window: Glass or plastic.
8. Stem: Aluminum and of length to suit installation.

    a. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Ferrous or Plastic Piping: Stainless steel.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.3 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. AMETEK, Inc.; U.S. Gauge.
    b. Ashcroft Inc.
    c. Ernst Flow Industries.
    d. Flo Fab Inc.
    e. Marsh Bellofram.
    f. Miljoco Corporation.
    g. Noshok.
    h. Palmer Wahl Instrumentation Group.
    i. REOTEMP Instrument Corporation.
    j. Tel-Tru Manufacturing Company.
    k. Trerice, H. O. Co.
    l. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
    m. Weiss Instruments, Inc.

n. WIKA Instrument Corporation - USA.
o. Winters Instruments - U.S.

2. Standard: ASME B40.100.
3. Case: Liquid-filled sealed type(s); cast aluminum or drawn steel 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Stainless steel, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
8. Pointer: Dark-colored metal.
9. Window: Glass or plastic.
10. Ring: Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.4 GAGE ATTACHMENTS

A. Valves: Stainless steel ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

G. Install valve in piping for each pressure gage for fluids (except steam).

H. Install connection fittings in accessible locations for attachment to portable indicators.

I. Install thermometers in the following locations:

1. Two inlets and two outlets of each chiller.
2. Two inlets and two outlets of each hydronic heat exchanger.
3. Inlet and outlet of each thermal-storage tank.
4. Inlet and outlet of cooling equipment and cooling tower at process water connections.

5. Where otherwise indicated on Drawings.

J. Install pressure gages in the following locations:

1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
3. Inlet and outlet of heat exchanger connection.
4. Suction and discharge of each pump. Where approved by the engineer the pump suction and discharge may share a pressure gage when the appropriate interconnecting tubing and valves are provided.
5. Where indicated otherwise on Drawings.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Process Water Systems Piping not Listed Below: 0 to 100 deg F and minus 20 to plus 50 deg C.

B. Scale Range for Chilled-Water Piping: Minus 40 to plus 160 deg F and minus 40 to plus 100 deg C.

C. Scale Range for Condenser-Water Piping: 0 to 100 deg F and minus 20 to plus 50 deg C.

3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Process Water Systems Piping not Listed Below: 0 to 100 psi and 0 to 600 kPa.

B. Scale Range for River-Water Piping: 0 to 60 psi and 0 to 400 kPa.

C. Scale Range for Reuse-Water Piping: 0 to 30 psi and 0 to 200 kPa.

D. Scale Range for Booster Pump Piping: 0 to 60 psi and 0 to 400 kPa.

E. Scale Range for Gravity-Water Piping: 0 to 15 psi and 0 to 200 kPa.

END OF SECTION 13412

SECTION 15050 – PROCESS WATER SYSTEMS BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to process water piping and equipment systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
8. Equipment installation requirements common to equipment sections.
9. Painting and finishing.
10. Concrete bases.
11. Supports and anchorages.

1.2 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts and spaces above ceilings.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. HDPE: High density polyethylene plastic.
2. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

B. Welding certificates.

1.4 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

C. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."

D. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

E. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.6 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 42 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 42 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

1. Available Manufacturers:

   a. Dresser Industries, Inc.; DMD Div.
   b. JCM Industries.
   c. Romac Industries
   d. Smith-Blair, Inc.
   e. Viking Johnson.

2. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.
3. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.
4. Thermal Expansion Couplings: AWWA C221, Romac EJ400 Series or equal
5. Aboveground Pressure Piping: Pipe fitting.

B. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

1. Available Manufacturers:

   a. Fernco, Inc.
   b. Mission Rubber Company.
   c. Plastic Oddities, Inc.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

1. Available Manufacturers:

   a. Capitol Manufacturing Co.
   b. Central Plastics Company.
   c. Epco Sales, Inc.

d. Hart Industries, International, Inc.
e. Watts Industries, Inc.; Water Products Div.
f. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
1. Available Manufacturers:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.
d. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Available Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

1. Available Manufacturers:

a. Calpico, Inc.
b. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

1. Available Manufacturers:

a. Perfection Corp.
b. Precision Plumbing Products, Inc.
c. Sioux Chief Manufacturing Co., Inc.
d. Victaulic Co. of America.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Available Manufacturers:

    a. Advance Products & Systems, Inc.
    b. Calpico, Inc.
    c. Metraflex Co.
    d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

B. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

    1. Finish: Polished chrome-plated and rough brass.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

E. One-Piece, Floor-Plate Type: Cast-iron floor plate.

F. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 15 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping to permit valve servicing.

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

    a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
    b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
    c. Insulated Piping: One-piece, cast-brass type with polished chrome-plated finish.
    d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
    e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with concealed hinge and set screw.
    f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough brass finish.
    g. Bare Piping in Equipment Rooms: One-piece, cast-brass type with rough brass finish.
    h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

K. Sleeves are not required for core-drilled holes.

L. Install sleeves for pipes passing through concrete floor slabs.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
   3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

      a. Steel Pipe Sleeves: For pipes smaller than NPS 6.

   4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint.

M. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

   1. Install steel pipe for sleeves smaller than 6 inches in diameter.
   2. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

N. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

   1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Verify final equipment locations for roughing-in.

P. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 42 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to ASW's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Grooved Joints: Assemble joints with grooved-end pipe coupling with coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

J. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fitting according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fitting according to ASTM D 2855.
3. PVC Nonpressure Piping: Join according to ASTM D 2855.

K. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

L. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

M. HDPE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.5 PAINTING

A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

B. Paint exterior exposed PVC pipe with two coats of Acrylic latex paint, minimum dry film thickness of 4 mils each coat for UV protection.

3.6 IDENTIFICATION

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.

1. Stenciled Markers: According to ASME A13.1.
2. Plastic markers, with application systems. Install on insulation segment if required for hot noninsulated piping.
3. Locate pipe markers on exposed piping according to the following:

    a. Near each valve and control device.
    b. Near each branch, excluding short takeoffs for equipment and terminal units. Mark each pipe at branch if flow pattern is not obvious.
    c. Near locations where pipes pass through walls or floors or enter inaccessible enclosures.
    d. At manholes and similar access points that permit view of concealed piping.
    e. Near major equipment items and other points of origination and termination.

B. Equipment: Install engraved plastic-laminate sign or equipment marker on or near each major item of equipment.

1. Lettering Size: Minimum 1/4 inch high for name of unit if viewing distance is less than 24 inches, 1/2 inch high for distances up to 72 inches, and proportionately larger lettering

for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.

2. Text of Signs: Provide name of identified unit. Include text to distinguish among multiple units, inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Adjusting: Relocate identifying devices that become visually blocked by work of this or other Divisions.

3.7 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions, where indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Section 033000 – Cast-in-Place Concrete.

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Section 05120 – Structural Steel for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.9 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor mechanical materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.10 GROUTING

A. Mix and install grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 15050

SECTION 15110

PROCESS WATER SYSTEMS VALVES AND GATES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. The work covered by this section consists of furnishing labor, materials, and equipment required to provide and install process water systems valves and gates as shown on the Drawings and as specified.

1.2 REFERENCE STANDARDS

Reference	Title
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250 and 800
ANSI B16.5	Pipe Flanges and Flanged Fittings ASTM A48-83 Gray Iron Castings
ASSE 1060	Performance Requirements for Outdoor Enclosures for Backflow Prevention Assemblies
ASTM A108	Steel Bars, Carbon, Cold-Finished, Standard Quality
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A216/A216M	Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service
ASTM A276	Stainless and Heat-Resisting Steel Bars and Shapes
ASTM A351	Standard Specification for Castings, Austenitic, Austenitic-Ferritic (Duplex), for Pressure Containing Parts
ASTM A436	Austenitic Gray Iron Castings
ASTM A536	Ductile Iron Castings
AWWA C500	Metal-Seated Gate Valves for Water Supply Service
AWWA C504	Rubber-Seated Butterfly Valves
AWWA C508	Swing-Check Valves for Waterworks Service, 2 In. through 24 In. NPS
AWWA C509	Resilient Seated Gate Valves for Water Supply Service
AWWA C510	Double Check Valve Backflow Prevention Assembly
AWWA C511	Reduced-Pressure Principle Backflow Prevention Assembly

1.3 SUBMITTALS

A. Manufacturer's product data, catalog cuts, or shop drawings describing construction, pressure classification, end connection, dimensions, weights, and materials. Include a list indicating each valve and its application.

B. Affidavits of compliance with AWWA C504 for butterfly valves.

C. Affidavits of compliance as required by AWWA C500 for Gate Valves, and by AWWA C506 for backflow preventers, include a certificate of approval and results of testing for backflow preventers in accordance with AWWA C506.

D. Operation and maintenance information for each type of valve and operator.

E. Hydrostatic test results.

1.4 DELIVERY, STORAGE AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set gate valves closed to prevent rattling.
4. Set butterfly valves closed or slightly open.
5. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use slings to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

1.5 QUALITY ASSURANCE

A. Backflow preventers shall meet the factory and field test provisions of AWWA C510 or C511.

PART 2 - PRODUCTS

2.1 GENERAL

A. Valves shall be manufacturer's standard design unless otherwise specified and shall be furnished with operating wheel, wrench nut or lever. Unless otherwise indicated, the direction of rotation of the wheel, wrench nut or lever to open the valve shall be to the left (counter-clockwise) and shall have cast thereon the word OPEN. Unless otherwise specified or shown on the drawings, 2-1/2 inch or larger buried valves shall have nonflanged ends, 2-1/2 inch or larger exposed valves shall have flanged ends, and 2 inch or smaller valves shall have threaded ends. Flanges shall conform to ANSI B16.5. A union, flanged, grooved or shouldered type connection shall be provided within 2 feet of each threaded end valve unless the valve can be otherwise easily removed and such technique of removal is approved by the Owner’s Representative. Exposed valves four-inch and smaller shall have lever operators with 10-position stops. Exposed valves 2-inch and smaller shall be ball valves or globe valves as designated on the Drawings.

B. Valves of the same type shall be from a single manufacturer. Valves three inch and larger shall be identified with labels.

C. All buried valves shall have restrained end connections to match the pipe system shown on the drawings and specified in Section 15200 – Process Piping Systems.

2.2 BUTTERFLY VALVES

A. Butterfly valves are specified according to size as follows.

1. Size 3 through 36 Inches shall be constructed of the following materials unless otherwise specified:

Component	Material
Shaft	Stainless steel, ASTM A276, type 304
Disc	Ductile iron, ASTM A536, or cast iron, ASTM A436, type 1 (Ni-Resist); or ASTM A48, Class 40, or ASTM A126, Class B, or stainless steel
Seat mating surface	Rubber seats in the valve body
Body	Cast iron, ASTM A126, Class B

B. Butterfly Valves 6-inch and larger shall have gear operators with handwheels if exposed and 2-inch square nut operators if buried or if operator extension is required.

C. General:

1. Butterfly valves shall be the stub or through shaft design. Valves shall be flanged or grooved. Unless otherwise specified, valve flange drilling shall be per ANSI B16.1, Class 125.
2. Butterfly valves shall be designed in accordance with AWWA C504. Shafts shall be turned, ground and polished. Shaft dimensions and operator torque shall be chosen for the pressure specified in Section 426700 – Process Water Piping Systems and Class B as specified in AWWA C504.
3. Butterfly valves, size 3 through 24 inches, shall have seats that are molded and bonded to the valve body.
4. Manufacturer: Pratt Model 2FII or equal.

2.3 BALL VALVES

A. Process water valves 2-inch and smaller shall be true union ball valves, PVC body and ball, EPDM seals, rated for 150 psi operating pressure at 75 degrees F, Asahi America, Hayward, George Fischer or approved equal.

2.4 PLUG VALVES

A. Discharge line isolation valves shall be non-lubricated eccentric plug valves. Plug valves shall be resilient faced plug style and include bi-directional eccentric seating so that the opening movement of the plug results in the plug rising off of the body seat contact.

B. Rated working pressure shall be 175 psi (direct and reverse pressure) for 4" to 12" plug valves, and 150 psi (direct and reverse) for larger valves, and shall be designed for applications involving throttling service or frequent operation. Flanges, where required or shown on the drawings, shall be 125 pound, full faced, drilled per ANSI B16.1.

C. All plug valves shall pass a drop tight pressure test at the specified shutoff pressure and pass a body hydrostatic test at 1.5 times the working pressure rating prior to shipment.

D. Valve bodies and plugs shall be ASTM A126 Class B cast iron. Bodies in 4-inch and larger valves shall be furnished with a 1/8-inch welded stainless steel or nickel overlay seat. The seat area shall be raised, with the raised surface completely covered with weld to insure that the plug face contacts only stainless steel or nickel. Screwed in seats shall not be acceptable.

E. The interference between the plug face and the body seat, with the plug in the closed position, shall be externally adjustable in the field with the valve in the line under pressure. The plug shall be resilient faced with a Buna N, hycar or equivalent compound suitable for use with sewage, bonded to insure a permanent coating.

F. Valves shall have sleeve type metal bearings and shall be of sintered, oil impregnated permanently lubricated Type 316 steel. Valve shaft seals shall be of the multiple V-ring type and shall be externally adjustable and repackable under pressure without removing the bonnet from the valve. Non-metallic bearing or valves with O-ring or non-adjustable packing shall not be acceptable.

G. Valves in vaults shall be provided with operators operating facing up. All gearing shall be enclosed in a steel housing with seals provided on all shafts to prevent entry of dirt or water into the actuator, rated for submergence. The exposed shaft shall be stainless steel. All exposed nuts, bolts and washers shall be galvanized or stainless steel. For buried valves provided with a 2-inch square operating nut, the nuts shall have a flanged base on which shall be cast an arrow at least 2-inch long with the word "OPEN" cast on the nut to clearly indicate the direction of opening. All actuators shall be provided with externally adjustable open and closed stops.

H. Unless otherwise specified, all valves shall be furnished with a fusion-bonded epoxy coating inside and outside conforming to the requirements of AWWA C-550.

I. Valve actuators shall be mounted such that the plug shaft is horizontal and the plug is up when open, with the square nut oriented upward. For horizontal installations, the valve shall be configured for installation with flow entering the seat end of the valve (ie. seat end toward the pump).

J. Plug valves shall be Val-Matic 5800 series eccentric plug valves with 8A or approved equivalent, as shown on the drawings.

2.5 SLIDE GATES

A. Slide Gate Schedule—No gate schedule is provided see gate callouts on notes in Contract Drawings.

B. Aluminum, 6061-T-6 guides and square slide with UHMW polyethylene bearing bars, ASTM D-200 neoprene seals, type 304 stainless stem, steel fasteners and wedges.

C. Leakage under the seating or unseating head shown in the Sluice Gate Schedule shall not exceed 0.1 US gallons per minute per foot of seating perimeter.

D. Refer to the Sluice Gate Schedule for type of gate (self-contained or non-self contained) and type of operator.

E. Maximum effort of 40 lb on crank or handwheel. Provide a T-wrench of sufficient length to operate any below-slab lift operators.

F. Manufactured by Golden Harvest, Model GH-40 for upward opening and Model GH-60 for downward opening weir type, or approved equal.

2.6 CAST IRON SHEAR GATES

A. Provide where drawings call for shear gates.

B. Shear gates are double wedge type with bronze seat and trim. The wedges are removable for easy replacement. Each gate is furnished with a lifting handle. Gates are designed for low seating pressure applications (not suitable for unseating heads).

C. Shear gates shall be designed to effectively control flows under seating head conditions. Frame shall be of cast iron with pads to receive the bolt on wedges and shall be of the flanged type drilled for mounting to an ANSI 125# flange or mounting to a wall. The seating surface shall be bronze machined to a smooth surface. The wedges shall be cast bronze and be securely attached to the frame utilizing two stainless steel bolts per wedge and shall be adjustable to ensure proper closure.

D. The cover shall be cast iron with machined bronze seat attached (sizes 4" and 6" shall be cast bronze with machined seating surface) and incorporate cast wedge pads for mating with the wedges. The cover shall be mounted to the frame utilizing a stainless steel hinge bolt. A cast iron lifting lug shall be bolted to the cover in such a manner as to allow a swiveling action. The lug shall be made so that it accepts a pipe type lifting rod which is to be field cut to the desired length.

E. Lift rods are used to manually raise and lower the Shear Gate disc from a position above the gate. A cast iron catch hook may be adjusted on the lift rod to allow the rod to be hung on a hanger placed in the wall. Lift rod material is ¾” dia. Carbon steel. Catch and loop handle are cast iron. Lift rods may be made to specified length in 6” increments.

F. Shear gates shall be M&H Valve Style 44-02, Waterman Industries, Inc. Model C-16, or approved equal.

2.7 KNIFE GATE VALVE

A. Knife Gates Valves shall be cast type 304 stainless steel construction, suitable continuous immersion in river water, with integral metal seat, lug style body for mounting on steel fabricated flange. Pressure rated to 50 psi.

B. Provide with operator extension and handwheel as shown on the drawings. Provide additional supports for valve and operator as required to prevent movement or misalignment.

C. Valves to be Dezurik, KGC, or approved equal.

2.8 SWING CHECK VALVE WITH LEVER AND SPRING

A. Materials of construction shall be as follows:

Component	Material
Class B Flanged Body	Cast iron, ASTM A126, Class B
Disc	Cast iron, ASTM A126, Class B
Seat rings	Stainless steel,
Hinge shafts and hinge pins	Stainless steel, 18-8
Spring	Steel

B. Valve body shall be full water way design, with replaceable stainless steel body seat.

C. The valve shall have external lever and spring to assist valve closure.

D. Manufacturer: Golden Anderson 230, or approved equal.

2.9 CONTROL VALVES

A. Pressure-Reducing Valves

1. Basis-of-Design Product: Subject to compliance with requirements, provide Cla-Valve Model 90-01 or a comparable product by one of the following:

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett Domestic Pump; a division of ITT Industries.
    d. Conbraco Industries, Inc.
    e. Spence Engineering Company, Inc.
    f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    g. Wilkins.

2. Body: Globe Style
3. Trim (Disc Guide, Seat and Cover Bearing): Stainless steel.
4. Rubber: Buna-N synthetic rubber.
5. Pressure Rating: 150 psi.

B. Pressure Relief Valve:

1. Hydraulically operated, pilot controlled valve. Fast opening and slow closing, with adjustable pressure setting.
2. Body and Cover: Ductile iron ASTM A536.
3. Trim (Disc Guide, Seat and Cover Bearing): Stainless steel.
4. Disc: Buna-N rubber.

5. Diaphragm: Nylon reinforced Buna-N rubber.
6. Stem, nut and spring: Stainless steel.
7. Pressure Rating: 150 psi.
8. Manufacturer: The pressure relief valve shall be Cla Valve Model 50-01 or approved equal.

2.10 AIR VALVES

A. Pump Air and Vacuum Valve:

1. Regulate the exhaust of air on pump start-up, and admit air to protect against vacuum conditions in the pipeline.
2. Dual port design, with an adjustable air discharge regulator port and a separate vacuum port.
3. Air/vac valve shall be Valmatic VMC-100S or approved equal.
4. Materials of construction

    a. Body, Cover: Cast iron, ASTM A 126, Grade B.
    b. Float: Stainless steel, T316.
    c. Seat: Buna-N.
    d. Exterior Paint: Alkyd primer.

2.11 OPERATORS

A. Except as specified in valve and gate specification sections, manual operators shall be as specified herein. Operators shall be mounted on the valve, damper or gate and provided as a unit. Each valve body or operator shall have cast thereon the word "OPEN," an arrow indicating the direction to open, and flow direction arrows.

B. Manual Operators - General: Manual operators shall have operating torques less than 80 foot-pounds. Unless specified otherwise, each manual operator shall be provided with an operating wheel. Unless specified otherwise, the direction of rotation of the operator shall be counterclockwise for opening.

C. Wrench Nuts: Wrench nuts shall comply with Section 3.16 of AWWA C500. A minimum of two operating keys, but no less than one key per every ten valves, shall be provided for operation of the wrench nut operated valves.

D. Chain Wheels: Chain wheels shall be ductile iron. Operating chains shall be galvanized.

2.12 OPERATOR APPURTENANCES

A. Valve Boxes: Valve boxes shall be cast iron and shall have suitable base castings to fit properly over the bonnets of their respective valves and heavy top sections with stay-put covers. Valve boxes shall be set in 12 inch by 12 inch by 8 inch thick gravel pad at 2 inches above surrounding ground except where valve box is set in concrete slab or shown otherwise on the Drawings. Covers shall be cast iron and impressed with service type label, example: “WATER”, “SEWER”, or “STORM”. Valve box covers shall be painted with epoxy paint

suitable for cast iron in outdoor application. Color to be coordinated with Owners Representative.

B. Floor Boxes: Floor boxes shall be hot-dip galvanized. Where the operating nut is in the concrete slab, the floor box shall be bronze bushed. Where the operating nut is below slab, the opening in the bottom of the box shall be sufficient for passage of the operating key.

C. Adjustable Shaft Valve Boxes: Adjustable shaft valve boxes shall be concrete or cast iron Brooks No. 3RT, Christie G5, Empire 7 1/2 valve extension box, or equal. Box covers on water lines shall be impressed with service type label, example: “WATER”, “SEWER”, or “STORM”.

PART 3 - EXECUTION

3.1 GENERAL

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Valves shall be installed where indicated on the Drawings, and in accordance with the manufacturer's recommendations.

C. Gate valves shall be installed in the closed position.

D. Manufacturer’s authorized representative shall be available for customer service during installation and start-up and to train personnel in the operation, maintenance, and troubleshooting of each valve type.

E. Valve operators shall be located so that they are readily accessible for operation and maintenance. Valve operators shall be mounted for unobstructed access, but mounting shall not obstruct walkways. Valve operators shall not be mounted where shock or vibration will impair their operation. Support systems shall not be attached to handrails, process piping, or mechanical equipment.

3.2 OPERATORS

A. General: Valves and gates shall be provided with manual operators, unless specified otherwise. Where possible, manual operators shall be located between 48 inches and 60 inches above the floor or a permanent work platform.

B. Wrench Nuts: Wrench nuts shall be provided on buried valves, on valves which are to be operated through floor boxes, and where specified. Extended wrench nuts shall be provided if necessary so that the nut will be within 6 inches of the valve box cover.

C. Chain Wheels: Unless otherwise specified, valves with centerlines more than 7 feet, 6 inches above the specified operating level shall be provided with chain wheels and operating chains. Chain wheel operated valves shall be provided with a chain guide. Operating chains shall be looped to extend within 4 feet of the specified operating level below the valve. For plug-type

valves 8 inches and larger, the operator shall be provided with a hammer blow wheel. Hooks shall be provided for chain storage where the chain may hang in a walkway.

3.3 OPERATOR APPURTENANCES

A. Valve Boxes: Valve boxes extending to finished surfaces shall be provided for buried valves.

B. Floor Boxes: Floor boxes shall be provided for wrench operation of valves located below concrete slabs. Each floor box and cover shall be of the depth required for installation in the slab.

3.4 PAINTING

A. Exposed valving and fittings shall be factory epoxy coated or standard factory coating.

END OF SECTION 15110

SECTION 15132

SUBMERSIBLE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes submersible pumps for the following:

1. River Intake Pump Station.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Wiring Diagrams: For power, signal, and control wiring.

C. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 SUBMERSIBLE PUMPS

A. Submersible, Quick-Disconnect, Double-Seal Pumps:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Flygt NP style pump or comparable product by one of the following:

   a. ABS Pumps Inc.

2. Description: Factory-assembled and -tested submersible-pump unit with guide-rail supports.
3. Pump type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.
4. Pump Construction:

   a. Major pump components shall be of grey cast iron, ASTM A-48, Class 35B, with smooth surfaces devoid of blow holes or other irregularities. All exposed nuts or bolts shall be of stainless steel construction. All metal surfaces coming into contact with the pumpage, other than stainless steel or brass, shall be protected by a factory applied spray coating of acrylic dispersion zinc phosphate primer with a polyester resin paint finish on the exterior of the pump.
   b. Sealing design shall incorporate metal-to-metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or optional Viton rubber O-rings. Fittings will be the result of controlled compression of rubber O-rings in two planes and O-ring contact of four sides without the requirement of a specific torque limit.
   c. Rectangular cross sectioned gaskets requiring specific torque limits to achieve compression shall not be considered as adequate or equal. No secondary sealing compounds, elliptical O-rings, grease or other devices shall be used.

5. Cable Entry Seal:

   a. The cable entry seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall consist of dual cylindrical elastomer grommets, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter. The grommets shall be compressed by the cable entry unit, thus providing a strain relief function. The assembly shall provide ease of changing the cable when necessary using the same entry seal. The cable entry junction chamber and motor shall be sealed from each other, which shall isolate the stator housing from foreign material gaining access through the pump top. Epoxies, silicones, or other secondary sealing systems shall not be considered equal.

6. Motor:
   a. Refer to Section 16152 – Submersible Motors.

7. Bearings

a. The integral pump/motor shaft shall rotate on two bearings. The motor bearings shall be sealed and permanently grease lubricated with high temperature grease.

b. The upper motor bearing shall be a two row angular contact ball bearing. The lower bearing shall be a two row angular contact ball bearing to handle the thrust and radial forces. The minimum L_{10} bearing life shall be 50,000 hours at any usable portion of the pump curve.

8. Mechanical Seals

a. Each pump shall be provided with a positively driven dual, tandem mechanical shaft seal system consisting of two seal sets, each having an independent spring. The lower primary seal, located between the pump and seal chamber, shall contain one stationary and one positively driven rotating corrosion resistant tungsten-carbide ring. The upper secondary seal, located between the seal chamber and the seal inspection chamber, shall contain one stationary and one positively driven rotating corrosion resistant tungsten-carbide seal ring All seal rings shall be individual solid sintered rings. Each seal interface shall be held in place by its own spring system. The seals shall not depend upon direction of rotation for sealing. Mounting of the lower seal on the impeller hub is not acceptable. Shaft seals without positively driven rotating members or conventional double mechanical seals containing either a common single or double spring acting between the upper and lower seal faces are not acceptable. The seal springs shall be isolated from the pumped media to prevent materials from packing around them, limiting their performance.

b. Each pump shall be provided with a lubricant chamber for the shaft sealing system. The lubricant chamber shall be designed to prevent overfilling and shall provide capacity for lubricant expansion. The seal lubricant chamber shall have one drain and one inspection plug that are accessible from the exterior of the motor unit. The seal system shall not rely upon the pumped media for lubrication.

c. The area about the exterior of the lower mechanical seal in the cast iron housing shall have cast in an integral concentric spiral groove. This groove shall protect the seals by causing abrasive particulate entering the seal cavity to be forced out away from the seal due to centrifugal action.

d. A separate seal leakage chamber shall be provided so that any leakage that may occur past the upper, secondary mechanical seal will be captured prior to entry into the motor stator housing. Such seal leakage shall not contaminate the motor lower bearing. The leakage chamber shall be equipped with a float type switch that will signal if the chamber should reach 50% capacity.

9. Pump Shaft

a. The pump and motor shaft shall be a single piece unit. The pump shaft is an extension of the motor shaft. Shafts using mechanical couplings shall not be acceptable. The shaft shall be stainless steel – ASTM A479 S43100-T. Shaft sleeves will not be acceptable.

10. Impeller

a. The impeller shall be of (ASTM A-48, Class 35B gray iron or ASTM A-532 (Alloy III A) 25% chrome cast iron) dynamically balanced, semi-open, multi-vane,

back swept, screw-shaped, non-clog design. The impeller leading edges shall be mechanically self-cleaned automatically upon each rotation as they pass across a spiral groove located on the volute suction. The screw-shaped leading edges of the gray iron impeller shall be hardened to Rc 45 and shall be capable of handling solids, fibrous materials, heavy sludge and other matter normally found in wastewater. The screw shape of the impeller inlet shall provide an inducing effect for the handling of up to 5% sludge and rag-laden wastewater. The impeller to volute clearance shall be readily adjustable by the means of a single trim screw. The impellers shall be locked to the shaft, held by an impeller bolt and shall be coated with alkyd resin primer.

11. Volute / Suction Cover

    a. The pump volute shall be a single piece gray cast iron, ASTM A-48, Class 35B, non-concentric design with smooth passages of sufficient size to pass any solids that may enter the impeller. Minimum inlet and discharge size shall be as specified. The volute shall have a replaceable suction cover insert ring in which are cast spiral-shaped, sharp-edged groove(s). The spiral groove(s) shall provide trash release pathways and sharp edge(s) across which each impeller vane leading edge shall cross during rotation so to remain unobstructed. The insert ring shall be cast of (ASTM A-48, Class 35B gray iron or ASTM A-532 (Alloy III A) 25% chrome cast iron) and provide effective sealing between the multi-vane semi-open impeller and the volute housing.

12. Protection

    a. Each pump motor stator shall incorporate three thermal switches, one per stator phase winding and be connected in series, to monitor the temperature of the motor. Should the thermal switches open, the motor shall stop and activate an alarm. A float switch shall be installed in the seal leakage chamber and will activate if leakage into the chamber reaches 50% chamber capacity, signaling the need to schedule an inspection.
    b. The thermal switches and float switch shall be connected to a Mini CAS control and status monitoring unit. The Mini CAS unit shall be designed to be mounted in the pump control panel.

13. Control-Interface Features:

    a. Remote Alarm Contacts: For remote alarm interface.
    b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:

        1) On-off status of pump.
        2) Alarm status.

14. Guide-Rail Supports:

    a. Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
    b. Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.

c. Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
d. Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
e. Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
f. Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
g. Lifting Cable: Stainless steel; attached to pump and cover at manhole.

B. Performance Requirements – River Intake Pumps (PMP-101, PMP-102)
Based on Flygt NP 3171 MT3 – 435

		Design Point A	*Secondary Point B
1.	Capacity (GPM):	1350	700
2.	Total Dynamic head (Ft):	56	75
3.	Minimum Efficiency (%)	78	67
4.	Maximum NPSHR (Ft):	23.1	24
5.	Rated Speed (rpm):	1770	1770
6.	Maximum Motor Size (HP):	30	30

*Secondary Operating Points shall have values $\pm$ 5% maximum of those listed for items 1-4.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine roughing-in for process piping to verify actual locations of piping connections before pump installation.

B. Pump Installation Standards:

1. Comply with HI 1.4 for installation of centrifugal pumps.

C. Wiring Method: Comply with requirements in Division 16. Provide manufacture supplied pump power and control cables with adequate length to reach the hand hole outside of the pump wet well with no splices.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2 CONNECTIONS

A. Install piping adjacent to equipment to allow service and maintenance.

B. Install power and control cables so that splices can be disconnected in the hand hole and pulled out of the pump station through sealed conduit when the pump is removed.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Notify Owner’s Representative of testing schedule.
2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Pumps and controls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust control set points.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

END OF SECTION 15132

SECTION 15135

CENTRIFUGAL PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the close-coupled, end-suction centrifugal pumps for the following:

1. Reuse Pumps (PMP-201, PMP 202)

2. Booster Pump (PMP-400)

1.2 ACTION SUBMITTALS

A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

A. Basis-of-Design Product: Provide Bell & Gossett Model e-1532-6G for PMP-201 & PMP-202. Provide Bell & Gossett Model e-1532-2BD for PMP-400. Comparable products by one of the following, subject to compliance with requirements:

1. American-Marsh Pumps.
2. Armstrong Pumps Inc.
3. Aurora Pump; Division of Pentair Pump Group.
4. Crane Pumps & Systems.
5. Flowserve Corporation.
6. ITT Corporation; Bell & Gossett.
7. ITT Corporation; Goulds Pumps.
8. PACO Pumps.
9. Patterson Pump Co.; a subsidiary of the Gorman-Rupp Co.
10. Peerless Pump Company.
11. TACO Incorporated.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

C. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and flanged connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft: Stainless steel.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: Permanently lubricated ball bearings.

D. Motor: Single speed and rigidly mounted to pump casing with integral pump support.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Division 16.

    a. Enclosure: Appropriate for intended location.
    b. Enclosure Materials: Cast iron.
    c. Motor Bearings: Permanently lubricated or Grease-lubricated ball bearings.
    d. Efficiency: Premium efficient.

e. NEMA Design: B.
f. Service Factor: 1.15.

3. Motors shall be designed for and compatible with variable frequency drives.

E. Capacities and Characteristics (PMP-201, PMP-202):

1. Capacity: 1350 gpm.
2. Total Dynamic Head: 40 feet.
3. Minimum Efficiency at Design Point: 78%.
4. Maximum Operating Pressure: 175 psig.
5. Maximum Continuous Operating Temperature: 225 deg F.
6. Inlet and Outlet Size: 8-inch suction; 6-inch discharge.
7. Impeller Size: 11.625-inch diameter.
8. Motor Speed: 1,200 rpm.
9. Motor Horsepower: 20 hp.
10. Electrical Characteristics:
    a. Volts: 240 V.
    b. Phase: Three.
    c. Hertz: 60.

F. Capacities and Characteristics (PMP-400):

1. Capacity: 190 gpm.
2. Total Dynamic Head: 54 feet.
3. Minimum Efficiency at Design Point: 74%.
4. Maximum Operating Pressure: 175 psig.
5. Maximum Continuous Operating Temperature: 225 deg F.
6. Inlet and Outlet Size: 2.5-inch suction; 2-inch discharge.
7. Impeller Size: 8.375-inch diameter.
8. Motor Speed: 1,800 rpm.
9. Motor Horsepower: 5 hp.
10. Electrical Characteristics:
    a. Volts: 240 V.
    b. Phase: Three.
    c. Hertz: 60.
11. Manufacturer furnished pump controller with VFD in NEMA 4X enclosure. Controls to regulate pump speed to maintain constant discharge pressure setpoint. Controls shall include motor protection and pump speed manual override.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Equipment Mounting: Install base-mounted pumps on cast-in-place concrete equipment bases.

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct bases to withstand, without damage to equipment, seismic force required by code.
3. Construct concrete bases 4 inches high and extend base not less than 6 inches in all directions beyond the maximum dimensions of base-mounted pumps unless otherwise indicated or unless required for seismic-anchor support.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to pump, allow space for service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

F. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.

G. Ground equipment according to Division 16

H. Connect wiring according to Division 16

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Check piping connections for tightness.
3. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.

4. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
5. Start motor.
6. Open discharge valve slowly.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 15135

SECTION 15200

PROCESS PIPING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. The work covered by this section consists of utility and process piping systems. The systems shall include piping, fittings, hangers, couplings, and connections to equipment. Building domestic and sanitary plumbing shall be as specified in this section. Valves are specified in section 15110. Electrical conduits shall be as specified in Division 16.

B. All work performed under this section shall be in accordance with all approved trade practices and manufacturers' recommendations.

1.2 REFERENCE STANDARDS

Reference	Title
ANSI A13.1	Scheme for the Identification of Piping Systems
ANSI B1.20.1	Pipe Threads, General Purpose (Inch)
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250, and 800
ANSI B16.5	Pipe Flanges and Flanged Fittings
ASTM A74	Cast Iron Soil Pipe and Fittings
ASTM A403/A403M	Wrought Austenitic Stainless Steel Piping Fittings
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-Series)
ASTM F679	Poly (Vinyl Chloride) (PVC) Plastic Drain Pipe –Large Diameter
AWWA C105	Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110	Ductile-Iron and Gray-Iron Fittings, 3 Inch Through 48 Inch, for Water
AWWA C111	Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings
AWWA C115	Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151	Ductile-Iron Pipe, Centrifugally Cast for Water
AWWA C200-05	Steel Water Pipe – 6 in. and Larger
AWWA C227	Bolted, Split Sleeve Couplings for Plain End Pipe.
AWWA C651	Disinfecting Water Mains

AWWA C900/905	Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings
AWWA C906-07	Polyethylene (PE) Pressure Pipe and Fittings, 4 In. Through 63 In. (HDPE)
Handbook of PE Pipe	Plastic Pipe Institute (PPI) Handbook of Polyethylene Pipe for applicable HDPE pipe sizes and applications
UPC	Uniform Plumbing Code

1.3 SUBMITTALS

A. Manufacturer's product data and other information for each pipe size and fitting to be furnished. Individual submittals shall be marked to indicate each system where the piping item is to be used.

B. Piping layouts and layout schedule by area showing pipeline locations for all piping systems in that area with respect to structures, other piping and utilities and details and location of joints, anchors, supports, fittings, connections, penetrations, supports, valves, piping appurtenances, flexible couplings, manholes, and cleanouts as applicable. Drawings shall be original layouts by the Contractor; photocopies of contract drawings are not acceptable.

C. Restrained joint anchorage calculations required by this section of the specifications. Joint restraint product data for fittings and pipe joints. Pipe joint restraint schedule.

D. Installation Instructions: Manufacturer’s printed instructions for installation of each type and size of pipe, fitting, and appurtenance.

E. Certified copies of all tests required by the standards for the manufacture of pipe, fittings, joints, coatings, valves, and pipe supports.

F. Affidavit of compliance that each type and size of pipe complies with all provisions for pipe manufacture and materials as specified in this section.

1.4 CONTRACT DRAWINGS

A. The contract drawings indicate the general design, arrangement and extent of piping systems. The indicated positions shall be followed as closely as possible. Do not scale drawings for roughing in measurements nor use as shop drawings. Prepare shop drawings per “Submittals,” specified herein. The exact location of various items is subject to building construction, and the actual materials and equipment furnished. Verify the location of items to be furnished, installed, or connected, and incorporate this information when preparing shop drawings. Coordinate work with other specification sections and divisions.

B. Piping systems shall be located from dimensions given on drawings or implied locations shall be determined at the building site after field measurements have been taken.

C. Should interferences or discrepancies prevent the installation of any part of the work, the Owner’s Representative shall be notified and the Owner’s Representative will determine the steps necessary to complete the true development of the intent of the drawings and specifications.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 61, "Drinking Water System Components-Health Effects; Sections 1 through 9," for domestic water service and fish process water piping and components. Any pipe, fittings, components, and chemicals used on fish water supply systems will also comply with NSF 61 unless indicated otherwise.

C. Comply with pipe and fitting manufacturer installation requirements and perform recommended testing, unless more stringent requirements are specified herein. General requirements are:

1. Clean and protect pipe ends, and securely cover ends when waiting for work to proceed.
2. Backfill with recommended materials and perform compaction testing.
3. Document flange torque procedure.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery, storage, and handling for all ductile iron materials shall be in accordance with ANSI/AWWA C600 and AWWA C605 for PVC materials. Other pipe materials shall be as required by the manufacture and including the Plastic Pipe Institute for HDPE pipe.

B. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.

C. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.

D. Linings and Coatings: Prevent excessive drying.

E. Cold Weather Storage: Locate products to prevent coating from freezing to ground.

F. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Pipe schedule shall be as shown in the Contract Drawings.

B. Unless otherwise specified, piping materials, including pipe, gaskets, fittings, connection and joint assemblies, linings and coatings, shall be selected from those listed in the Contract Drawings on the Pipe Schedule and indicated in the Pipe Systems table. Piping materials shall conform to detailed specifications herein for each type of pipe.

C. Where temporary piping and valving are required, piping material and accessories shall be selected by the Contractor. Such piping shall be suitable for operation at the test pressure and maximum range of operating service temperature of the permanent piping system which the temporary piping is replacing, as specified. Plastic, steel, RCP, ductile iron, and polyethylene pipe may all be used at the Contractor's discretion. Temporary piping shall be provided with supports at intervals which prevent sagging or liquid accumulation.

2.2 COUPLINGS

A. Flanges, gaskets and bolts: Ductile-iron or Cast-iron flanges shall conform to ANSI B16.1, Class D. Steel flanges including AWWA C207 flanges may be bolted to cast-iron valves, fittings, or other parts having either integral Class 125 companion flanges or screwed Class 125 companion flanges. When such construction is used, the raised face on mating flanges shall be removed. Flanges shall be flat faced unless otherwise noted. Flange gaskets shall be full-face type, synthetic rubber or other material, suitable for the intended service including working media, pressure and temperature. Substitution of other gasket materials shall be only with the express written consent of the Owner's Representative or as noted herein. Gasket thickness shall be 1/16 inch for pipe 10 inches and less and 1/8 inch for larger pipe. Flange assembly bolts shall be heavy pattern hexagon head carbon steel machine bolts with heavy pattern, hot pressed, heavy hexagon nuts, all ANSI B18.2. Threads shall comply with ANSI B1.1, coarse threads series, Class 2 fit. Bolts and nuts for normal service including buried and above ground conditions shall conform to the chemical and mechanical requirements of ASTM A307B and shall be zinc plated. Bolts and nuts for use in submerged or under continual water spray service conditions shall be 304 stainless steel ASTM A193, Grade B8 bolts and ASTM A194 Grade B8 nuts. Stainless steel nuts shall be coated to prevent galling.

1. Forged steel flanges, where required, shall be welding neck, conforming to ASTM A 181 Grade I and ANSI B16.5. Forged steel flange gaskets shall be suitable for intended service. On 3-1/2-inch forged steel flanges and smaller, gaskets shall be 1/16 inch thick. Forged steel flange assembly bolts shall be alloy steel studs, ASTM A 193 with 2 F.S. hexagon nuts ASTM A 194 per stud.
2. For low-pressure service, 20 psig and under, Class B lightweight flanges conforming to AWWA C 207 may be used.
3. Fittings and Coupling Compatibility: To assure uniformity and compatibility of piping components, fittings and couplings for grooved end piping systems shall be furnished by the same manufacturers.

B. Pipe threads: Unless otherwise noted, all pipe threads shall conform in dimension and limits of size to ANSI B2.1 Class 2 NPT, taper pipe thread.

C. Flexible rubber couplings, for pump connections or where otherwise shown or specified, shall be of resilient arch type specifically designed for the intended exposure and shall be standard or tapered as shown. Couplings shall be filled arch type.

1. Couplings shall have a liner of neoprene and shall have a smooth surface to the flow, extending through the bore of each coupling in one single unbroken piece to full face both flanges. The carcass of each coupling shall be constructed of elastomers with internal reinforcing materials sufficient to provide pressure resistance at temperatures in accordance with a design to burst safety factor of 3 to 1 and shall contain integrally molded flanges. Each coupling shall be covered with a heavy-duty neoprene-hypalon jacket designed to be resistant to abrasion, heat, petroleum products, ozone, and weathering. Flanges shall be fitted with steel retaining rings. Drilling and bolting shall comply with ANSI B16.1, Class 125, or as required by the conditions of service. Flexible couplings for pump inlets shall be Uniroyal Style 4150, Belmont Style 5404, General Rubber Style 1050, Unaflex Style 150, or equal. All couplings shall be rated for a minimum working pressure of 140 psig and shall be equipped with suitable expansion restraints designed for a minimum total pressure of 150 psig or as required by the conditions of service specified. Numbers and size of restraints shall be as determined by

the manufacturer. Restraints shall be hot-dip galvanized. Discharge couplings shall be American Rubber Manufacturing Company Style P, Belmont Style 5404, General Rubber Style 1075, Unaflex Style 150, or equal.

2. A flexible coupling shall be provided in all piping at all structural expansion joints unless otherwise directed by the Owner's Representative. The flexible coupling shall be located within 2.5 pipe diameters of the structural expansion joint.

D. Mechanical pipe couplings

1. Flexible pipe couplings: Where flexible pipe couplings are shown or specified for use with plain end steel, ductile-iron, or PVC pipe installed above or below grade. The couplings used shall be Dresser Style 38, Smith-Blair Type 411 or 441, Romac 501, or equal and shall conform to AWWA C219 Bolted, Sleeve-Type Couplings. Couplings used for pipe under pressure where not otherwise secured or anchored against expansion shall be equipped to take tension by means of joint harnesses with shackle rods meeting the requirements of AWWA Manual M11, Section 19.8. Use of locking pins in drilled holes is not acceptable. Restraint components shall be hot-dip galvanized.

   a. Couplings for connecting steel pipe to ductile-iron pipe shall be Smith-Blair Type 413, Dresser Style 62, or equal. Insulating couplings shall be Smith-Blair Type 416, Dresser Style 39, or equal.
   b. Flanged coupling adapters shall be used where shown or where valve and piping are secured against expansion with shackle rods or other means, they shall be Dresser Style 128, Romac Style FCA 501, or equal, for plain end pipe.
   c. Donut-type fittings may be used on gravity drain lines only.
   d. All coupling gaskets shall be a synthetic rubber suitable for exposure to water containing grease or petroleum products and shall be as recommended by the coupling manufacturer for the service intended. Mechanical pipe couplings and flexible pipe couplings shall be provided where required by good piping practice and as necessary for disassembly.

2. Bolted split sleeve coupling: Victaulic Depend-O-Lok, Romac Armor Seal, or Straub couplings conforming to AWWA C227. Shall be used where shown or may be used as a flexible pipe coupling when working pressure is less than 20 psi for use with plain end steel, ductile-iron, or PVC pipe.

E. Expansion joints: Expansion joints and anchors shall be provided as recommended by the manufacturer to accommodate pipe movement due to temperature changes. Details shall be submitted to the Owner's Representative for acceptance before installation. All expansion joints shall be suitable for pressures and temperatures set forth in the Piping System Table, without crimping of corrugations. Corrugated types shall be suitable for a minimum 100,000 pressure, temperature and deflection cycles. Packed type joints shall have packing suitable for the service involved and shall be Certain-Teed Fluid Tite PVC, Johns-Manville PVC double bell expansion joint, or equal, for buried services.

1. The location and spacing of expansion joints, anchors, hangers and supports shall be as required by good piping practice and as recommended by the Expansion Joint Manufacturers Association to accommodate pipe movement due to temperature changes, unless noted otherwise.

2. Expansion joints for polyvinylchloride piping shall be Celanese "Chemtrol," CPVC slip type with teflon impregnated seal ring; Certain-Teed Fluid Tite PVC; Johns-Manville PVC double bell expansion joint, or equal.

F. Thermal Expansion Joints: AWWA C221, Type A36 steel body, type 304 stainless steel slip pipe, high strength, low alloy corrosion resistant stell nuts and bolts per AWWA C111alternating rubber and wax impregnated flax packing, flanged ends, fusion bonded epoxy coating, Romac EJ-401 or Approved equal.

G. Modular mechanical expanding rubber seals (link seals) shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tightening of the bolts shall cause the rubber sealing elements to expand and provide an absolutely watertight seal between the pipe and wall opening. The seal shall be constructed so as to provide electrical insulation between the pipe and wall, thus reducing chances of cathodic reaction between these 2 members.

1. Contractor shall determine the required inside diameter of each individual wall opening or sleeve before ordering, fabricating, or installing. The inside diameter of each wall opening shall be sized as recommended by the manufacturer to fit the pipe.

H. Unions 1-1/2-inch and smaller: Ground joint, malleable type; 2 inches and larger, flange type. Grinnell, Crane, Walworth, or equal.

I. Dielectric unions shall meet the dimensional requirements and tensile strength of pipe unions in accordance with Fed. Spec. WW-U-531. The unions or flanges shall be suitable for the required operating pressures and temperature conditions. The unions shall have metal connections on both ends of union. The ends of the unions shall be threaded or soldered to match adjacent piping. The metal parts of the union or flange shall be separated to prevent current flow between the dissimilar metals.

J. Escutcheons shall be Grinnell Figure 13 nickel-plated, or equal.

K. Quick connect/disconnect (Cam-Lok) adapters shall be aluminum and come with end cap and stainless steel chain attached to both items. The fitting shall be as manufactured by P.T. Coupling or equal.

2.3 SCHEDULE 40/80 PVC PIPE AND FITTINGS

A. Polyvinylchloride pipe: Polyvinylchloride (PVC) material for pressure pipe fittings and couplings shall conform to ASTM D 1784, Type 1, Grade 1, with 2,000-psi design stress. Pipe and fittings shall be Schedule 80 unless indicated otherwise on the drawings and shall be in accordance with ASTM D 1785. Thickness schedule shall be as specified on pipe specification sheets.

B. PVC fittings shall be socket type conforming to ASTM D 2466/2467 unless specifically called out otherwise elsewhere on the specifications or drawings. Solvent cement shall comply with ASTM D 2564.

C. Exposed PVC pipe shall be coated with a single coat of an epoxy coating system, Tnemec Series N69 Hi-Build Epoxoline, or equal. Total dry film thickness shall be 4 to 6 mils.

2.4 C900 / C905 PVC PIPE AND FITTINGS

A. Pipe 4" to 12" diameter shall meet requirements of AWWA C900. Wall thickness shall be DR 25 unless shown otherwise on the drawings. Pipe 14" and larger shall meet requirements of AWWA C905. Wall thickness shall be DR 25 unless shown otherwise on the drawings.

B. PVC shall comply with ASTM D 1784 and gasketed joints shall comply with ASTM D3139. The gaskets shall comply with ASTM F 477.

C. Fittings shall be ductile iron with restrained mechanical joints. See section on ductile iron pipe and fittings for additional fitting requirements.

2.5 D3034 / F679 PVC GRAVITY PIPE AND FITTINGS

A. PVC gravity pipe and fittings sizes 4" through 15" shall conform to ASTM D3034. PVC gravity pipe and fittings sizes 18" through 48" shall conform to ASTM F679. Pipe shall be DR 35 unless shown otherwise on the drawings. PVC material shall comply with ASTM D 1784 cell class 12454.

B. Pipe shall have integral bell gasket joints. Rubber gaskets shall be factory installed and conform to ASTM F477. Joint design shall meet requirements of ASTM C3212 under both pressure and 22" Hg vacuum. Pipe shall be installed according to ASTM D2412.

2.6 STEEL PIPE AND FITTINGS

A. Steel pipe shall meet the requirements of ASTM A 53 or ASTM A-106, Grade B, and shall be standard weight except as otherwise specified or shown on the drawings. Ends of pipe shall be flanged or plain end, as indicated on the Drawings. Where flanges are used, they shall be ANSI B16.5, Class 150, with flat face.

B. Fittings shall meet ASME/ANSI B16.9, standard weight.

C. All welded joints shall be performed in a shop with AWS certified welders, and conform to the requirements of AWWA C200. Pipe shall be joined in the field with either flanged joints or solid sleeve solid sleeve flexible couplings.

D. Galvanized pipe and fittings shall be zinc hot-dip galvanized complying with ASTM A 153

E. Pipe that is not galvanized shall be epoxy lined and coated per AWWA C213.

2.7 STAINLESS STEEL PIPE AND FITTING

A. Stainless-steel pipe shall meet the requirements of ASTM A 312 or ASTM A 409. Stainless-steel pipe shall be of the following minimum thickness unless otherwise noted for specific usage:

Diameter	Minimum Thickness
2-1/2 inches and smaller	Schedule 40S
3 inches and larger	Schedule 10S

B. Ends of pipes shall be threaded with couplings for 2-1/2 inches and smaller and butt-welded for 3 inches and larger pipes. All welding shall be performed in a shop with AWS certified welders. Pipe and fittings shall be joined in the field with flexible couplings or flanges. Flanges shall be class 150 with flat faces.

2.8 DUCTILE IRON PIPE AND FITTINGS

A. Ductile-iron pipe and fittings: All ductile-iron pipe shall conform to the current provisions of ANSI A21.51. Unless otherwise designated, ductile-iron pipe shall be standard thickness Class No. 52 for pipes with non-grooved joints and Class 53 for pipes with grooved joints.

B. Joints for pipe and fittings for exposed piping shall be flanged or flexible couplings. Flanged fittings shall conform to AWWA/ANSI C110/A21.10.

C. Buried fittings shall be mechanical joint per ANSI A21.11. Fittings shall be restrained with a Mega Lug or similar retainer gland. Buried pipe joints may be of the push-on type, provided it is restrained at bends, tees, and dead-ends, for sufficient distance on each side of the fitting to prevent pulling at the joint during testing. Mechanical joints, exclusive of grooved mechanical, shall not be used for exposed piping.

D. Ductile iron pipe and fittings shall have a cement mortar lining per ANSI/AWWA C104/A21.4. Cement shall be ASTM C150, Type II or V, low alkali, containing less than 0.60 percent alkalies. There shall be no seal coat over the cement mortar lining.

E. Exposed pipe and fittings shall be furnished with a shop primer and coated with 2 coats of an epoxy-polyamide coating, Tnemec N69 Hi-Build Epoxoline or approved equal. Dry film thickness (DFT) of the first and second coats shall be 4 to 6 mils each, for a total DFT of 8 to 12 mils.

F. Buried pipe and fittings shall be furnished with the manufactures standard asphaltic per ANSI/AWWA C151/A21.51

2.9 PIPELINE DETECTION

A. Toning Wire: All buried piping shall be installed with toning wire. Toning wire shall be continuous insulated #12 gauge solid core copper toning wire. Insulation shall be 30 mil HDPE green in color. All splices in toning/tracer wire shall be completed with watertight and corrosion resistance splices (waterproof wire nuts). Toning wire shall be located on top of pipe. Additional wire shall be supplied as necessary to allow the toning wire to be looped up at all valves, ARVs, manholes or other structures on all lines.

B. Locate Tape: All buried piping shall be installed with located tape buried 12-inches above the pipe crown. Locate tape shall be 4-inches wide, a minimum 4.0 mil (0.004") thick, virgin low

density polyethylene plastic film formulated for extended use underground. Tape shall be labeled the to identify the type utility or piping system.

PART 3 - EXECUTION

3.1 PIPING IDENTIFICATION

A. Pipe coding and marking shall be as specified in Section 15050.

3.2 INSTALLATION

A. General: The types and sizes of pipes to be used shall be as specified and shown. Where sizes or locations of small pipe are omitted from the drawings and not mentioned in the specifications, the sizes to be used shall correspond to the latest edition of the Uniform Plumbing Code requirements. In any event, undesignated pipe shall be proper for the functions to be performed and as accepted by the Owner's Representative. Installation shall be in accordance with the manufacturer's written manual.

1. Location: Piping shall be provided as specified except for adjustments to avoid architectural and structural features and shall be coordinated with electrical construction. Piping installed adjacent to equipment and machines shall be located to allow for service and maintenance.
2. Joint and Fitting Options: Pipe connection (joint and fitting) options for a particular piping system shall be as specified unless otherwise indicated in the Pipe Schedule and Pipe System information shown on the drawings. Takedown couplings shall be provided for all piping systems. Takedown couplings shall be provided both around equipment and at standard pipe lengths for all straight runs of pipe. Continuous welding for straight runs of pipe is acceptable only where the individual pipe system allows welding as a connection option. Where connections are shown, the connections shall be specifically where shown; however, if several connection options are allowed for the particular piping system, then any option may be consistently used; i.e., if flanged or grooved are acceptable and flanged are shown, then grooved may be substituted. Integrity of rigid, non-rotating connections must be maintained at all valves and other equipment.
3. Unless otherwise specified, the crowns of all buried pipe shall be at least 30 inches below finished grade. Pipes with less than 30 inches of cover shall be encased in concrete.
4. All pipe shall be carefully placed and supported at the proper lines and grades, and where possible shall be sloped to permit complete drainage. Piping runs shown on the drawings shall be followed as closely as possible, except for minor adjustments to avoid equipment, architectural, and structural features. If major relocations are required, they shall be acceptable to the Owner's Representative.
5. In erecting the pipe a sufficient number of screw unions, flanged or grooved end type joints shall be used to allow any section or run of pipe to be disconnected without taking down adjacent runs. Flanged and mechanical pipe coupling joints shall be employed on pipelines 3 inches in diameter and larger. The provision of an adequate number of appropriate take-down fittings must be rigidly adhered to whether or not such fittings are indicated on the drawings. Take-down fittings shall also be provided for removal of valves and other appurtenances. Where piping passes through concrete or masonry walls, take-down fittings shall be employed as near the wall as possible. Dielectric unions shall

be used at all locations to join pipe or equipment of dissimilar metals. Eccentric reducers shall be used to keep the top of piping at pump suctions level.

6. Unless otherwise specified, all pipes passing from concrete or steel to earth shall be provided with a flexible coupling. Wherever a metallic pipe 1 inch in diameter or larger passes from concrete to earth horizontally, 2 flexible pipe couplings spaced from 2 feet to 4 feet apart depending on pipe size shall be installed, whether shown or not. Only one flexible pipe coupling is required on vertical runs from the Structure. One coupling shall be within I foot of the structure. Particular care shall be taken to ensure a full support of the pipe in the earth between and beyond the joints.
7. All pressure taps on the suction and discharge sides of all pumps, blowers, and compressors shall be provided with ball valves unless otherwise shown. Provide taps in all piping for flow switches, pressure switches, etc., as required, to match instrumentation drawings. Taps to be a minimum diameter of 3/4 inch with bushings for smaller sizes. For taps larger than 3/4 inch, tap actual size to be coordinated with electrical instrumentation.
8. Unless otherwise specified, the suction and discharge of all pumps, blowers, fans, and compressors shall be provided with flexible couplings suitable for the intended service.

B. Pipe supports

1. Unless part of a pipe system indicated as designed by the Contractor (Delegated Design), all pipe shall be secured in place by use of the standard piping support details shown on the mechanical detail drawings. The Contractor shall make use of these standard pipe supports in order to support the piping in accordance with the criteria outlined in the general mechanical (or plumbing where applicable) drawings and specified herein.

    a. Supplemental to the above, the contract drawings indicate the location of pipe stanchions and/or special supports where required.
    b. Additional pipe supports shall be installed where required to comply with pipe manufacturer recommended spacing to prevent sag, deflection of joints, and excess stress in the pipe system.
    c. In addition, in order to prevent swaying in piping system supported by hangers, the Contractor shall install side-sway bracing. Sway bracing shall be sufficient to eliminate horizontal pipe deflection during operation for all piping 4 inches and greater. As a minimum, sway bracing shall be installed at 20-foot intervals on system where hanger supports are used. Bracing shall be installed on pipe rack assemblies or other supported pipe runs that have observable movement during system operation. When directed by the Owner’s Representative additional bracing shall be installed to minimize pipe movement.

2. Supports for exposed piping shall conform to the latest requirements of the ANSI Code for Pressure Piping B31-10 and MSS standard Practice SP-58, except as supplemented or modified by the requirements of this specification.

    a. Designs generally accepted as exemplifying good engineering practice, using stock or production parts, shall be utilized wherever possible.

3. Hanger supports shall be as noted, with at least one support adjacent to the joint for each length of pipe, at change in direction and at branch connections. Sufficient hangers shall be provided to maintain proper slope without sagging. Support spacing shall not exceed

the pipe and hanger manufacturer's recommendations or those stipulated on the drawings whichever is more stringent.

4. Spacing of clamps for support of horizontal or vertical piping shall be spaced close enough to keep the pipe in alignment as well as to support the weight of the piping and contents, but in no case shall be more than 10 feet.
5. Provide adjustable hangers complete with adjusters, swivels, rods, etc. Size hangers to clear insulation and guide where required, as well as support piping. All rigid hangers shall provide a means of vertical adjustment after erection. Hanger rods shall be machine-threaded. Continuous threaded or "all thread" rods will not be allowed unless otherwise noted.
6. Clevis or band-type hangers: Grinnel. 260 or 269, Elcen, or equal, shall be provided. Strap hangers not permitted.
7. Provide floor stands, wall bracing, concrete piers, etc., for all lines running near the floors or near walls and which can be properly supported or suspended by the walls or floors. Pipe lines near concrete or masonry walls may also be hung by hangers carried from wall brackets at a higher level than pipe. Hanging of any pipe from another is prohibited.
8. Equipment shall be so positioned and aligned that no strain shall be induced within the equipment during or subsequent to the installation of pipework.
9. When temporary supports are used, they shall be sufficiently rigid to prevent any shifting or distortion of the piping or related work.
10. Flexible couplings shall be installed where shown on the drawings and shall be added at such other points as required for ease of installation or removal of the pipe, subject to approval of the Owner’s Representative. Flexible couplings shall be of the restrained type where necessary to prevent separation of pipe due to internal pressure.
11. All pipe supports, hangers, racks, and anchors shall be hot-dip galvanized after fabrication.

C. Installation at concrete walls and footings

1. Whenever a pipeline of any material terminates at, or extends through, a structural wall or sump, the Contractor shall install in advance of pouring of concrete the fittings, sleeves or special casting required for the particular installation.
2. Unless otherwise shown on the drawings, no pipe other than ductile iron, steel, and concrete shall be cast in concrete or masonry walls.
3. Pipe other than concrete to be cast in water-bearing walls or more than 4 feet below grade shall have water-stop rings (or seep rings). Water stop rings shall be cast integrally with pipe or fabricated. If fabricated, they shall be at least 6 inches larger diameter than pipe, 1/4-inch thick, and continuous welded all around on both sides.

D. Piping through walls, slabs, and footings: Unless otherwise indicated, pipes passing through walls and slabs shall be installed with sleeves in accordance with the standard details shown on the drawings. Care shall be taken to ensure no contact between embedded sleeves or pipes and reinforcing steel. Pipe must be isolated from reinforcing steel.

E. Pipe welding: All welding of steel pipe shall be by the shielded arc method. All welders must be qualified for pipe welding in all positions and for the materials to be welded in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section IX. The Contractor shall provide the Owner’s Representative with welding certificates specifically validated for this project. This certification supersedes all other certification requirements of other specifications noted herein.

1. All butt welding of stainless steel shall be by the MIG or TIG method. Fillet welds at slip-on flanges shall be by MIG, TIG or SMA method. Qualification, certification shall be as noted above for steel piping.
2. Gas purging of the backside of the weld during the initial root pass is required. Purge gas shall be the same composition as the shielding gas supplied to the welding gun.
3. Fill and cover passes on butt welds are required to provide a cross section of weld metal equal to, or greater than, the parent metal.
4. All welding, weld testing, and weld repair shall be in accordance with ANSI B31.1 and B31.3, as applicable.
5. All pipe welding on system not previously noted shall conform to the requirements of AWWA C206, and all weld repairs shall be in accordance with AWWA C206.

F. Pipe cutting: The Contractor shall perform all work of cutting pipe and fittings or special castings necessary to the proper and accurate assembly, erection, and completion of the work. All pipe shall be cut to fit accurately with smooth edges and faces.

G. Pipe threads: Pipe ends shall be reamed to the full bore of the pipe. Threads shall conform in dimension and limits of size to ANSI B2.1, tapered pipe thread. In making up threaded joints, an accepted thread lubricant shall be applied to the male threads only.

H. Flanged joints shall be made up square with even pressure upon the gaskets and shall be watertight.

I. Solder joints: Solder to be used in copper piping shall be 95% tin and 5% antimony. All pipe and fittings to be joined with solder shall be free from all burrs and wire brushed or steel wool cleaned. After cleaning, a paste flux shall be evenly and sparingly applied to the surfaces to be joined. Solder shall then be applied and flame passed toward the center of the fitting until the solder disappears. All excess solder shall be removed while it is still plastic. Absolutely no acid flux or acid wipe shall be used in making solder joints.

J. Grooved and shoulder-type joints shall be in accordance with AWWA C606.

K. Pressure piping

1. Anchorage: Buried pressure pipe and where indicated drain pipe shall have restrained joints.
2. Manual air vents and pipe drains: Manual air vents shall be installed at the high points of all pipelines carrying liquid, except acids, caustics, or other dangerous liquids, as instructed by the Owner’s Representative, of any service class which cannot be vented through service connections or vent cocks provided with equipment. Manual air vents for liquid pipelines 2-1/2 inches and larger shall consist of a 1/2-inch valve as specified for flushing and for smaller piping shall be 3/8-inch size consisting of bronze cock and short copper tubing return. Vents shall include piping to floor level with valve located 4 feet above floor.

    a. All exposed liquid lines 4 inches and larger shall be provided with a tap or guided nipple and valve drain on the bottom of the pipe. This drain connection shall be provided at all low points with a spacing not to exceed that in the table and where shown. Size and minimum spacing shall be as follows:

Size	Water and Other Liquids	Sewage and Sludge
4" through 12"	1" at 200 feet	2" at 200 feet
14" and larger	2" at 100 feet	2" at 100 feet

b. Drain piping and isolating valves shall be the size noted above unless otherwise shown and shall be the same as shown in the Piping Specification Sheets. Drains shall be piped to a sump, gutter, floor drain, or other collection point.

c. Vent and drain provisions do not apply to buried or encased pipe except where shown.

3. Laying and jointing of buried piping

a. Pipe laying: Laying of ductile-iron, cast-iron, and steel pressure pipelines shall conform to applicable portions of AWWA C600, and AWWA C605 for PVC. Laying of high density polyethylene pipe shall conform to Plastic Pipe Institute standards and ASTM D 2774.

1) Anchorage shall be provided for fittings where there is a possibility of pulling the joint under pressure. Anchors shall be in accordance with applicable portions of AWWA C600, except as otherwise shown.

2) Pipe shall be handled with canvas slings or devices to prevent damage to the pipe exterior. Each piece of pipe shall be laid in such a manner as to prevent any sudden offsets in the flow line. As the work progresses, the interior of the pipe shall be cleared of all dirt and debris of every description. Pipe shall not be laid when the condition of the trench or the weather is unsuitable. At times when work is not in progress, open ends of pipe and fittings shall be closed.

3) Unless otherwise indicated or directed by the Owner’s Representative, pipe shall be placed on bedding material at least 6 inches deep below the barrel of the pipe. The bedding and backfill material shall be as specified in Section 02222.

b. Pipe jointing

1) Restrained joints and fittings shall be installed in accordance with the manufacturer's recommendations. Grooved and shoulder type couplings shall not be used for buried services.

L. Gravity pipelines

1. General: The types and sizes of pipe to be used shall be as specified and shown. Bell-and-spigot pipe laying shall proceed upgrade with the spigot ends of pipe pointing in the direction of flow. Each piece shall be laid true to line and grade and in such manner as to form a close concentric joint with the adjoining pipe and to prevent sudden offsets in the flow line. As the work progresses, the pipe interior shall be cleared of all dirt and debris of every description. Where cleaning after laying is difficult because of small pipe size, a suitable swab or squeegee shall be kept in the pipe and pulled forward past each joint immediately after jointing has been completed. Pipe shall not be laid when the condition of the trench or the weather is unsuitable. At times when work is not in progress, open ends of pipe and fittings shall be closed.

a. Dewatering, excavation, backfill, bedding, etc., shall be in accordance with the contract drawings and other sections of these specifications.
b. Gravel or crushed rock required to stabilize a soft, wet, or spongy foundation shall be provided at the Contractor's expense.

M. Temporary piping and pipelines: All temporary piping shall conform to the appropriate Piping Specification Sheet and shall be cleaned and tested as specified herein. All buried temporary lines shall be filled with sand, capped and abandoned in place or shall be removed. Temporary lines on the ground surface shall be removed and salvaged.

N. The Contractor shall have on the site at all times three inflatable pipe plug for each size pipe up to and including 12 inches in diameter and one inflatable plug for all pipes greater than 12 inches in diameter. The plugs shall be used to exclude dirt and debris from pipelines during construction. Temporary blocking of pipe with anything other than inflatable plugs (unless all are in use) will not be allowed.

3.3 PIPELINE TESTING

A. General: All piping, both gravity and pressure pipelines, shall be subject to acceptance tests. The Contractor shall provide all necessary utilities, labor, and facilities for testing and shall dispose of all waste, including water.

1. All piping including valves, fittings, hydrants, etc., shall be pressure tested prior to connection to equipment such as pumps. Perform tests in sections between isolation valves or structures. Test all pipe penetrations with clean water in wet wells.
2. All exposed piping shall be pressure tested and flushed in accordance with these specifications before they are either painted or insulated. Furthermore, no concrete or concrete slabs shall be poured over or around any piping (except wall penetrations) until the pipe has been tested for acceptance. If a piping system (or portion thereof) fails to meet an acceptance test, repairs shall be made at the Contractor's expense. The repair method used shall be subject to the Owner’s Representative approval and the unacceptable portion shall be retested until it meets these testing specifications.
3. Any equipment which may be damaged by the specified test shall be isolated.

B. Gravity pipelines

1. Obstructions: After backfilling and restoration of surfaces, all gravity pipelines shall be inspected for obstructions and shall be cleaned. Pipes 24 inches in diameter and smaller shall be cleaned using the sewer ball method. Lines larger than 24 inches in diameter may be cleaned by flushing as long as it is first visually inspected to assure that no physical obstructions exist. Flushing shall be such that velocities are at least 2.5 feet per second.
2. Leakage: All gravity pipe drain lines including interior buried and encased lines shall be tested for leakage after backfilling in accordance with Acceptance Test by Pressure Drop Method shown below. The Contractor shall, at its own expense, correct any excess leakage and repair any damage to the pipe and their appurtenances or to any structures resulting from or caused by these tests. No pipe sealant or welding will be allowed in the repair. Where required by the Owner’s Representative, the line shall be retested at the Contractor's expense to meet the specifications.

a. Install access tees, valves, temporary caps or plugs, gages, meters and fittings not called out on the Drawings if required to isolate pipe for testing.

3. Acceptance Test by Pressure Drop Method leakage criteria:

a. All gravity sewers shall be tested by the low pressure air test for plastic gravity sewer lines per ASTM F-1417

4. Acceptance test by pressure drop method procedures:

a. Plug all pipe outlets with suitable test plugs. Brace each plug securely.
b. All gauge pressures in the test should be increased by the amount of groundwater pressure at the center of the pipe.
c. Add air slowly to the portion of the pipe installation under test until the internal air pressure is raised to 4.0 psig.
d. After an internal pressure of 4.0 psig is obtained allow at least 2 minutes for air temperature to stabilize, adding only the amount of air required to maintain pressure.
e. After the 2 minute period, disconnect air supply.
f. When pressure has decreased to 3.5 psig, start stop watch. Determine the time in seconds that is required for the internal air pressure to reach 2.5 psig. This time interval should then be compared with the time required by ASTM F-1417
g. List size, length, and pressure drop allowed of all portions of pipe under test in a table format. Test record shall include appropriate description of the test and sketches of the test configuration and apparatus. Perform testing in the presence of the Owner’s Representative. The maximum reach to be tested in one operation shall be the reach between two consecutive manholes.

C. Pressure pipelines

1. General: Test pressures, testing media, and test duration shall be as specified in Piping System Table. Care shall be exercised to isolate equipment which is not rated for the specified test pressure to avoid damage to the equipment. System operating at less than 15 psi will be subject to 24 hours of leak proof operation as an additional requirement to pressure tests. All joints which will later be encased in concrete or insulated, whether buried or not, shall be tested prior to encasement. Pipe with leakage greater than allowed herein shall be repaired and retested at the Contractor's expense.

2. Liquid system: Leakage for all unburied liquid piping shall be zero throughout the duration of the test. Leakage for buried piping conveying chemicals shall be zero throughout the duration of the test.

3. Leakage for other buried liquid piping shall not exceed the allowable leakage as set forth in AWWA C600 Hydrostatic Testing. Contractor shall be responsible for making all necessary provisions for conveying water to the points of use and for disposal of the test water, including temporary taps and plugs.
a. Seal pipe ends and secure pipe with temporary thrust restraint, as required, to maintain line and grade and to prevent damage.
b. Furnish all equipment and materials for the test including:

1) Test pump approved by the District.

2) Suitable suction and discharge pipes and hoses.
3) Suitable graduated containers for measuring water loss.
4) Pressure gages with pressure range at least 20% greater than the required test pressure and with graduations in 2 psi maximum increments.

c. Conduct the hydrostatic test so the lowest point along the test section is subjected to a hydrostatic pressure of 100 psi or 1.5 times the operating pressure, whichever is greater.

d. Expel air from the test section. Install corp stops at all unvented high points to expel air. After filling the pipeline and before and before application of the test pressure, the test section shall be maintained at the operating pressure for 30 minutes to demonstrate that the pressure has stabilized. Several cycles of pressurizing and air bleeding may be required prior to beginning the test.

e. Apply and maintain the test pressure for a minimum duration of two hours and measure the leakage during this period. Operate the test pump as required to maintain the pressure within plus or minus 5 psi of the test pressure throughout the test period.

f. At the conclusion of the test period, operate the pump until the test pressure is obtained. The pump suction shall be in the graduated container so the amount of water required to restore the test pressure is accurately measured.

g. The measured leakage shall not exceed the allowable leakage amount calculated by the following formula:

$$AL = \frac{LD(P)^{1/2}}{148{,}000}$$

Where: AL = Allowable leakage in gallons per hour
L = Length of pipe tested in feet
D = Diameter of pipe (nominal) in inches, and
P = Test pressure in pounds per square inch

h. If the measured leakage is in excess of the allowable leakage, the section of pipe tested shall be repaired and retested until the actual leakage is reduced below the allowable amount.

i. Visible leaks in the wetwell and vaults shall be eliminated regardless of the leakage amount.

j. Record pressure test data in a standard format to document all pipe tests. Document pipe size, length, location, material type and conditions of the test. Provide a sketch of the pipe segment tested and the test apparatus. Perform testing in the presence of the Owner’s Representative.

3.03 CLEANING

A. Flush system after testing by circulating test medium and filtering until clean.

END OF SECTION 15200

SECTION 16010

ELECTRICAL - GENERAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Scope

1. This section specifies general requirements for electrical work. Detailed requirements for specific electrical items are specified in other sections, but are subject to the general requirements of this section. The electrical drawings and schedules included in this project manual are functional in nature and do not specify exact locations of equipment or equipment terminations.
2. The Contractor shall examine all mechanical and civil drawings and Specifications to determine actual locations, sizes, materials, and ratings of all equipment provided by others.
3. Items of Work shown on drawings and not specified, or similarly mentioned in the specifications yet not shown on the drawings; shall be considered required as if they had been both specified and shown on the Drawings. Any work or material omitted from the description of the work but which is clearly implied shall be furnished by the Contractor as though specifically stated. The Drawings and Specifications contemplate a finished piece of Work of such character and quality as described in and reasonably inferred from them, and fitting with the Work of other Contractors and the Owner. The Contractor agrees that the failure to show details or repeat on any drawings the figures or notes given on another shall not be cause for additional charges or claims.
4. When record drawings are provided with the contract drawing set, they constitute the best available information pertaining to the relevant systems at the time of design. Their accuracy is specifically not guaranteed and they are provided only for the Contractor's convenience. It is the Contractor's responsibility to field-verify these record drawings prior to use. Actual field conditions are specifically and entirely the responsibility of the Contractor. Deviation of the record drawings provided from actual field conditions shall not constitute a basis for any increase in time allowed for completion or compensation for the Contractor.
5. The Contractor shall notify the Engineer in writing of perceived discrepancies, errors, or omissions in the Contract Documents prior to bid. The Engineer shall provide clarification to resolve these issues prior to bid. The Contractor shall resolve his questions regarding the perceived inconsistency, errors, or omissions in the Contract Documents prior to bid. Failure of the contractor to resolve his questions prior to bid shall result in the residual issues of the aforementioned kind providing no basis of claim

for an increase in compensation for the Work or the time allowed for the completion of the contract and the Engineer's interpretation shall govern.

B. Definitions

1. Provide: Furnish and install.
2. Contractor: The party who is wholly responsible for the execution of work under this Contract.
3. Control System Integrator / System Integrator/ Integrator: A party who is engaged by the Contractor, or by one of their lower-tier sub-contractors to perform unit responsibility for process control instrumentation and equipment. Unit responsibility for the System Integrator shall including, but not limited to:
   a. Selection, ordering and furnishing of all process related field instrument devices
   b. Development of detailed control wiring diagrams and interconnecting schematics
   c. Layout and fabrication of custom UL-508A labeled control panels
   d. Integration of process controls with various vendor packaged controls
   e. Other items as specified in Division 17
4. Elementary or Schematic or Control Diagram: Illustrating by means of graphic symbols, the electrical connections and functions of a specific circuit arrangement. The schematic diagram shows all circuit functions without regard to the actual physical size, shape, or location of the component devices or parts.
5. Single-Line Diagram/ One-Line Diagram: Shows, by means of lines and graphical symbols, the course of the electrical distribution system and the components, devices, or parts used therein.
6. Wiring Diagram or Connection Schematic: Includes all of the devices in a system and shows their physical relationship to each other, including terminals and interconnecting wiring in assembly. This diagram shall be (a) in a form showing interconnecting wiring only by terminal designation (wireless diagram), or (b) a panel layout diagram showing the physical location of devices plus the elementary diagram.
7. Interconnection Diagram: Illustrates external connections between terminals of equipment and outside points, such as motors and auxiliary devices. References shall be shown to all connection diagrams that interface to the interconnection diagrams. Interconnection diagrams shall be of the continuous line type. Bundled wires shall be shown as a single line with the direction of entry / exit of the individual wires clearly shown. Each wire identification as actually installed shall be shown. The wire identification for each end of the same wire shall be identical. All devices and equipment shall be identified. Terminal blocks shall be shown as actually installed and identified in the equipment complete with individual terminal identification. All jumpers, shielding and grounding termination details not shown on the equipment connection diagrams shall be shown on the interconnection diagrams. Wires or jumpers shown on the equipment connection diagrams shall not be shown again on the interconnection diagram. Signal and DC circuit polarities and wire pairs shall be shown. Spare wires and cables shall be shown.
8. Arrangement, Layout, or Outline Drawings: Shows the physical space and mounting requirements of a piece of equipment. Diagrams may also indicate ventilation requirements and space provided for connections or the location to which connections are to be made.

1.3 GENERAL DESCRIPTION OF WORK

A. The Contractor shall provide all labor, material, tools, equipment and services required to complete the furnishing, installation, wiring, connection, calibration, adjustment, testing and operation of all electrical equipment, devices and components as indicated and implied by the plans and these Specifications. General descriptions include:

1. For items provided under this Contract: Complete the procurement, installation, wiring, connection, calibration, adjustment, testing and operation of all electrical devices, components, accessories and equipment.
2. For items provided by others for Contractor installation under this Contract: Complete the electrical wiring, termination, adjustment and calibration, and testing of furnished components.
3. Install equipment so it is readily accessible for maintenance. Installations shall have electrical working and dedicated equipment clearances in accordance with NEC and shall be installed in locations that will provide adequate cooling.
4. Check electrical equipment prior to installation so that defective equipment is not installed.
5. Provide field services of qualified technicians to supervise and check out the installation of the equipment, to supervise and check out interconnecting wiring, to conduct start-up of operation of the equipment, and to correct any problems that occur during start-up.
6. Provide circuit breakers, conduit, wire and installation for all items requiring electrical power.
7. The Contractor shall provide all permits, licenses, approvals and other arrangements for work on this project and all fees shall be paid for by the Contractor. The Contractor shall include these fees in the bid price.

1.4 PROJECT DESCRIPTION

A. General

1. In general, the project shall consist of all electrical, control, and telemetry construction required to make a complete and operating system. The following is a description of the work anticipated by the Electrical Contractor. The Electrical Contractor shall coordinate with the Control System Integrator during bid to establish exact division of responsibility.

B. The following is the scope of work for this project (but not limited to):

1. Power distribution, including lighting, and receptacles for the facilities indicated on the plans, including the Cooling Tower, Switchgear area, Re-use pump station building, wet well, and all vaults.

2. Equipment power and control systems for process water pumps, fans, miscellaneous process equipment, and all related instrumentation.

3. Fabrication, testing, installation and commissioning of a custom fabricated control panel with PLC and telemetry equipment.

4. Remote telemetry monitoring and alarming of critical processes and equipment parameters.

1.5 TEMPORARY OPERATION AND CONSTRUCTION POWER

A. The Contractor shall provide a separately metered temporary power service for construction power. The temporary service shall provide:

1. Power for operation of all equipment during testing
2. Power for operation of all equipment including lighting and HVAC equipment until certificate of occupancy is obtained

B. All coordination with the utility and associated construction costs for temporary construction power shall be paid for by the Contractor. The Contractor shall pay the for the energy costs as billed by the utility on the construction power meter.

1.6 THERMAL (TEMPERATURE) RATINGS OF EQUIPMENT TERMINATIONS

A. All materials shall conform to the National Electrical Code Article 110-14C. Wiring and circuit breakers on this project are designed for 75^{o}C operation above 100 amperes; 60^{o}C for 100 amperes and below. All products furnished on this project shall have electrical terminations rated for 60^{o}C for ampacities of 100 amperes and below, and rated for 75^{o}C for ampacities above 100 amperes.

B. These requirements cover all electrical equipment provided under this Contract.

1.7 STANDARDS AND CODES

A. References: This section contains references to the following documents. They are part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

1. National Electrical Code (NEC)
2. Underwriters' Laboratories, Inc. (UL)
3. National Electrical Manufacturers Association (NEMA)
4. Canadian Standards Association (CSA)
5. Electrical Testing Laboratories (ETL)
6. Factory Mutual (FM)

B. Identification of Listed Products

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing label.
2. Equipment listed/labeled by an NRTL shall be subject to acceptance by the local authority having jurisdiction.
3. When a product is not available with a testing laboratory listing for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer’s place of assembly. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.8 SITE FAMILIARIZATION

A. The Contractor shall become familiar with all features of the site which may affect the execution of the work prior to submitting a bid. The Contractor shall take all field measurements necessary for the work and shall assume full responsibility for their accuracy. The Contractor shall take full responsibility for locating and avoiding all substructures and utilities. Any damage to existing equipment or utilities shall be repaired or replaced by the Contractor at the Contractors expense.

1.9 AREA CLASSIFICATIONS

A. The following classification of areas shall be used as a reference in determining application of material covered by this Contract unless specifically shown otherwise on the drawings. Areas that fall under two or more of the following classifications shall utilize materials which conform to requirements of all area classifications listed.

1. Outdoor and Damp Areas: Vaults, all outdoor areas

    a. Raceways shall be galvanized rigid steel (GRS), or aluminum. Conduit entrances shall be threaded and fittings shall have gasketed covers. Threaded fastening hardware and rods shall be stainless steel. Raceway supports such as channel, clamps, and brackets shall be stainless steel or aluminum. Panels, boxes, and enclosures shall be NEMA 4X - aluminum, stainless steel or FRP (or as shown on the drawings). Enclosures shall be mounted 1 inch from walls to provide an air space unless specifically shown otherwise. Device boxes shall be cast, copper free aluminum.

2. Below Grade Areas:

    a. Conduits shall be Schedule 80 PVC, or concrete encased Schedule 40 PVC, as indicated on the drawings.

3. General Purpose Areas: All other areas not described above

    a. Raceways shall be GRS. Raceways concealed in walls or ceilings for general purpose lighting and receptacle circuits may be EMT. Exposed boxes shall be NEMA 12. Concealed boxes may be NEMA 1. Boxes poured in concrete shall be cast copper free aluminum.

4. Hazardous (Classified) Locations: All installations in hazardous locations shall comply with NEC articles 500 through 517. All items and materials installed in classified locations and the methods used to install them shall be listed and approved for the area classification. Conduit installed in Class 1 Divisions 1 and 2 areas shall be PVC coated GRS. Conduit seals shall be installed in all conduit runs leaving classified areas.

1.10 ELECTRICAL SUBMITTALS

A. Electrical submittals shall be submitted, labeled with the project name and Contractor's name, and Project Manager’s name. An index sheet shall be provided showing each product being

submitted. Submittals shall be provided with section tabs per the electrical specifications by section and paragraph or equipment. Each equipment submittal sheet shall be labeled with the individual equipment name and number.

B. Submittals shall include:

1. Manufacturer’s name, address, and telephone number
2. Trade name, catalog model or number, nameplate data and size
3. Layout dimensions, capacity, project specification and paragraph reference
4. Local manufacturers representative (if applicable) name, address and telephone number

C. Submittal Packaging:

1. Submittals shall be substantially complete for this division’s initial submittal.
2. Submittals acceptable for individual packaging;

    a. Long lead items required to meet a tight critical path schedule, may be submitted separately.
    b. Shop and fabrication drawings for custom equipment
    c. Lighting Equipment
    d. Distribution gear with MCC’s, branch panelboards and transformers
    e. Process instruments

3. Each item shall be clearly marked and provided with adequate sales and technical information to clearly show conformance with all aspects of the specification. Packages not provided as described above or largely incomplete shall be returned to the Contractor, without review or comment.
4. Provide detailed part ordering numbers and Supplier contact information where applicable.

D. The Contractor shall ensure that the material being proposed conforms to the Contract requirements. In the event of any variance, the Contractor shall state specifically which portions vary and shall request a variance in writing.

E. The Contractor shall certify that all furnished equipment can be installed in the spaces allocated by stating on each item:

1. “This equipment can be installed in the spaces allocated.”

F. The Contractor shall provide shop drawings on 11” x 17” sheets (maximum), and shall be scaled using standard engineering or architectural scales. Wiring diagrams shall identify circuit terminals, and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment.

G. Failure to submit a specified item does not relieve the Contractor from meeting the requirements of the Specification.

H. The Engineer will review the original submittal and one re-submittal on each item. Subsequent submittal reviews shall be conducted at the Contractor's expense. The Owner may back-charge the Contractor to compensate the Engineer, at the Engineer's current billing rates, for any subsequent resubmittal reviews required beyond those prescribed above.

1.11 PROJECT RECORD DRAWINGS

A. The contractor shall maintain one set of record drawings at the job showing any deviations in the electrical systems from the original design.

B. Markings shown on the drawings shall conform with the following color coding (marked with pencil):

1. Red - Additions, changes in routing, etc., showing placement different than shown on the original drawings
2. Green - Deletions, modifications in routings etc., deleting lines depicting placements different than shown on the original drawing
3. Black - Dimensional data showing exact placement of concealed or buried equipment, raceways, etc.

1.12 CORRECTION OF WORK

A. All work, all materials, whether incorporated in the work or not, all processes of manufacture, and all methods of construction shall be at all times and places subject to the inspection of the Engineer, who shall be the final judge of the quality and suitability of the work, materials, processes of manufacture, and methods of construction for the purposes for which they are used. Should they fail to meet the Engineer’s approval; they shall be forthwith reconstructed, made good, replaced, and/or corrected, as the case may be, by the Contractor.

B. The Contractor shall not be compensated for time, materials, or any indirect costs associated with planning or implementing corrective measures taken to remedy unsuitable work or materials.

C. Remove rejected materials from the site without delay.

D. If, in the opinion of the Engineer, it is undesirable or otherwise impractical to remedy work or materials not meeting requirements of this Contract; work and materials shall remain in place with equitable adjustment to Contract compensation made. The amount of equitable adjustment shall be at the sole discretion of the Engineer, based on factors including but not limited to:

1. Reduced capital value.
2. Additional future energy use.
3. Additional future maintenance and operating costs.
4. Reduced functionality.
5. Reduced useful life.
6. Evaluation and Engineering costs.
7. Administrative costs.
8. Temporary work-around provision costs.

1.13 GUARANTEE

A. The Contractor shall guarantee all work and all components thereof, excluding lamps, for a period of 1 year from date of acceptance of the installation. The Contractor shall remedy any

defects in workmanship and repair or replace any faulty equipment which shall appear within the guarantee period without additional cost to the Owner.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIALS

A. General

1. Equipment and materials shall be new and free from defects. All material and equipment of the same or a similar type shall be of the same manufacturer throughout the work. Standard production materials shall be used wherever possible.

B. Equipment Finish

1. Unless otherwise specified, electrical equipment and materials shall be painted by the manufacturer.

C. Galvanizing

1. Where specified, galvanizing shall be in hot dipped.

2.2 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall prepare and assemble detailed operation and maintenance (O&M) manuals in accordance with the project general requirements and other requirements in other specification sections. The manuals shall be bound in a 3 ring binder and tabbed with an index. The O&M manual format shall follow the submittal data specified format in Paragraph 16010.1.10. The manuals shall include, but not be limited to, the following:

1. Catalog data and complete parts list for all equipment and devices
2. All cut sheets of equipment and components
3. Preventative maintenance procedures
4. Trouble-shooting
5. Calibration
6. Testing
7. Replacement of components
8. Automatic mode operation
9. Manual mode operation
10. System schematics / shop drawings and record drawing.
11. As-built wiring diagrams of cabinet and enclosure contained assemblies
12. As-built wiring diagrams of overall system
13. Listing of recommended spare parts
14. Listing of recommended maintenance tools and equipment

PART 3 - EXECUTION

3.1 GENERAL

A. Storage and Installation Environment

1. The Contractor shall store all electrical equipment in a dry environment free from dust, moisture, sprays or vapors which may be detrimental to their new condition. After installation of equipment, the Contractor shall take care to protect all equipment from all dust, moisture, paint and other spray, harmful vapors.
2. Equipment shall not be installed in indoor areas until the area is covered, dry and finished to the point that other work will not create dust, vapors, or moisture. Equipment with integral heaters and fans shall not be installed until power is available at the location, and the heater and fan shall be energized within 6 hours of the equipment being installed.

B. Housekeeping

1. The premises shall be kept free of accumulated materials, rubbish and debris at all times. Surplus material, tools and equipment must not be stored at the job site.
2. Upon completion of the project, all equipment and fixtures shall be cleaned and in proper condition for their intended use.

3.2 TESTS

A. The Contractor shall conduct testing in accordance with Section 16030 and individual specification sections.

B. The Contractor shall verify motors are connected to rotate in the correct direction. Verification may be accomplished by momentarily energizing the motor, provided the Contractor confirms that neither the motor nor the driven equipment will be damaged by reverse operation.

3.3 FINAL ACCEPTANCE

A. Prior to final acceptance, the Engineer will perform one or more site observation trips to develop a “punch list” of items deemed incomplete. The Electrical Contractor and Control System Integrator shall be present while these inspections are taking place and shall be available for opening cabinets and operating and adjusting the system as is necessary for the Engineer to verify all equipment is installed and operates to the requirements of the contract documents.

B. The Contractor shall complete all items of work, including wire markers, nameplates, final tests and final test reports prior to requesting final acceptance inspections. All equipment shall be checked for proper operation and all signals verified for correct calibration and wiring. Fixtures shall have been cleaned, and burned out or defective lamps shall have been replaced.

3.4 TRAINING

A. The Contractor shall provide training in accordance with the specific requirements in other sections of these Specifications. In addition to training required in other Sections of the Specifications, the Contractor shall conduct specifically organized training sessions in the overall operation and maintenance of the electrical system for personnel employed by the Owner. The training sessions shall be conducted to educate and train the personnel in operation and maintenance of all components of the electrical system outside the training requirements in the other sections of these Specifications. Training shall include, but not be limited to, the following:

1. Preventative maintenance procedures
2. Trouble-shooting
3. Calibration
4. Testing
5. Replacement of components
6. Equipment operation

B. At least two training sessions, each at least four (4) hours in duration, shall be conducted at the facility after start-up of the system. The Contractor shall prepare and assemble specific instruction materials for each training session and shall supply such materials to the Owner at least one (1) week prior to the time of the training.

END OF SECTION 16010

SECTION 16030

ELECTRICAL FIELD TESTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes field testing, cleaning, adjusting, and lubrication of electrical equipment and wiring systems.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI):

   a. C2, National Electrical Safety Code.
   b. C62.33, Standard Test Specifications for Varistor Surge-Protective Devices.

2. Institute of Electrical and Electronics Engineers (IEEE):

   a. 43, Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
   b. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
   c. 118, Standard Test Code for Resistance Measurement.
   d. 400, Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field.

3. National Electrical Manufacturers Association (NEMA):

   a. AB 4, Guideline for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
   b. WC 7, Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

4. International Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
5. National Fire Protection Association (NFPA):

   a. 70, National Electrical Code (NEC).
   b. 70E, Standard for Electrical Safety Requirements for Employee Workplaces.

1.3 ACTION SUBMITTALS

A. Submit schedules and sample copies of inspection forms in accordance with the General Provisions Supplemental Conditions and Section 16010.

B. Administrative Submittals: Submit 30 days prior to performing inspections or tests:

1. Schedule for performing inspection and tests.
2. List of references to be used for each test.
3. Sample copy of equipment and materials inspection form(s).
4. Sample copy of individual device test form.
5. Sample copy of individual system test form.
6. Copies of all testing personnel's certifications.

C. Quality Control Submittals: Within 30 days after completion of test and prior to substantial completion of project, submit test or inspection reports and certificates for each electrical item tested.

D. Contract Closeout Submittals:

1. Operation and Maintenance Data:

a. In accordance with Section 16010
b. After test or inspection reports and certificates have been reviewed by Owner's Representative and returned, insert a copy of each in operation and maintenance manual.

1.4 QUALITY ASSURANCE

A. Testing Firm Qualifications:

1. Corporately and financially independent organization functioning as an unbiased "third party" testing authority.
2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.
3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.
4. Supervising engineer accredited as Certified Electrical Test Technologist by National Institute for Certification of Engineering Technologists (NICET) or NETA and having a minimum of five years' testing experience on similar projects.
5. Technicians certified by NICET or NETA.
6. Assistants and apprentices assigned to project at ratio not to exceed two certified to one noncertified assistant or apprentice.
7. Professional electrical engineer registered in the state of California to provide comprehensive project report outlining services performed, results of such services, recommendations, actions taken, and opinions.
8. In compliance with OSHA Title 29, Part 1907 criteria for accreditation of testing laboratories or a full member company of NETA.

B. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.

C. Test instrument calibration shall be in accordance with NETA ATS.

1.5 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

C. Notify Owner’s Representative at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 - MATERIALS

2.1 NOT USED.

PART 3 - EXECUTION

3.1 GENERAL

A. Tests and inspection shall establish that:

1. Electrical equipment is operational within industry and manufacturer's tolerances.
2. Installation adequately performs intended functions
3. Instruments and devices are field-calibrated and properly adjusted based on their specific application.
4. Equipment will not be damaged, malfunction or harm personnel upon energizing.
5. Installation conforms to requirements of contract documents and NFPA 70, NFPA 70E, and ANSI C2.

B. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

C. Set, test, and calibrate protective relays, circuit breakers, and other applicable devices as required to coordinate with next upstream and downstream devices.

D. Adjust mechanisms and moving parts for free mechanical movement.

E. Adjust relays and sensors where possible to correspond with operating conditions or as recommended by manufacturer.

F. Verify nameplate data for conformance to contract documents.

G. Realign equipment not properly aligned and correct unlevelness.

H. Properly anchor electrical equipment that is found to be inadequately anchored.

I. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations or as otherwise specified.

J. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

K. Provide proper lubrication of applicable moving parts.

L. Inform Owner’s Representative of working clearances not in accordance with NFPA 70.

M. Investigate and repair or replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

N. Electrical Enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by Owner’s Representative, door and panel sections having dented surfaces.
5. Repair or replace, as determined by Owner’s Representative, poor fitting doors and panel sections.
6. Repair or replace improperly operating latching, locking, or interlocking devices.
7. Replace missing or damaged hardware.

O. Finish:

1. Provide matching paint and touch up scratches and mars.
2. If required due to extensive damage, as determined by Owner’s Representative, refinish the entire assembly.

P. Replace fuses and circuit breakers that do not conform to size and type required by the contract documents.

3.2 LOW-VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed power cable for:

a. Physical damage.
b. Proper connections in accordance with single-line diagram.
c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
d. Color coding conformance with specifications.
e. Proper circuit identification.

2. Inspect mechanical connections for:

    a. Proper lug type for conductor material.
    b. Proper lug installation.
    c. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.

3. Inspect shielded instrumentation cables for:

    a. Proper shield grounding.
    b. Proper terminations.
    c. Proper circuit identification.

4. Inspect control cables for:

    a. Proper termination.
    b. Proper circuit identification.

5. Cables Terminated Through Window Type CTs: Verify that neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 6 and Larger:

1. Insulation Resistance Tests:

    a. Utilize 1,000-volt d-c megohmmeter for 600-volt insulated conductors.
    b. Test each conductor with respect to ground and to adjacent conductors per IEEE 118 procedures for one minute.
    c. Evaluate ohmic values by comparison with conductors of same length and type.
    d. Investigate values less than 50 megohms.

2. Continuity test by ohmmeter method to ensure proper cable connections.

3.3 DISCONNECT SWITCHES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Proper blade pressure and alignment.
2. Proper operation of switch operating handle.
3. Adequate mechanical support for each fuse.
4. Proper contact-to-contact tightness between fuse clip and fuse.
5. Cable connection bolt torque level in accordance with NETA ATS, Table 10.1.
6. Proper phase barrier material and installation.
7. Verify that fuse sizes and types correspond to single-line diagram.
8. Perform mechanical operational test and verify electrical and mechanical interlocking system operation and sequencing.

B. Electrical Tests:

1. Insulation Resistance Tests:

a. Applied megohmmeter d-c voltage in accordance with NETA ATS, Table 10.2.
b. Phase-to-phase and phase-to-ground for one minute on each pole.
c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

2. Contact Resistance Tests:

a. Contact resistance in microhms across each switchblade and fuse holder.
b. Investigate deviation of 50% or more from adjacent poles or similar switches.

3.4 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Visually check current, potential, and control transformers for:

a. Cracked insulation.
b. Broken leads or defective wiring.
c. Proper connections.
d. Adequate clearances between primary and secondary circuit wiring.

2. Verify mechanically that:

a. Grounding and shorting connections have good contact.
b. Withdrawal mechanism and grounding operation, when applicable, operate properly.

3. Verify proper primary and secondary fuse sizes for potential transformers.

B. Electrical Tests:

1. Current Transformer Tests:

a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts d-c for 30 seconds.
b. Polarity test.

2. Potential Transformer Tests:

a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 7.1.1 for one minute on:
   1) Winding-to-winding.
   2) Winding-to-ground.
b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.

3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 7.1.1.

3.5 METERING

A. Visual and Mechanical Inspection:

1. Verify meter connections in accordance with appropriate diagrams.
2. Verify meter multipliers.
3. Verify that meter types and scales conform to contract documents.
4. Check calibration of meters at cardinal points.
5. Check calibration of electrical transducers.

3.6 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor control centers and panelboards assemblies for proper connection and tightness.
2. Ground bus connections in motor control centers and panelboard assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:

1. Fall-of-Potential Test:

a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
b. Main ground electrode system resistance to ground to be no greater than 3 ohms.

2. Two-Point Direct Method Test:

a. In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
b. Equipment ground resistance shall not exceed main ground system resistance by 0.50 ohm.

C. Testing Per 16060

3.7 A-C INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 1/2 hp and larger.

B. Visual and Mechanical Inspection:

1. Proper electrical and grounding connections.
2. Shaft alignment.
3. Blockage of ventilating air passageways.
4. Operate motor and check for:

a. Excessive mechanical and electrical noise.
b. Overheating.
c. Correct rotation.
d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionality and proper operation.
e. Excessive vibration.

5. Check operation of space heaters.

C. Electrical Tests:

1. Insulation Resistance Tests:

a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 10.2 for motors 200 hp and less for one-minute duration with resistances tabulated at 30 and 60 seconds.
b. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

2. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
3. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes.
4. Additional field testing specified in Section 16152.

3.8 LOW-VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:

1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.
4. Improper blockage of air cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check door and device interlocking system by:

a. Closure attempt of device when door is in OPEN position.
b. Opening attempt of door when device is in ON position.

8. Check nameplates for proper identification of:

a. Equipment title and tag number with latest single-line diagram.
b. Push buttons.
c. Control switches.
d. Pilot lights.
e. Control relays.
f. Circuit breakers.
g. Indicating meters.

9. Verify that circuit breaker sizes and types conform to contract documents.
10. Verify that current and potential transformer ratios conform to contract documents.
11. Check bus connections for high resistance by low-resistance ohmmeter and calibrated torque wrench applied to bolted joints:

    a. Ohmic value to be zero.
    b. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.

12. Check operation and sequencing of electrical and mechanical interlock systems by:

    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.

13. Verify performance of each control device and feature furnished as part of the motor control center.
14. Control Wiring:

    a. Compare wiring to local and remote control and protective devices with elementary diagrams.
    b. Check for proper conductor lacing and bundling.
    c. Check for proper conductor identification.
    d. Check for proper conductor lugs and connections.

15. Exercise active components.
16. Inspect contactors for:

    a. Correct mechanical operations.
    b. Correct contact gap, wipe, alignment, and pressure.
    c. Correct torque of all connections.

17. Compare solid-state overload setting with full-load current for proper size and setting.
18. Compare overload heater rating with full-load current for proper size.
19. Compare motor protector and circuit breaker with motor characteristics for proper size.

B. Electrical Tests:

1. Insulation Resistance Tests:

    a. Applied megohmmeter d-c voltage in accordance with NETA ATS, Table 10.2.
    b. Bus section phase-to-phase and phase-to-ground for one minute on each phase.
    c. Contactor phase-to-ground and across open contacts for one minute on each phase.
    d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
    e. Test values to comply with NETA ATS, Table 10.2.

2. Overpotential Tests:

    a. Maximum applied a-c or d-c voltage in accordance with NETA ATS, Table 7.1.2.

b. Phase-to-phase and phase-to-ground for one minute for each phase of each bus section.
c. Test results evaluated on pass/fail basis.

3. Current Injection Through Overload Unit at 300% of Motor Full-Load Current and Monitor Trip Time:

a. Trip time in accordance with manufacturer's published data.
b. Investigate values in excess of 120 seconds.

4. Control Wiring Tests:

a. Apply secondary voltage to control power and potential circuits.
b. Check voltage levels at each point on terminal boards and each device terminal.
c. Insulation resistance test at 1,000 volts d-c on control wiring except that connected to solid-state components. Insulation resistance to be 1 megohm minimum.

5. Operational test by initiating control devices to affect proper operation.

3.9 VARIABLE FREQUENCY DRIVES

A. Visual and Mechanical Inspection:

1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Ensure vent path openings are free from debris and that heat transfer surfaces are not fouled by oil, dust, or dirt.
4. Motor Running Protection:

a. Compare drive overcurrent set points with motor full-load current rating to verify correct settings.
b. Apply minimum and maximum speed set points. Confirm set points are within limitations of the load coupled to the motor.

5. Inspect bolted electrical connections for high resistance using one of the following methods:

a. Use of low-resistance ohmmeter in accordance with NETA ATS, Section 7.17.2 (Electrical Tests).
b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data or NETA ATS, Table 10.12.
c. Perform thermographic survey in accordance with NETA ATS, Section 9.

B. Electrical Tests:

1. Perform resistance measurements through bolted connections with low-resistance ohmmeter, if applicable, in accordance with NETA ATS, Section 7.17.1 (Visual and Mechanical Inspection).
2. Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
3. Perform start-up of drive in accordance with manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.
4. Perform operational tests by initiating control devices.

    a. Check motor rotation operating on the drive and on the bypass.
    b. Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual vibration. If excessive vibration occurs, enter these critical frequencies into the drive's programmed step-over frequencies so operation at these speeds will not occur.
    c. Verify operation of drive from remote start/stop and speed control signals.
    d. Measure and record total harmonic distortion of current and voltage in accordance with IEEE 519.
    e. Test input circuit breaker by primary injection in accordance with NETA ATS, Section 7.6.
    f. Test for the following parameters in accordance with relay calibration procedures outlined in NETA ATS, Section 7.9 protective relays:

        1) Input phase loss protection.
        2) Input overvoltage protection.
        3) Output phase rotation.
        4) Overtemperature protection.
        5) D-C overvoltage protection.
        6) Overfrequency protection.
        7) Drive overload protection.
        8) Fault alarm outputs.

C. Test Values:

1. Overload test trip times at 300% of overload element rating shall be in accordance with manufacturer's published time-current curve.
2. Harmonic values at the point of common coupling shall be in accordance with ANSI/IEEE 519.
3. When critical test points are specified, the relay shall be calibrated to specified critical points even though other test points may be out of tolerance.
4. Bolt-torque levels shall be in accordance with NETA ATS, Table 10.12, unless otherwise specified by the manufacturer.

END OF SECTION 16030

SECTION 16060

GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Grounding systems and equipment.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Qualification Data: For qualified testing agency and testing agency’s field supervisor.

C. Field quality-control reports.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:

1. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, grounding connections for separately derived systems based on NETA MTS

    a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
    b. Include recommended testing intervals.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.2 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel, sectional type, 3/4 inch in diameter by 10 feet long(19 mm by 3 m.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install tinned copper conductor, No. 2/0 AWG minimum.

1. Bury at least 24 inches (600 mm) below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.3 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

C. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
1. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.4 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

C. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes shall be at least 12 inches (300 mm) deep, with cover.

1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

F. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

3.5 LABELING

A. Comply with requirements in Section 16075 "Electrical Identification" for instruction signs. The label or its text shall be green.

B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.

1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistancelevel is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

1. See electrical ground rod test report at the end of this section.

E. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 > ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.

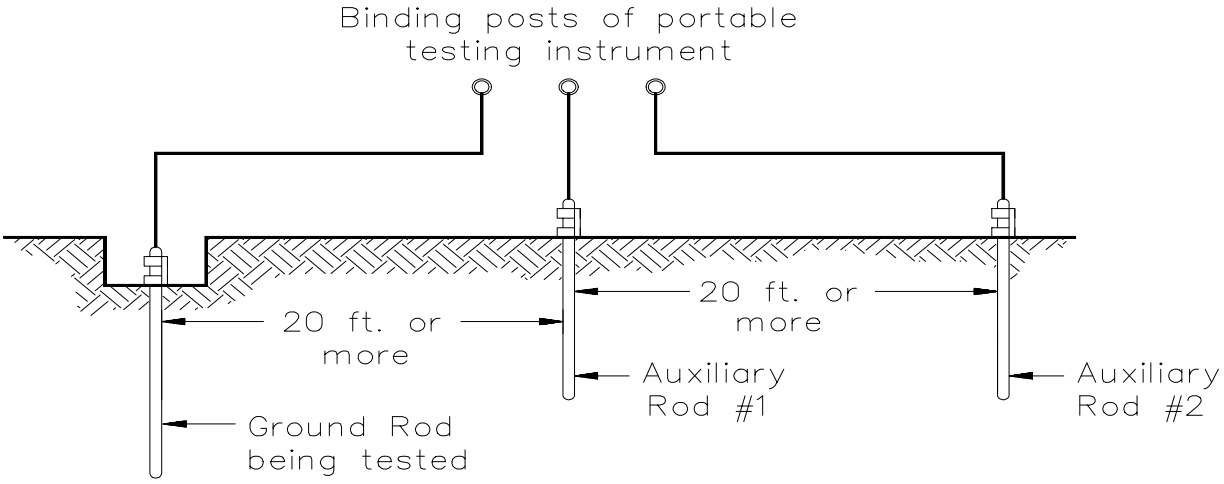
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify the Project Representative promptly and include recommendations to reduce ground resistance.

END OF SECTION 16060

ATTACHMENT: GROUND ROD TEST REPORT

16060 - ELECTRICAL GROUND ROD TEST REPORT



GROUND ROD RESISTANCE TESTING

PROCEDURE:
To measure ground resistance, two additional temporary grounds, consisting of short rods 2 or 3 ft long, shall be driven in the ground at least 20 ft. away from the rod being tested. A direct-reading ground resistance tester shall then be connected to the three ground rods by means of insulated leads. The battery operated ground resistance tester reads the resistance of the ground rod being tested directly in ohms. The ground rod location / designation and its measured ohm value shall be recorded in chart below.

GROUND ROD LOCATION / DESIGNATION	OHM VALUE
1.	*
2.	*
3.	*
COMPOSITE GROUND	*

* Ohm value of a single ground rod shall not exceed 15 Ohms. If additional ground rod(s) are added, the "composite" ground electrode shall have a maximum acceptable reading of 15 Ohms which shall be recorded in chart above.

SECTION 16073

HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the requirements for furnishing and installing seismic restraint devices for electrical equipment.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. When it applies, this section is referenced in other sections of the specifications.

1.3 ACTION SUBMITTALS

A. Submit shop drawings in accordance with the General Provisions Supplemental Conditions and Section 16010.

B. Submit seismic anchoring calculations with equipment and raceway submittals. Calculations shall be performed by a licensed structural engineer employed by the equipment manufacturer and registered in the state of California.

C. Submit equipment anchoring methods. Include anchoring locations, anchor types, and minimum anchor embedment depths.

PART 2 - MATERIALS

2.1 SEISMIC DESIGN OF EQUIPMENT

A. Equipment fabricated or assembled at manufacturers' premises shall be designed and constructed in such a manner that all portions, elements, subassemblies, and/or parts of said equipment and the equipment as a whole, including their attachments, shall have the capability of withstanding seismic forces specified under "Equipment Anchors and Restraints" below.

2.2 SEISMIC ANCHORING AND RESTRAINTS

A. Equipment Anchors: Electrical equipment shall be securely anchored. Anchoring shall have the capability of withstanding seismic forces per Section 1613 of the California Building Code, Seismic Design Category D, SDS = 0.891, and Ip = 1.0.

B. Raceway Supports:

1. Seismically support raceway (conduit, cable tray, busway, etc.) of 2.5-inch inside diameter and larger and suspended 12 inches or more from the top of the raceway to the bottom of the support for the hanger. Raceway supports shall have the capability of withstanding seismic forces per Section 1613 of the California Building Code, Seismic Design Category D, SDS = 0.891, and Ip = 1.0.
2. Provide Kin-Line seismic bracing system, Midland Ross superstrut seismic restraint system, Cooper B-Line Seismic Bracing System, or equal. Install per manufacturer's requirements.

PART 3 - EXECUTION

3.1 EQUIPMENT AND RACEWAYS

A. Install equipment anchors and raceway supports in accordance with the final shop drawing and manufacturer's recommendations. Properly torque all bolts to the required values.

END OF SECTION 16073

SECTION 16074

VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Spring isolators.
3. Restrained spring isolators.
4. Channel support systems.
5. Restraint cables.
6. Hanger rod stiffeners.
7. Anchorage bushings and washers.

B. Related Sections include the following:

1. Section 16073 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.2 DEFINITIONS

A. The IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Refer to Structural drawings for Seismic design criteria.

2. Non-structural Importance Factor = 1.0

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.

    a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other electrical Sections for equipment mounted outdoors.

2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
3. Field-fabricated supports.
4. Seismic-Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
    c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For professional engineer.

C. Welding certificates.

D. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Mason Industries.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.

D. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

E. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

F. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.2 SEISMIC-RESTRAINT DEVICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings, or a comparable product by one of the following:

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti Inc.
5. Loos & Co.; Seismic Earthquake Division.
6. Mason Industries.
7. TOLCO Incorporated; a brand of NIBCO INC.
8. Unistrut; Tyco International, Ltd.

D. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

E. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

F. Restraint Cables: ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

G. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Do not weld stiffeners to rods.

H. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

I. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.

J. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

K. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

L. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.3 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.

3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:

1. Install restrained isolators on electrical equipment.
2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after isolated equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 16074

SECTION 16075

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.3 ACTION SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 POWER AND CONTROL RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:

1. Black engraved letters on natural material background.
2. Legend to include:

a. Source equipment designation and voltage
b. Circuit numbering
c. Unique tag ID of equipment served
d. Example 1 - Power

1) Top line ‘MCC2A (480V)’
2) Middle line ‘CKT 1E’
3) Bottom line ‘PMP-101 (RIVER)’

e. Example 2 – Field instrument power

1) Top line ‘CP-1 (24VDC)’
2) Middle line ‘PS2 / FU-3 (1.5A)’
3) Bottom line ‘FE/FIT-001’

f. Example 3 – Instrument I/O

1) Top line ‘CP-1 (4-20mA)’
2) Middle line ‘TB3-8,9,10’
3) Bottom line ‘FE/FIT-001’

C. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with black paint-filled engraved legend, punched for use with self-locking cable tie fastener.

2.2 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.

B. Self-Adhesive, Self-Laminating Polyester Labels: Preprinted, 3-mil- thick flexible label with acrylic pressure-sensitive adhesive that provides a clear, weather- and chemical-resistant, self-laminating, protective shield over the legend. Labels sized to fit the cable diameter such that the clear shield overlaps the entire printed legend.

2.3 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Self-Adhesive, Self-Laminating Polyester Labels: Preprinted, 3-mil- thick flexible label with acrylic pressure-sensitive adhesive that provides a clear, weather- and chemical-resistant, self-laminating, protective shield over the legend. Labels sized to fit the conductor diameter such that the clear shield overlaps the entire printed legend.

2.4 FLOOR MARKING TAPE

A. 2-inch- wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

2.5 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE (as applicable.)

C. Material:

1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the system type buried below, compounded for direct-burial service.
2. Overall Thickness: 5 mils.
3. Foil Core Thickness: 0.35 mil.
4. Weight: 28 lb/1000 sq. ft..
5. 3-Inch Tensile According to ASTM D 882: 70 lbf, and 4600 psi.

2.6 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 7 by 10 inches.

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 10 by 14 inches.

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."
3. Arc Flash Warning: (comply with NFPA 70E, current version.)

2.7 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.8 EQUIPMENT IDENTIFICATION LABELS

A. Provide screw-mounting for all areas, except where penetrations would compromise listing and labeling of equipment required for installation.
   1. Field applied with durable epoxy adhesive, Engraved, Laminated phenolic plastic nameplate label with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.
   2. Engraved, Laminated phenolic plastic nameplate label, punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

2.9 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

   1. Minimum Width: 3/16 inch.
   2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
   3. Temperature Range: Minus 40 to plus 185 deg F.
   4. Color: Black except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

   1. Minimum Width: 3/16 inch.
   2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
   3. Temperature Range: Minus 40 to plus 185 deg F.
   4. Color: Black.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.

   1. Minimum Width: 3/16 inch.
   2. Tensile Strength at 73 deg F, According to ASTM D 638: 7000 psi.
   3. UL 94 Flame Rating: 94V-0.
   4. Temperature Range: Minus 50 to plus 284 deg F.
   5. Color: Black.

2.10 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Epoxy-adhered Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

F. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

G. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

H. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches overall.

I. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30A, and 120V to ground: Identify with metal tags at each terminal end.

Where raceway system contains more than one feeder or circuit, provide one tag for each feeder or circuit contained therein.

B. Accessible junction and pull-boxes within Buildings: Identify each junction and pull box with legible permanent ink marker applied to the box in a conspicuously visible location. Do not apply labeling directly/exclusively to cover-plates which can be removed and reinstalled contrary to their labeling. In addition to the source / voltage / circuit information, include one of the following system descriptions:

1. Utility Power.
2. Standby Power.
3. UPS.
4. Control.
5. Instrumentation.

C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.

a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
b. Colors for 240/120-V Circuits:

1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.

c. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

E. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive, self-laminating polyester labels with the conductor or cable designation, origin, and destination.

F. Control-Circuit Conductor Termination Identification: For identification at terminations provide heat-shrink preprinted tubes with the conductor designation.

G. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

H. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

I. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.
2. Install underground-line warning tape for both direct-buried cables and cables in raceway.

J. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

K. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:

    a. Power transfer switches.
    b. Controls with external control power connections.

L. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

M. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer.

N. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

    a. Equipment: Laminated phenolic plastic nameplates. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.
    b. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

2. Equipment to Be Labeled:

    a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved, laminated acrylic or melamine label.
    b. Enclosures and electrical cabinets.
    c. Access doors and panels for concealed electrical items.
    d. Switchboards.
    e. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
    f. Emergency system boxes and enclosures.
    g. Motor-control centers.
    h. Enclosed switches.
    i. Enclosed circuit breakers.
    j. Enclosed controllers.
    k. Variable-speed controllers.
    l. Push-button stations.
    m. Power transfer equipment.
    n. Contactors.
    o. Remote-controlled switches, dimmer modules, and control devices.
    p. Monitoring and control equipment.
    q. UPS equipment.

END OF SECTION 16075

SECTION 16110

RACEWAYS, FITTINGS, AND SUPPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This section specifies raceways for electrical conductors including fittings and supports. Raceways shall be provided for power, control, instrumentation, grounding, lighting, receptacles, and signaling systems. Raceways consist of conduits, tubing, and tray systems. For the purpose of this specification, conduit and tubing is described collectively as conduit.

1.3 STANDARDS AND CODES

A. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing label.

B. Equipment listed/labeled by an NRTL shall be as dictated by the latest printing of the *Electrical Testing Laboratories Accreditation Report* available from the State of Washington Department of Labor and Industries, Electrical Inspection Division. Any NRTL listing/labeling shall be as accepted by the local authority having jurisdiction.

C. When a product is not available with a testing laboratory listing for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer's place of assembly. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.4 ACTION SUBMITTALS

A. The Contractor shall submit catalog data showing material information and conformance with Specifications in accordance with the "Submittals" requirements of section 16010.

PART 2 - PRODUCTS

2.1 GENERAL

A. Material

1. All materials shall be new, free from defects, of current manufacture, of quality specified or shown. Each type of material shall be of the same manufacturer throughout the work.

B. Unscheduled Raceway

1. With the exception of lighting, communication, paging, security and receptacle circuits, the type and size of raceway shall be as specified on the drawings or schedules. Lighting and receptacle raceway are unscheduled and shall be sized by the contractor in accordance with the NEC. Minimum size shall be 3/4 inch for exposed and 1 inch for embedded raceway.
2. The number and size of communication, paging, and security raceways shall be as required for the particular equipment provided subject to the minimum sizes specified above. The type of raceway shall be in accordance with Section 16010, Part 1.9 “Area Classifications”.

C. Scheduled Raceway

1. The size and type of raceway shall be as specified on the drawings or schedules.

2.2 RACEWAY

A. Application:

1. All conduits shall be Galvanized Rigid Steel (GRS) or aluminum, unless otherwise noted or specifically allowed in Section 16010, Area Classification.
2. All connections to vibrating equipment or motors shall be liquidtight flexible metallic conduit.
3. PVC conduit shall be used only for underground work and for utility pole risers, no other use is allowed. Provide GRS elbows, risers and sweeps for underground raceways systems.

B. Rigid Steel Conduit

1. Rigid conduit shall be steel, hot dipped galvanized. Final conduit terminations shall be by means of threaded hubs or double locknuts and insulating grounding type bushings.

2. To prevent excessive corrosion, rigid steel conduit installed below grade in contact with soil, shall be wrapped with 4”-wide, 40-mil minimum thickness rubber mastic self-adhesive tape. Overlap successive laps by 50-percent of tape width. Extend wrap a minimum of 6” above finished grade, or to the top of the raceway, whichever is less.

C. Liquid Tight Flexible Metallic Conduit

1. Flexible conduit shall be interlocking single strip, hot dipped galvanized and shall have a polyvinyl chloride jacket extruded over the outside to form a flexible watertight raceway.

D. Nonmetallic Conduit

1. Nonmetallic conduit shall be rigid PVC, Schedule 80. Fittings shall be of the same material as the raceway and installed with solvent cement per the manufacturer's instructions. Conduit, fittings and solvent cement shall all be manufactured by the same manufacturer.

E. PVC Coated Rigid Steel Conduit

1. Conduit shall be hot dip galvanized, then coated with urethane inside and on threads, then covered with 40 mil PVC coating.

F. Aluminum Conduit

1. Aluminum conduit shall be rigid ANSI C80.5, threaded.

G. Electrical Metallic Tubing (EMT)

1. EMT shall be UL 797 and ANSI C80.3, steel tubing, hot-dip galvanized. EMT fittings shall be ANSI/NEMA FB 1, steel, raintight, insulated throat, compression type.

2.3 FITTINGS AND BOXES

A. Material

1. Materials for fittings and boxes shall be chosen to satisfy the requirements of Section 16010, Part 1.9 “Area Classifications.” All screws, nuts, bolts, and other hardware used with fittings and boxes shall be stainless steel unless installed in general purpose areas.

B. Unions

1. All unions of the type designated as UNF and UNY and shall be suitable for use in moist atmospheres. Unions shall be of cast ferrous alloy, electroplated with zinc.

C. Locknuts

1. All locknuts used in general purpose areas shall be extra heavy steel electroplated with zinc for sizes ¾ inch to 2 inches. Locknuts larger than 2 inches shall be of malleable iron, electroplated with zinc. Locknuts used in damp and outdoor areas shall be stainless steel. Locknuts in corrosive areas shall be FRP.

D. Bushings

1. All bushings shall be steel or malleable iron threaded type electroplated with zinc or hot-dip galvanized. Bushings shall have a molded-phenolic or nylon insulating collar.

a. Grounding Bushings: Grounding-type bushings shall have a projecting portion drilled for the size grounding cable used and shall be provided with a clamp or set

screw for securing the cable. In addition, a set screw shall be provided to securely lock the bushing to the conduit. Grounding bushings shall be GEDNEY Type IBC-L-BC, or T&B No. 3870 through 3880, or T&B BG Series, or equal.

b. Bushed Openings: Bushings for protection of cables passing through metal boxes or troughs shall all be phenolic type and shall be OZ Type ABB, or equal.

c. Hubs for connection of conduit to boxes shall be of zinc. Hubs for use in damp or corrosive areas shall be non metallic or aluminum to match the raceway. The hubs shall provide a liquidtight connection to the box and an insulating bushing for the wiring. Hubs shall be Thomas and Betts bullet type, or equal.

E. Liquidtight Flexible Metallic Conduit Connectors:

1. Connectors for liquidtight flexible metallic conduit shall be electroplated zinc malleable iron. An O-ring gasket and an approved grounding insert shall be part of the unit. Where applicable, 45 degree and 90 degree fittings may be used. Liquid-tight connectors shall be by O.Z. GEDNEY, or equal.

F. Expansion Fittings

1. Expansion fittings in exposed runs shall be weatherproof type and shall be provided with an external bonding jumper. The expansion fittings shall allow for 4 inch longitudinal movement and shall be designed so that when completely assembled the end of each conduit entering the fitting is bushed. Fittings shall be O.Z. GEDNEY Type EX, or equal.
2. Deflection fittings in embedded runs shall be of the watertight type and shall be provided with an internal bonding jumper. The expansion material shall be neoprene and shall allow for ¾ inch movement in any direction. Fittings shall be O.Z. GEDNEY Type DX, or equal.

G. Junction Boxes

1. Junction boxes, device boxes, fixture support boxes, oblong, round and rectangular conduit fittings (condulets) shall be of the same material as required by the area classification for the raceway. Junction boxes for use in general purpose areas shall be zinc electroplated cast ferrous alloy. Integrally cast threaded hubs or bosses shall be provided for all conduit entrances and shall provide for full 5 thread contact on tightening. Drilling and threading shall be complete before finishing. Boxes shall be Crouse-Hinds type FS, FD, or approved equal.
2. Cover plates shall be of similar cast ferrous alloy material and finish. Full body neoprene gaskets shall be provided with all covers and shall fastened with stainless steel screws.
3. NEMA 12 boxes shall be of heavy gauge sheet steel, or cast metal. All NEMA 12 boxes shall be provided with a 5 mil thick light gray thermo-epoxy finish, and designed so that moisture will drain away from the gasketed cover joint. Covers for sheet steel boxes shall have turned edges, ground smooth to form a tight seal against the gasket when the cover is closed.

2.4 CONDUIT & CABLE SUPPORTS

A. Conduit Supports

1. Hot-dip galvanized framing channel shall be used to support groups of conduit. Individual conduit supports shall be one-hole galvanized malleable iron pipe straps used with galvanized clamp backs and nesting backs where required. Conduit supports for PVC or epoxy coated rigid steel and PVC conduit systems shall be one hole PVC or epoxy coated clamps or PVC conduit wall hangers.

B. Ceiling Hangers

1. Ceiling hangers shall be adjustable galvanized carbon steel rod hangers as specified. Straps or hangers of plumber's perforated tape are not acceptable. Unless otherwise specified, hanger rods shall be 1/2-inch all-thread rod and shall meet ASTM A193. Hanger rods in corrosive areas and those exposed to weather or moisture shall be stainless steel.

C. Racks

1. Racks shall be constructed from framing channel. Galvanized channels and hanger rods shall be steel, hot dip galvanized, 1.5 oz. / sq. ft. after fabrication. Field cuts shall be re-galvanized by the Galv-A-Weld process or by GAL-VAN-IZE as manufactured by LAWSON Products Inc., or equal. Channels attached directly to building surfaces shall be 14 gauge minimum thickness, 1-5/8 inch deep. Channel section shall be sufficient to limit deflection to 1/360 of span.
2. Framing channels on all exterior areas and in corrosive areas shall be aluminum, stainless steel, or fiberglass. All hardware shall be stainless steel. Channel section shall be sufficient to limit deflection to 1/360 of span. Framing channel shall be as manufactured by Unistrut, Cooper B-Line, or equal.

2.5 CONDUIT SCHEDULE

A. Refer to conduit schedule for raceway sizing and routing description.

PART 3 - EXECUTION

3.1 CONDUIT

A. General

1. The Contractor shall limit the number of directional changes of the conduit to a total not more than 270 degrees in any run between pull boxes. Conduit runs shall be limited to 400 feet, less 100 feet or fraction thereof, for every 90 degrees of change in direction. Bends and offsets shall be avoided where possible but, where necessary, shall be made without flattening or kinking, or shall be factory preformed bends. Turns shall be made with case metal fittings or conduit bends. Welding, brazing or otherwise heating of conduit is not acceptable.
2. Where required for pulling cable and as necessary to meet the requirements of the previous Paragraph, the Contractor shall provide cast junction or pull boxes. Pull boxes used for multiple conduit runs shall not combine circuits fed from different MCCs, switchboards, or switchgear.

3. Conduit entering NEMA 1 type sheet steel boxes or cabinets shall be secured by locknuts on both the interior and exterior of the box or cabinet and shall have an insulating grounding or bonding bushing constructed over the conduit end. Conduit entering all other boxes shall be terminated with a threaded hub. Cast boxes and nonmetallic enclosures shall have threaded hubs. Joints shall be made with standard couplings or threaded unions. Metal parts of nonmetallic boxes and plastic coated boxes shall be bonded to the conduit system. Running threads shall not be used in lieu of conduit nipples, nor shall excessive thread be used on any conduit. The ends of conduit shall be cut square, reamed and threaded with straight threads.
4. Unless otherwise specified, conduit entering field equipment enclosures shall enter the bottom or side of the box. Where conduit comes from above, it shall be run down beside the enclosure and a tee condulet and drip leg shall be installed.
5. When new conduit is added to areas which are already painted, the conduit and its supports shall be painted to match the existing facilities. Where new conduit is used to replace existing conduit, the existing conduit and supports shall be removed, resulting blemishes shall be patched and repainted to match original conditions. Similarly, if existing conduits are to be reused and rerouted, resulting blemished shall be corrected in the same manner.

B. Conduit Penetrations

1. Unless otherwise specified, conduit routed perpendicular through floors, walls or other concrete structures shall pass through cast-in-place openings wherever possible. In cases where cast-in-place openings are not possible, appropriate size holes shall be bored through the concrete to accommodate the conduit passage. The size and location of the holes shall not impair the structure's integrity. After completion, grout or caulk around conduit and finish to match existing surroundings. Unless otherwise protected, conduits that rise vertically through the floor shall be protected by a 3 1/2-inch high concrete pad with a sloping top.
2. Conduits entering manholes and handholes shall be horizontal. Conduits shall not enter through the concrete bottom of handholes and manholes.
3. Wherever conduits penetrate outdoor concrete walls or ceilings below grade, the Contractor shall provide a watertight seal as manufactured by O.Z. Gedney Co., Type CSM Series; Thunderline Corp., Link Seal; or equal.
4. Wherever conduits enter buildings or structures below grade, seal the conduit opening (after installation of conductors and cables), with conduit sealing material, to prevent water from entering the structure, enclosure, etc. Sealing compound to be a pliable, removable putty-type compound listed for the application.

C. Conduit Separation

1. Signal conduits shall be separated from AC power or control conduits. The separation shall be a minimum of 12 inches for metallic conduits and 24 inches for nonmetallic conduits.

D. Conduit Seals for Hazardous or Corrosive Areas

1. Each conduit passing from a hazardous or corrosive area into a non-hazardous or non-corrosive area shall be provided with a sealing fitting which may be located on either side of the boundary. The seal shall be located at the boundary in accordance with the NEC.

2. Seal fittings for conduit systems in hazardous atmosphere locations shall be hot-dip galvanized case ferrous alloy. Sealing compound shall be hard type, Chico A, or equal, UL listed for explosion-proof sealing fittings. Sealing compound shall be non-hardening type for corrosive areas. Provide reducing bushings and larger seals as required to meet NEC 25% fill.

3.2 RACEWAY NUMBERING

A. Each conduit shall be provided with a number tag at each end and in each manhole and/or pullbox. Trays shall be identified by stencils at intervals not exceeding 50 feet, at intersections, and at each end.

END OF SECTION 16110

SECTION 16120

WIRE AND CABLE

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies conductors and cables rated to 600 volts used for power, lighting, receptacle, signal, and control circuits.

1.2 STANDARDS AND CODES

A. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing label.

B. Equipment listed/labeled by an NRTL shall be as dictated by the latest printing of the *Electrical Testing Laboratories Accreditation Report* available from the State of Washington Department of Labor and Industries, Electrical Inspection Division. Any NRTL listing/labeling shall be as accepted by the local authority having jurisdiction.

C. When a product is not available with a testing laboratory listing for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer's place of assembly. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.3 SUBMITTALS

A. Submit all catalog data in accordance with the Submittals requirements in Section 16010. Show material information and confirm compliance with these specifications.

PART 2 - PRODUCTS

2.1 GENERAL

A. With the exception of lighting, communication, paging, security and receptacle circuits, the type, size and number of conductors shall be as specified on the drawings or schedules. Lighting and receptacle circuit conductors are unscheduled and shall be sized by the Contractor in accordance with the NEC to limit voltage drop to 3 percent. Number and types of communication, paging, and security cables shall be a required for the particular equipment provided.

B. Conductors shall conform to all applicable ASTM standards.

2.2 LIGHTING AND RECEPTACLE BRANCH CIRCUIT CONDUCTORS

A. Lighting conductors shall be stranded except for 12 AWG which shall be solid. Minimum conductor size shall be 12 AWG.

B. Conductors shall be provided with the following characteristics:

1. Voltage: 600 volts
2. Conductor: Bare soft annealed copper, stranded or solid
3. Insulation: THWN/THHN, 90 degree C dry, 75 degree C wet polyvinylchloride (PVC)
4. Jacket: Nylon
5. Flame resistance: UL 83
6. Manufacturer: Okonite; Southwire; or equal

2.3 POWER AND CONTROL CONDUCTORS AND CABLE, 600 VOLT

A. Single Conductor:

1. Single conductor cable shall be stranded and shall be used in conduits for power and control circuits.
2. Conductor shall be provided with the following characteristics:

a. Voltage: 600 volts
b. Conductor: Uncoated, soft annealed copper, stranded
c. Insulation: Power: THHN/THWN-2, 90 degrees C continuous rating, wet or dry (as specified)
d. Control: THHN/THWN-2, 90 degrees C continuous rating, wet or dry
e. Flame resistance: UL 83
f. Manufacturer: Okonite, Southwire; or equal

B. Multiconductor Cable:

1. Multiconductor cable shall be used for power and control circuits routed in cable tray or raceways. Cables shall be UL labeled, Type TC, designed for cable tray installation in accordance with NEC 340. The type of insulation, number of conductors, and size of conductor shall be as specified.
2. Power Cable: Multiconductor power cable shall contain three or four conductors, as specified, plus an equipment grounding conductor.

a. Conductors shall be provided with the following characteristics:

1) Voltage: 600 volts
2) Conductors: Annealed copper, stranded
3) Insulation: XHHW-2, 90 degrees C dry or wet, ICEAS-95-658
4) Jacket: Polyvinylchloride (PVC)
5) Manufacturer: Okonite, FMR-P, Southwire; or equal

b. Control Cable: Unless otherwise specified multi conductor control cables shall be 14 AWG.

1) Voltage: 600 volts
2) Conductors: Annealed copper, stranded
3) Insulation: XHHW-2, 90 degrees C dry or wet, ICEAS-95-658
4) Jacket: Polyvinylchloride (PVC)
5) Manufacturer: Okonite, FMR-P, Southwire; or equal

2.4 SIGNAL CABLES

A. General

1. Signal cable shall be provided for instrument signal transmission, alarm, communication and any circuit operating at less than 100 volts. Cables shall be color coded black and white for pairs or black, white and red for triads. Circuit shielding shall be provided in addition to cable shielding. Circuits for type a and b signals specified in paragraph 17010.1.01.B, shall be provided in compliance with the instrument manufacturer's recommendations.

B. Single Circuit (TSP)

1. Cable shall consist of one pair or triad, 18 AWG conductors with 15 mils of 90 degree C polyvinylchloride (PVC) insulation, 4 mils nylon conduit or jacket, twisted on a 2-inch lay, and covered with a 100 percent 1.35 mil aluminum-Mylar tape shield with 18 AWG 7-strand tinned copper drain wire and a 45 mil PVC jacket overall. Cable shall be UL listed, Type TC, rated 600 volts. Cable shall be Okonite, Okoseal N TYPE P-OS, Southwire, or equal.

C. Multiple Circuit

1. Cable shall consist of four or more pairs or triads which are made up of 18 AWG conductors with 15 mils of 90 degree C PVC insulation, 4 mils nylon jacket, twisted on a staggered lay 1-1/2 to 2-1/2 inches, and covered with a 100 percent 1.35 mil aluminum-Mylar tape shield with 22 AWG 7-strand tinned copper drain wire. Overall cable shield shall be 2.35 mil aluminum-Mylar tape with a 20 AWG 7-strand tinned copper drain wire. Cable shall be UL listed, Type TC, 600 volts. Cable shall be Okonite, Okoseal-N Type SP-OS, Southwire, or equal.

D. Thermocouple Extension

1. Extension cable shall be provided for the type of thermocouple circuit specified. Conductors shall be 16 AWG, solid alloy, with 15 mils of 90 degree C flame-retardant polyvinylchloride insulation, twisted and covered with 100 percent 2.35 mil aluminum polyester tape and a 20 AWG, 7-strand, tinned-copper drain wire and a 35 mil, flame-retardant PVC jacket overall. Cable shall be approved for cable tray installation and shall be Okonite P-OS, Type PLTC, or equal.

2.5 PORTABLE CORD

A. Portable cord shall be UL listed, Type SO for 10 AWG and smaller. Cords with conductors larger than 10 AWG shall be UL listed, Type G. Cords shall contain an equipment grounding conductor. Cable characteristics shall be as follows:

1. Conductors:Flexible rope stranded per ASTM B189 and B33. Conductors shall be coated except ground conductors may be uncoated.
2. Insulation: Insulation shall be EPDM and rated for continuous operation at 90 degrees C.
3. Jacket: Heavy-duty neoprene as per ICEA S-68-516
4. Manufacturer: General Cable, Southwire, Super Vu-Tron or approved equal.

2.6 CONNECTORS

A. Pre-insulated Connectors for splices and taps in conductors 10 AWG and smaller shall be Ideal Industries "Wing Nut" or 3M Company "SCOTCHLOCK", or equal. For 8 AWG and larger conductors shall be T&B compression connectors, or equal. Compress using manufacturers recommended die and tools.

B. Waterproof silicone filled “wing nut” type connectors or spade/lug type terminations and terminals and coat with liquid insulation shall be used for all connections of wire to cord to removable equipment provided with integral cords (such as floats, transmitters, limit switches, etc.) in junction boxes in underground handholes or outdoor junction boxes. Insulators shall be Thomas and Betts multi splice insulator MSLT112-4, or equal.

2.7 SPLICE INSULATION

A. Splice insulation shall be equal or greater than the insulation level of the conductor used.

B. All permanent splices that are underground or in damp or corrosive environments shall be insulated with cast epoxy type insulation which covers the jacket of all cords and the insulation on all wire. Epoxy splice shall be Scotch #3570 or equal.

2.8 WIRING SCHEDULE

A. Refer to cable schedule for description of conductors required.

2.9 MOTOR TERMINAL SPLICE INSULATION

A. Motor terminal splice insulation in the motor connection box shall be provided which will withstand constant vibration and abrasion without degrading the insulation of the splice. A product shall be used that is specifically designed for the purpose of motor terminations in accordance with the following:

1. Motor splices in general purpose areas: bolted splice with a TY-RAP boot type insulator, Thomas and Betts Splice insulator Series MSC, or equal. Splices using wire larger than 8

AWG may be heat shrinkable motor connection stub splices, Raychem, MCK-V series, or equal.

2. Motors in outdoor, damp, or corrosive environments: waterproof motor stub insulator, Thomas and Betts multi splice insulator MSLT112-4, or equal. Splices using wire larger than 8 AWG may be heat shrinkable motor connection stub splices, Raychem, MCK-V series, or equal.

2.10 SHIELDED POWER CABLE

A. Non-Armored cables in conduit

1. Stranded copper conductors with crosslinked polyethelyne insulation conforming to UL 44
2. Three stranded, uncoated copper ground wires
3. 5 mil un-coated copper tape shield
4. PVC outer jacket
5. Flame test conforming to applicable provisions of IEEE 1202
6. Southwire Type TC VFD power cable, or equal

2.11 WIRE MARKERS

A. Field installed wire markers shall be T&B SMS pre-printed clip-on markers, or equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Each power and control conductor shall be identified at each terminal to which it is connected.

B. Pulling wire and cable into conduit or trays shall be completed without damaging or putting undue stress on the cable insulation. Soapstone, talc or UL listed pulling compounds are acceptable lubricants for pulling wire and cable. Grease is not acceptable. Raceway construction shall be complete, cleaned, and protected from the weather before cable is placed in the raceway.

3.2 600 VOLT CONDUCTOR AND CABLE

A. Conductors in panels and electrical equipment, 6 AWG and smaller, shall be bundled and laced at intervals not grater than 6 inches, spread into trees and connected to their respective terminals. Lacing shall be made up with plastic cable ties. Lacing is not necessary in plastic panel wiring duct. Conductors crossing hinges shall be bundled into groups not exceeding 12 and shall be so arranged that they will be protected from chafing when the hinged member is moved.

B. Slack shall be provided in junction and pull boxes, handholes and manholes. Slack shall be sufficient to allow cables or conductors to be routed along the walls of the box. Amount of

slack shall be equal to largest dimension of the box. Where plastic panel wiring duct is provided for wire runs, lacing is not required.

C. Solid wire shall not be lugged, nor shall electrical spring connectors be used on any except for solid wires in lighting and receptacle circuits. Lugs and connectors shall be installed with a compression tool.

D. All splices and terminations are subject to inspection by the Engineer prior to and after insulating. Connections shall be insulated and sealed with factory-engineered kits. Bolt connection area shall be kept free of mastics and fillers to facilitate rapid stripping and re-entry. Motor connection kits shall accommodate a range of cable sizes for both in-line and stub-type configurations. Connection kits shall be independent of cable manufacturer's tolerances.

E. In-line splices and tees, where approved, shall be made with tubular compression connectors and insulated as specified for motor terminations, except that conductors 10 AWG and smaller may be spliced using self-insulating connectors. Splices and tees in underground handholes or pull boxes shall be insulated using Scotch-cast epoxy resin splicing kits. Terminations at devices with 120 volt pigtail leads shall be made using self-insulating tubular compression connectors.

F. Terminations at solenoid valves, 120 volt motors, and other devices furnished with pigtail leads shall be made using self insulating tubular compression connectors.

G. In the case where multiple field located instrumentation and control devices require parallel or series wiring configuration, it shall be done at one location in one junction box or marshalling enclosure with terminals. Interconnection of instrumentation and control devices shall not be done within conduit bodies (i.e. LBs, condulets, etc.)

H. Provide shielded power cable for leads extending from VFDs to motors, where indicated.

3.3 SIGNAL CABLING

A. Circuit runs shall be of individually shielded twisted pairs or triads. In no case shall a circuit be made up using conductors from different pairs or triads. Triads shall be used wherever 3-wire circuits are required. Terminal blocks shall be provided at instrument cable junctions unless otherwise specified. Signal circuits shall be run without splices between instruments, terminal boxes, or panels.

B. Shields shall not be used as a signal path, except for coaxial cable circuits operating at radio frequencies.

C. Unless otherwise specified, shields shall be bonded to the signal ground bus at the control panel and isolated from ground and other shields at other locations. Terminals shall be provided for running signal leads and shield drain wires through junction boxes.

D. Spare circuits shall be terminated on terminal blocks at both ends of the cable run and be electrically continuous through terminal boxes. Shield drain wires for spare circuits shall not be grounded at either end of the cable run. Terminal boxes shall be provided at instrument cable splices. If cable is buried or in raceway below grade at splice, an instrument stand shall be provided as specified with terminal box mounted approximately 3 feet above grade.

E. Cable for paging, telephone, and security systems shall be installed and terminated in compliance with the manufacturer's recommendations.

3.4 PORTABLE CORD

A. Portable cord feeding permanent equipment, such as pendant cords, pumps, cranes, hoists and portable items shall have a wire mesh cord grip of flexible stainless steel wire to take the tension from the cable termination. Connection of portable cords to permanent wiring shall be accomplished with the use of terminals. In-line taps and splices shall be used only where specified.

3.5 COLOR CODING

A. Wiring shall conform to the following color code, unless otherwise specified.

B. Insulation on phase conductor sizes 8 AWG and smaller shall be colored, 6 AWG and larger may have black insulation with plastic tape of the appropriate color from the table below.

C. Insulation on the grounded conductor (neutral) sizes 6 AWG and smaller shall be colored; 4 AWG and larger may have black insulation with plastic tape of white or gray in accordance with the table below.

Description	240Y/120V	480Y/277V	Control
Phase A (Left, Top, Front)	Black	Brown	--
Phase B (Center, Center, Center)	Red	Orange	--
Phase C (Right, bottom, Back)	Blue	Yellow	--
Neutral	White	Gray	White
Ground	Green	Green	Green
120 VAC Control	--	--	Red
120 VAC Control	Neutral	--	White
DC Control (+)	--	--	Purple
DC Control (-)	--	--	Gray
External Source	--	--	Yellow

D. All control wiring in control panels or other enclosures that is powered from an external source and is not disconnected by the control panel disconnect shall be terminated at a disconnecting terminal block (with energization indicator light) upon entering the enclosure. The color of the wire shall then be changed to yellow to identify it as being powered from an external source. Provide identification nameplate on exterior of enclosure to indicate sources of external power.

E. All wiring in industrial machines and equipment shall be in accordance with NFPA 79. Notify owner of any deficiencies noted during installation.

3.6 TERMINAL MARKING

A. All terminals in instrument and relay compartments, motor control centers, in control panels, instrument panels, field panels and control stations, as well as connections to mechanical equipment shall have reference number and letter in accordance to the following.

1. h = Control power hot
2. n = neutral
3. g = ground
4. x = PLC input
5. y = PLC output
6. ax = PLC signal/analog input
7. ay = PLC signal/analog output
8. c = control
9. p = power
10. s = signal

3.7 WIRE BENDING RADIUS

A. The radius of bends in all non-shielded wire (conductors and cables) shall not be less than eight (8) times the outside diameter of the wire. Shielded covered wire shall not be bent to a radius less than twelve (12) times the diameter of the wire. Any wire installed with bends less than the allowed diameter and which the Engineer deems has caused that insulation to be damaged, shall be removed and new wire shall be installed.

3.8 GENERAL TESTS

A. The Contractor shall perform voltage, current and resistance tests as required to complete the Electrical System Test Report form provided at the end of this section. Test reports shall be submitted to the Engineer prior to final acceptance by the Owner. The Contractor shall inform the Engineer of scheduled testing a minimum of 5 days prior to the testing. Testing shall not take place unless the Engineer or Owner Representative is present to witness the testing.

B. The Contractor shall undertake all such corrective measures if the test results indicate corrective measures are required. No additional compensation will be paid for corrective measures

C. Test Scope

1. The Contractor shall provide all material, equipment, labor and technical supervision to perform tests and inspections as specified herein.
2. It is the intent of these tests to assure that all electrical equipment as supplied and installed by the Contractor is operational within the industry and manufacturer's tolerances and is installed in accordance with the design documents.
3. The tests and inspection shall determine the suitability for energization.

D. Conductor Tests

1. Following the completion of installation, the following conductors shall be tested in accordance with Parts 3.8 F&G in this Section.
   a. Service conductors and feeder conductors

E. Visual and Mechanical Inspections

1. Inspect exposed section for physical damage.
2. Verify cable is supplied and connected in accordance with specifications and one line diagram, and that phases are labeled correctly.

F. Electrical Tests

1. Perform insulation resistance test on each cable in reference to ground and adjacent conductors in the same raceway.
2. Perform continuity test to ensure proper cable connection.

G. Test Values

1. Insulation resistance tests shall be performed at 1000 volts DC for one-half minute.
2. Minimum megger readings at 20 degrees C shall be one megohm.

END OF SECTION 16120

ATTACHMENT: ELECTRICAL SYSTEM TEST REPORT - 600V CABLE

16120 ELECTRICAL SYSTEM TEST REPORT - 600V CABLE

ELECTRICAL SYSTEM
DESCRIPTION DATA

SERVICE DESCRIPTION:
nominal voltage, phase to phase
phase to neutral - single or three phase-
number of conductors _____

SERVICE CONDUCTORS:
phase size and insulation type _____
neutral size and insulation type _____
ground size and insulation type _____

SERVICE DISCONNECT DESCRIPTION:
circuit breaker or disconnect switch _____
size (amps) _____
fuse (amps) _____

MEASURED CONDITIONS		DATA
Operating Load Voltage Volts		Vab_____ Vbc_____ Vca_____
		Van_____ Vbn_____ Vcn_____
Operating Load Feeder Current	Amps	Ia_____ Ib_____ Ic_____
Conductor Insulation Resistance (record the indicated measurement for each of the following circuits:)	Megohms	a-b_____ b-c_____ c-a_____
	Megohms	a-g_____ b-g_____ c-g_____

1. Service Feeder
2. Pump Feeders

SECTION 16137

UNDERGROUND ELECTRICAL DUCTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes materials, installation, and testing of ducts, handholes equipment pads, and related materials for power, telephone, control system, and signal system wiring on sites.

1.2 DEFINITIONS

A. Handhole: An access opening, provided in equipment or a below-the-surface enclosure used with underground lines, into which personnel can reach but do not enter, for the purpose of installing, operating, or maintaining equipment, cabling, or both.

B. Duct: The general term for an electrical conduit or raceway, either metallic or nonmetallic, for use under ground, embedded in earth or in concrete.

C. Duct Bank: A group of two or more ducts in a continuous run between two points.

1.3 ACTION SUBMITTALS

A. Submit shop drawings in accordance with the General Provisions Supplemental Conditions and Section 16010.

B. Submit product data for the following:

1. Ducts, fittings, and joining cement.
2. Handholes.
3. Warning tape.

C. Submit shop drawings for precast Handholes and equipment pads, showing duct or raceway entry types and sizes, locations and elevations of duct banks and individual ducts, reinforcement details, , and grounding details. Include dimensioned detailed location of pulling irons.

1.4 QUALITY CONTROL

A. UL Compliance and Labeling: Comply with requirements of UL standards. Provide duct products and components listed and labeled by UL or Electrical Testing Laboratory, Inc. (ETL).

B. ANSI Compliance: Comply with requirements of ANSI C2, National Electrical Safety Code, pertaining to construction and installation of underground conduit systems, vaults, manholes, and handholes.

C. Code Compliance: Comply with requirements of NEC.

D. Prefabricators: Provide products of firms regularly engaged in manufacture of factory-fabricated handholes and equipment pads of types and sizes required, whose products have been in satisfactory use in similar service for not less than three years.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

PART 2 - MATERIALS

2.1 CONCRETE MATERIALS

A. Comply with Section 033000 for forming of concrete, reinforcement and placement of cast-in-place concrete.

2.2 IDENTIFICATION

A. Provide bead weld on enclosure covers to indicate usage as follows:

1. "ELECTRIC - LV" (for systems 600 volts or less.
2. "SIGNAL" (for telephone, instrumentation, or communications systems).

B. Identify enclosure number as indicated in drawings.

2.3 RIGID STEEL CONDUIT AND FITTINGS

A. Rigid Steel Conduit and Fittings: As specified in Section 16110.

B. Externally PVC-Coated Rigid Steel Conduit and Fittings: As specified in Section 16110.

2.4 RIGID NONMETALLIC CONDUIT (PVC) AND FITTINGS

A. As specified in Section 16110.

2.5 RIGID PVC UTILITY DUCT, EB

A. Material: PVC, meeting NEMA TC-6.

B. UL Listing: Listed as meeting UL 651 for concrete encasement in outdoor trenches, rated for 90°C wire and cable.

C. Fittings: UL-listed products of the same manufacturer as the duct. Manufactured fittings shall include 90-, 45-, and 30-degree long-radius ells and sweeps, end bells, plugs, adapters to rigid steel conduit, expansion fittings, and spacers.

D. Joint Cement: As recommended by the manufacturer of duct as suitable for the climate, furnished with instructions to achieve watertight joints.

E. Manufacturers: Carlon, Can-Tex Industries, or equal.

2.6 HANDHOLES AND PULL BOXES

A. Provide handholes for pulling, splicing, and terminating conductors, in types and sizes indicated.

B. Handholes: Precast concrete, with traffic-rated concrete or cast-iron covers.

C. Cover Hold-downs: Stainless steel, penta-head, flush with cover, bolts.

D. Handhole have identification on covers pertaining to type of service or as indicated in the drawings.

E. Manufacturer: Brooks Products, Associated Concrete Products, Oldcastle or equal.

2.7 CONDUIT SEALANT

A. As specified in Section 16110.

2.8 WARNING TAPE

A. Material as specified in Section 16075 – Electrical Identification. The warning tape shall be continuously imprinted "CAUTION--ELECTRICAL CONDUIT BELOW" unless otherwise indicated or directed by the Owner's Representative.

2.9 EQUIPMENT PADS

A. Provide steel-reinforced, precast concrete equipment pads, sizes and details as indicated. Construct with chamfered edges and grounding pigtail.

PART 3 - EXECUTION

3.1 DUCT USAGE SCHEDULE

A. Install the following types of ducts and fittings in locations listed, unless otherwise noted in the drawings. Definitions and requirements of NEC and the National Electrical Safety Code apply unless specifically modified below. Duct entries into buildings and structures shall comply with Section 16110.

1. Underground, Direct Burial:
   a. Material: Rigid nonmetallic conduit (PVC) and fittings.Minimum Size: 1inch.
   b. Elbows and vertical sweep material: rigid steel conduit long-radius elbows with field applied mastic tape.
2. Underground, Concrete Encased:
   a. Material: Rigid PVC utility duct, EB and manufactured fittings or rigid nonmetallic conduit (PVC) and fittings. For bends exceeding 45 degrees, provide the metal conduit as specified for "Underground, Direct Burial."
   b. Minimum Size: 2 inches.
3. Underground, In Directional Bored Encasement:
   a. Material: Flexible PVC utility duct (EP).
   b. Minimum Size: 1 inch.

3.2 TRENCHING AND BACKFILLING

A. See Section 02222. Bedding material shall be sand.

3.3 DUCT LAYOUT

A. Underground ducts shall be direct buried unless identified as concrete encased in the drawings. Provide 3-inch-minimum sand above and below direct buried duct banks as specified in Section 312316.

B. Limit the maximum change of direction in any plane between lengths of straight duct without use of bends to 5 degrees.

C. Where other utility piping systems are encountered or are being installed along a duct route, maintain a 12-inch minimum separation between duct and other systems at crossings and when running in parallel.

D. Do not place ducts over valves or couplings in other piping systems.

E. Slope: Pitch ducts to drain towards handholes and away from buildings and equipment. Minimum slope shall be 4 inches in 100 feet. Ducts may slope from a high point in the run to drain in both directions. Drive stakes in the bottom of the trench at 25-foot intervals maximum, and use to establish slope.

F. Minimum Cover: 24-inch minimum cover for branch circuits and instrumentation, 36-inch minimum cover for Utility and Power direct burial underground ducts.

3.4 DUCT INSTALLATION

A. Comply with the installation provisions of NEMA TC2 and TC6, except as modified below.

B. Use factory-made conduit spacers to provide 2-inch minimum separation between conduits. Locate spacers not less than 4 feet center-to-center along entire length of ducts. Secure ducts and spacers to prevent movement during placement of concrete or earth backfill.

C. Place duct couplings side-by-side horizontally but staggered at least 6 inches vertically.

D. Make joints in accordance with manufacturer's recommendations. In the absence of specific recommendations, make the joints as follows:

1. Brush a plastic solvent cement on the inside of the coupling and on the outside of the duct ends.
2. Slip duct and fitting together with a quick one-quarter turn to set the joints.

E. Duct Entrances to Handholes: Space end bells approximately 10 inches center-to-center for 5-inch ducts and vary proportionately for other duct sizes. The change from regular spacing to end bell spacing shall start 10 feet from the end bell and shall be made without reducing duct line slope and without forming a low point in the line.

F. Install expansion fittings. Expansion fittings are required when the duct is left exposed in trenches for a period of time during which the duct temperature can vary more than 2 degrees. Install expansion fittings near the fixed end of the run and 100 feet on center.

3.5 HANDHOLES

A. Install handholes where indicated in the drawings.

B. Provide a compacted 6-inch deep crushed rock base consisting of ¾-minus material for bedding handholes.

3.6 CONDUIT SEALING

A. As specified in Section 16110.

3.7 EQUIPMENT PADS

A. Verify pad-mounted equipment size using reviewed shop drawings before ordering or placing pads. Unless otherwise indicated, pad shall be at least 4 inches larger, all around, than the equipment's footprint.

B. For precast pads, prepare setting bed by excavating an area 6 inches beyond the outside edge of the pad, compact the subgrade, and fill with 6 inches of crushed rock, per Section 312316. [Set at a 1/8-inch to 1-foot slope to drain.]

C. At Contractor's option, pads may be cast in place on a bed specified for precast units. Install in accordance with Section 02222 – Cast in Place Concrete using Class A concrete.

3.8 ACCEPTANCE TEST

A. Pull a mandrel of a diameter approximately 1/4 inch less than the duct inside diameter, through each duct and through each existing duct in which new conductors will be installed.

B. Pull a bristle brush of a diameter approximately 1/4 inch greater than the duct inside diameter through each duct to remove debris.

C. Provide 200-pound minimum strength nylon pull rope in each spare conduit or cord of higher strength if so required by the utility company for which the conduit is intended.

D. Repair or replace any portion of the new duct through which the mandrel and brush will not pass at the Contractor's expense. Notify Owner’s Representative of any problems with existing ducts for resolution.

END OF SECTION 16137

SECTION 16140

WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Weather-resistant receptacles.
4. Snap switches and wall-box dimmers.
5. Solid-state fan speed controls.
6. Wall-switch and exterior occupancy sensors.
7. Communications outlets.
8. Pendant cord-connector devices.
9. Cord and plug sets.
10. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.
1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Cooper Wiring Devices; Division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand (Pass & Seymour).

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 5351 (single), CR5362 (duplex).
b. Hubbell; HBL5351 (single), HBL5352 (duplex).
c. Leviton; 5891 (single), 5352 (duplex).
d. Pass & Seymour; 5361 (single), 5362 (duplex).

2.4 GFCI RECEPTACLES

A. General Description:

1. Straight blade, non-feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; VGF20.
b. Hubbell; GFR5352L.
c. Pass & Seymour; 2095.
d. Leviton; 7590.

2.5 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; CWL520R.
b. Hubbell; HBL2310.
c. Leviton; 2310.
d. Pass & Seymour; L520-R.

2. Description:

a. Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
b. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap.

Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.6 PENDANT CORD-CONNECTOR DEVICES

A. Description:

1. Matching, locking-type plug and receptacle body connector.
2. NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and FS W-C-596.
3. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
4. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.7 CORD AND PLUG SETS

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.8 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Single Pole:

1) Cooper; AH1221.
2) Hubbell; HBL1221.
3) Leviton; 1221-2.
4) Pass & Seymour; CSB20AC1.

b. Three Way:

1) Cooper; AH1223.
2) Hubbell; HBL1223.
3) Leviton; 1223-2.

4) Pass & Seymour; CSB20AC3.

2. Description: Labeled to comply with NFPA 70, "Receptacles, Cord Connectors, and Attachment Plugs (Caps)" Article, "Tamper-Resistant Receptacles in Dwelling Units" Section.

2.9 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant die-cast aluminum with lockable in-use cover.

2.10 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: Gray unless otherwise indicated or required by NFPA 70 or device listing.

B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 16075 "Electrical Identification."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 16140

SECTION 16145

LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Photoelectric switches.

B. Related Requirements:

   1. Section 16140 "Wiring Devices" for manual light (toggle) switches.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show installation details for occupancy and light-level sensors.

   1. Interconnection diagrams showing field-installed wiring.
   2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of lighting control device to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 OUTDOOR PHOTOELECTRIC SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide NSi Industries LLC; TORK Button W/P 120V or comparable product by one of the following:

1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. NSi Industries LLC; TORK Products.
4. Tyco Electronics; ALR Brand.

C. Description: Solid state, with SPSTdry contacts rated for 1800 VA, to operate connected load, complying with UL 773.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lux), with an adjustment for turn-on and turn-off levels within that range.
3. Time Delay: Thirty-second minimum, to prevent false operation.
4. Lightning Arrester: Air-gap type.
5. Mounting: Twist lock complying with NEMA C136.10, with base.

2.2 HIGH-BAY OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide Hubbell Building Automation; OMNIDT-BP or comparable product by one of the following:

1. Hubbell Building Automation, Inc.

C. General Description: Solid-state unit. The unit is designed to operate with the lamp and ballasts indicated.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operation: Turn lights on when coverage area is occupied, and to half-power when unoccupied; with a time delay for turning lights to half-power that is adjustable over a minimum range of 1 to 16 minutes.
3. Continuous Lamp Monitoring: When lamps are dimmed continuously for 24 hours, automatically turn lamps on to full power for 15 minutes for every 24 hours of continuous dimming.
4. Operating Ambient Conditions: 32 to 149 deg F (0 to 65 deg C).
5. Mounting: Threaded pipe.

6. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
7. Detector Technology: PIR.
8. Power and dimming control from the lighting fixture ballast that has been modified to include the dimming capacitor and MyzerPORT option.

D. Detector Coverage: User selectable by interchangeable PIR lenses, suitable for mounting heights from 12 to 50 feet (3.7 to 15.2 m).

E. Accessories: Obtain manufacturer's installation and maintenance kit with laser alignment tool for sensor positioning and power port connectors.

2.3 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 16120 "Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 16120 "Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14AWG. Comply with requirements in Section 16120 "Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 WIRING INSTALLATION

A. Wiring Method: Comply with wiring and raceway requirements specified in other sections.

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Section 16075 "Electrical Identification."

1. Identify circuits or luminaires controlled by photoelectric sensors at each sensor.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate lighting control devices and perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Lighting control devices will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust outdoor photocell to face North and adjust sensitivity.

END OF SECTION 16145

SECTION 16152

SUBMERSIBLE ELECTRICAL MOTORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes materials, testing, and installation of submersible electric motors for water wells.

1.2 Related Work Specified Elsewhere

A. Operation and Maintenance Data: 01730.

B. General Electrical Requirements: 16010.

C. Variable Frequency Drives: 16269.

1.3 ACTION SUBMITTALS

A. Submit shop drawings in accordance with the General Provisions, Supplemental Conditions and Section 16010.

B. Show ratings, performance data, type, frame, speed, voltage, phase, cycles, enclosure, temperature rise, service factor, thrust bearing capacity, mounting arrangements, accessories or special features, and guarantees.

C. Submit copies of certified test reports for factory no load current and speed and locked rotor current tests.

D. Submit operation and maintenance manuals in accordance with Section 01730.

PART 2 - MATERIALS

2.1 GENERAL

A. The pump motor shall be a NEMA B design, induction type with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber.

B. Motor rating shall be selected so that the load at design is not greater than the nameplate rating at 1.0 service factor, and at no point on the curve shall the load exceed the nameplate rating. Motor shall operate on a 240-volt, 60-cycle, 3-phase a-c power supply.

C. The stator windings shall be insulated with moisture resistant Class H insulation rated for 180°C (356°F). The stator shall be insulated by the trickle impregnation method using Class H monomer-free polyester resin resulting in a winding fill factor of at least 95%. The stator shall be heat-shrink fitted into the cast iron stator housing. The use of multiple step dip and bake-type stator insulation process is not acceptable. The use of pins, bolts, screws or other fastening devices used to locate or hold the stator and that penetrate the stator housing are not acceptable.

D. The motor shall be inverter duty rated in accordance with NEMA MG1, Part 31.

E. The motor shall be designed for continuous duty while handling pumped media of up to 104°F. The motor shall be capable of no less than 15 evenly spaced starts per hour. The rotor bars and short circuit rings shall be made of aluminum. Three thermal switches shall be embedded in the stator end coils, one per phase winding, to monitor the stator temperature. These thermal switches shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the motor control panel.

F. The junction chamber shall be sealed off from the stator housing and shall contain a terminal board for connection of power and pilot sensor cables using threaded compression type terminals. The use of wire nuts or crimp-type connectors is not acceptable. The motor and the pump shall be produced by the same manufacturer.

G. The motor service factor (combined effect of voltage, frequency and specific gravity) shall be 1.15. The motor shall have a voltage tolerance of +/- 10%. The motor shall be designed for continuous operation in up to a 40°C. ambient and shall have a NEMA Class B maximum operating temperature rise of 80° C. A motor performance chart shall be provided upon request exhibiting curves for motor torque, current, power factor, input/output kW and efficiency. The chart shall also include data on motor starting and no-load characteristics.

H. Motor horsepower shall be as indicated on the drawings.

I. Motor shall meet, as minimum requirements, the published standards, rules, and regulations of ANSI, NEMA, and the IEEE, as applicable.

J. Motor performance data shall specify guaranteed minimum efficiencies including thrust bearing losses with no external thrust applied, power factor, operating current, rpm, kilowatt power at 50%, 75%, 100%, and 115% load. Performance data shall also specify full load torque, breakdown torque, locked rotor torque, locked rotor current, and code letter.

2.2 WATER WELL PUMP MOTOR

A. Motor shall be rated for a combination of a maximum water temperature of 25°C and minimum velocity of 0.5 fps past the motor. Motor diameter shall suit the well casing.

B. Motors shall have an all-metal corrosion-resistant coating. Shafting and accessory hardware shall be stainless steel. Nitrile rubber, Hydrin, or equal shall be used for components such as diaphragms, slingers, and O-rings. Shafts shall be splined.

C. The stator windings shall be the hermetically sealed, canned type consisting of a core and winding within an all-metal enclosure with seams welded and watertight. Both the inner and outer liners shall be stainless steel, completely sealing the windings from the surrounding water.

The inside of this can shall be impregnated with a special thermosetting resin including anti-tracking agents. Copper magnet wire shall be utilized with Class F insulation. Motor shall operate within Class A.

D. Motors shall include instrumentation required by the Contract, such as seal fail sensors, temperature switches for windings, and other items as required.

E. Design motor for water lubrication. The inner bore of the motor, including the rotor assembly and all bearings, shall be completely filled at the factory with a solution of water and propylene glycol or other nontoxic, USDA/FDA-approved anti-rust and anti-freeze fluid. The bearings shall have access to water from the well for lubrication and shall require no other lubricant.

F. Radial bearings located in the top and bottom of the motor shall be sleeve type consisting of carbon sleeves and stainless steel shaft journals. The sleeves and the journals shall be microfinished to facilitate water lubrication.

G. Provide a thrust bearing in the lower end of the motor to support downthrust from the pump. It shall be a Kingsbury-type bearing consisting of a carbon rotating disc and stationary stainless steel segments or pads. The segments shall be pivoted and equalized to optimize lubricating film thickness and load distribution. Both the disc and the segments shall be microfinished to facilitate water lubrication.

H. Provide an upthrust bearing to support short-term upthrust during starting or low head operation.

I. Provide a diaphragm to allow for freezing and to equalize the pressure between the inner bore and the outside of the motor. If some internal lubricant is lost and the diaphragm cannot equalize the pressure, a check valve shall allow filtered fresh well water to enter the motor to maintain pressure equalization.

J. Pressure test motor before shipment to prove the integrity of all welded seams in the stator assembly, assuring that no water can leak into the windings from submergence pressures.

K. Motors shall be rated for a minimum average number of starts per hour of four (12 for motors rated 5 horsepower or less) where it shall be allowed to start a motor after a shutdown with no time delay.

L. Motor shall be manufactured by Franklin Electric, Hitachi, or equal.

2.3 CABLES

A. Manufacture cables from Hypalon or Protolon synthetic rubber-jacketed, Type SPC multiconductor cable, suitable for submersible pump application and heavy mechanical stresses.

B. Power cable shall be field replaceable if damaged. When the lead jam nut is tightened, the lead's connection to the motor shall be made watertight by the compression of a rubber bushing. Design the internal connections of the lead to eliminate any possibility that water entering a damaged portion of the lead or supply wires will wick down into the motor.

C. Size the power cable such that the voltage drop will not exceed 3% at the motor rated full-load current and voltage. Cables shall be designed specifically for submersible pump service and shall consist of either three single conductors individually insulated or three individual conductors individually insulated, all covered with an outer jacket.

D. The control cable shall have the necessary number of conductors for the functions indicated on the schematic diagrams. Design cable specifically for submersible applications. Cable shall consist of conductors individually insulated and covered with an outer jacket.

2.4 NAMEPLATES

A. The motor shall have a stainless steel nameplate which shall provide the following information: manufacturer's type and frame construction, insulation system, temperature rise, horsepower output, rated load amperes, rpm, voltage, time rating, "continuous" frequency, number of phases, NEMA code letter for locked rotor kva, NEMA design letter, service factor, thrust bearing load capacity, full-load efficiency and power factor at full load, and essential bearing information such as bearing type and bearing numbers.

2.5 FACTORY TESTS

A. Motor shall be given routine factory tests to determine that it is free from electrical or mechanical defects and to provide assurance that it meets the design specifications.

B. Tests shall be as follows and a certified test report provided to the Owner's Representative:

1. No load readings of current and speed at rated voltage and frequency.
2. Current at rated frequency with rotor at standstill.
3. High potential.
4. Stator winding resistance.
5. Bearing inspection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motor with pump as specified under Section 11421.

B. Provide controller for installation in the motor starter specified in Section 16443 and as shown in the electrical drawings.

3.2 FIELD TESTS

A. Motor shall be subjected to a field test as follows:

B. Megger test before installation.

C. Run motor with its control as nearly as possible under operating conditions to demonstrate correct rotation direction, wiring capacity, and satisfactory operation. Test interlocks and control features to verify correct wiring and operation.

D. Record current in each phase and submit to Owner's Representative. Repair or replace motor or driven equipment if current exceeds motor nameplate current.

END OF SECTION 16152

SECTION 16269

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This section specifies pulse width modulated (PWM) variable frequency drive (VFD) units, hereafter referred to as VFD's, for operation on 240 volt, three phase, 60 cycle power systems. This section also specifies requirements for the provision of harmonic mitigation equipment required to address the current and voltage distortion effects caused by the application of VFD's.

1.3 ACCEPTABLE VFD CONFIGURATIONS

A. Power system compliance with all components of the most current version of IEEE 519 is mandatory when operating from the utility power source and shall be predicted by analysis and demonstrated by field testing.

1. 6 pulse VFD's with line reactors and with or without Active Harmonic Filters depending on system harmonics.
2. 12 pulse VFD's with line reactors and with or without Active Harmonic Filters depending on system harmonics.
3. 18 pulse VFD's with line reactors and with or without Active Harmonic Filters depending on system harmonics.

1.4 STANDARDS AND CODES

A. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing label.

B. Equipment listed/labeled by an NRTL shall be as dictated by the latest printing of the *Electrical Testing Laboratories Accreditation Report* available from the State of Washington Department of Labor and Industries, Electrical Inspection Division. Any NRTL listing/labeling shall be as accepted by the local authority having jurisdiction.

C. When a product is not available with a testing laboratory listing for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at

the manufacturer's place of assembly. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.5 ACTION SUBMITTALS

A. Submit all catalog data in accordance with the Submittals requirements in Section 16010. Show material information and confirm compliance with these specifications.

B. In addition to the requirements of Section 16010, submittals shall include the following information:

1. Outline Dimensions with exterior and interior equipment elevation drawings.
2. Wiring diagrams with all interface points and terminal numbers clearly identified.
3. Specific information on the VFD's components provided for this project and all optional equipment provided.
4. Operations and programming manual.
5. Maximum watts dissipated at nominal current.
6. Calculations specific to this installation predicting harmonic voltage distortion to be less than the values given in IEEE 519 for each odd harmonic (3rd, 5th, etc.), THD(V) less than 5%, and compliance with all other components of the most current version of IEEE 519 utilizing utility source. THD(V) requirement may be relaxed to 10% when utilizing stand-by power source.
7. Test plan and blank start-up form per 16910-3.03.

1.6 COORDINATION

A. Coordinate all inputs and outputs with Control System Integrator per Division 17.

B. The Contractor shall coordinate the installation of the VFD's into the space provided and shown for them in the plans. The Contractor shall provide all additional equipment necessary for mounting and connection of all features and coordinate for the necessary space. If additional equipment is necessary for the proper operation of the VFD's, including equipment for reducing harmonic distortion, it is the Contractor and Manufacturers responsibility to coordinate space and installation requirements for this equipment.

1.7 WARRANTY

A. The Contractor shall guarantee the VFD's to be free of defects in design, materials and workmanship for a period of two (2) years following the date of acceptance, by formal action of the Owner, of all work under the contract. The guarantee shall include all parts and labor and shall be secured by a written guarantee from the Manufacturer to the Owner. The written guarantee shall be delivered to the Owner prior to date of acceptance of all work under the Contract.

PART 2 - PRODUCTS

2.1 GENERAL

A. The variable frequency drive (VFD) motor controller shall convert 240 volt, three-phase, 60 Hertz utility power to adjustable voltage (0 – 240 volt) and frequency (0 - 60 hertz) three-phase, AC power for stepless motor speed control with a capability of 10:1 speed range. All general options and modifications shall mount within the standard adjustable frequency controller enclosure.

B. The controller(s) shall be suitable for use with any standard configuration squirrel-cage induction motor(s) having a 1.15 Service Factor, or with existing standard squirrel-cage induction motor(s) with nameplate data as shown on the plans. At any time in the future, it shall be possible to substitute any standard motor (equivalent horsepower, voltage, and RPM) in the field.

C. The variable frequency control shall operate satisfactorily when connected to a bus supplying other solid state power conversion equipment which may be causing up to 10% total harmonic voltage distortion and commutation notches up to 36,500 volt microseconds, or when all other VFD's and other harmonics producing equipment are operated simultaneously from the same bus.

2.2 HARMONICS

A. Power system harmonics shall comply with all components of the most current version of IEEE-519 for total and individual harmonic voltage and current distortion. Compliance shall be maintained during operation of any and all specified equipment configurations from the utility power source. THD(V) limits shall be relaxed to 10% when the facility is operated from the standby generator. The Utility is the “Point of Common Coupling” for the purposes of IEEE-519 criteria.

2.3 SERVICE CONDITIONS

A. The VFD shall be designed and constructed to operate within the following service conditions:

1. Elevation: To 3300 Feet
2. Ambient Temperature Range: 0°C to 40°C
3. Atmosphere: Non-Condensing relative humidity to 95%
4. AC Line Voltage Variation: -5% to +10%
5. AC Line Frequency Variation: ±3 Hertz

2.4 BASIC DRIVE

A. Description

1. The VFD shall produce an adjustable AC voltage/frequency output. It shall have an output voltage regulator to maintain correct output V/Hz despite incoming voltage variations.
2. The VFD shall have a continuous output current rating of 100% of motor nameplate current.
3. The VFD shall be a Pulse Width Modulated type with diode bridge rectifier front end to convert incoming fixed voltage/frequency to a fixed DC voltage. The front end rectifier assembly shall comply with section 1.03. All components for front end rectifier assembly including phase shifting transformers must be integral to VFD enclosure and require no additional installation costs. The Pulse Width Modulation strategy shall be of the space vector type implemented in a microprocessor which generates a sine-coded output voltage.
4. The inverter output shall be generated by Darlington power transistors or Insulated Gate Bipolar Transistors (IGBT) which shall be controlled by identical base driver circuits. The worse-case RMS motor line current measured at rated speed, torque and voltage shall not exceed 1.05 times the rated RMS motor current for pure sine wave operation.
5. EMI/RFI Interference Suppression

    a. The VFD shall fulfill all electromagnetic compatibility immunity requirements per the following standards utilizing input and output EMI/RFI filters. These filters shall suppress all objectionable interference to AM and FM radio signals in the immediate vicinity of the facility

        1) IEC 618000-2 and -3
        2) EN 50082-1 and -2
        3) EN 61000-6-1, -6-2, and -6-4
        4) EN 61800-3+All

    b. Declaration of Conformity: The Manufacturer’s Declarations of Conformity assuring the compliance of the proposed drives with the above standards shall be made available upon request.

B. Selectable Drive Software

1. The VFD shall be software programmable to provide automatic restart after any individual trip condition resulting from either overcurrent, overvoltage, undervoltage, or overtemperature. The drive shall shut down and require manual reset and restart if the automatic reset/restart function is not successful within a maximum of three attempts within a short time period.
2. The VFD shall include a speed droop feature which shall reduce the speed of the drive on transient overloads. The drive shall return to set speed after the transient is removed. If the acceleration or deceleration rates are too rapid for the moment of inertia of the load, the drive shall automatically compensate to prevent drive trip.
3. The drive shall include a speed profile. Individual adjustable settings for start, stop, entry, slope, and minimum and maximum speed points. The drive shall include a process signal inverter, software selectable to allow speed of drive to vary inversely with input signal.
4. The drive shall be capable of picking up a spinning load. The VFD shall be able to determine the motor speed and resume control of a motor which is spinning in either direction without tripping.

C. Keypad Operator Interface

1. The VFD shall be provided with a door mounted keypad which shall include the following:

a. "POWER ON" light
b. VFD "FAULT" light
c. VFD "RUN" light
d. Manual stop pushbutton
e. Manual start pushbutton
f. Fault reset pushbutton
g. "AUTOMATIC" pushbutton
h. Increase/decrease speed pushbuttons.

2. The door-mounted membrane keypad shall be provided with an integral 2-line minimum, 24-character minimum LCD display, which shall be capable of controlling the VFD and setting drive parameters, and shall include the following features:

a. All diagnostic message and parameter values in English engineering units when accessed, without the use of codes.
b. A "self-test" software program which can be activated to verify proper keypad operations.
c. Allow the operator to enter exact numerical settings in English engineering units. A plain English user menu shall be provided in software as a guide to parameter setting (rather than codes). Drive parameters shall be factory set in EEPROM and resettable in the field through the keypad. The EEPROM stored drive variables must be able to be transferred to new boards to reprogram spare boards
d. Six (6) levels of password minimum.
e. Normally the digital display shall simultaneously display a minimum of the following parameters:

1) Speed demand in percent
2) Output current in amperes
3) Output frequency in hertz
4) Control Mode: Manual/Automatic
5) Output total three-phase KW
6) Output volts

2.5 ENCLOSURE

A. All VFD components shall be factory mounted and wired for installation in a NEMA 12 rated MCC section.

2.6 DRIVE PROTECTION

A. Faults / Short Circuits

1. The VFD shall be protected from single-phase fault or 3-phase short circuits on VFD output terminals without damage to any power component. Input power short circuit protection shall be a thermal magnetic circuit breaker mounted internal to the drive.

B. Overcurrent / Overvoltage

1. The VFD shall be protected from static instantaneous overcurrent and overvoltage trip with inverse overcurrent protection. The drive shall be provided with the following:

a. Static overspeed (overfrequency) protection.
b. Line or fuse loss and undervoltage protection.
c. Power unit overtemperature protection.
d. Electronic motor overload protection.
e. Responsive action to motor winding thermostatic switches.
f. LED monitor lamps for each inverter stage.
g. LED status indicators on regulator, printed circuit board face plates.
h. Isolated operator controls.
i. Input line fuses.
j. Be insensitive to incoming power phase sequence.
k. Have desaturation circuit to drive inverter section transistor base current to zero in event of controller fault.
l. Have DC bus discharge circuit for protection of operator and service personnel with an indicator lamp.
m. Input line noise suppression with line reactor (as required).
n. Individual transistor overcurrent protection.

2.7 PARAMETER SETTINGS

A. The VFD shall be provided with the following system configuring settings which shall be field adjustable through the keypad/display unit or via the serial communication port:

1. Motor Nameplate Data

a. Motor frequency
b. Number of poles
c. Full load speed
d. Motor volts
e. Motor full load amps
f. Motor kilowatts
g. Current minimum
h. Current maximum

2. VFD Operation Limits

a. Independent acceleration/deceleration rates
b. No load boost
c. Output voltage minimum, output voltage maximum, output Volts/Hertz ratio.
d. Full load boost
e. Overload trip curve select (Inverse or Constant)
f. Minimum/Maximum speed (frequency)

g. Auto reset for load or voltage trip select
h. Slip compensation
i. Catch a spinning load select
j. Overload trip time set

3. VFD Operation Parameters

a. Voltage loop gain
b. Voltage loop stability
c. Current loop stability

4. Controller Adjustments

a. Input signal scaling
b. Input signal select (4-20mA/0-5 Volts)
c. Auto start functions: On/Off, Delay On/Off,
d. Level Select On/Off
e. Speed Profile: Entry, Exit, Point Select
f. Minimum, Maximum Speed Select
g. Inverse profile select (allows VFD speed to vary directly or inversely with input signal.)

2.8 DIAGNOSTIC FEATURES AND FAULT HANDLING

A. The VFD shall include a microprocessor based digital diagnostic system that shall monitor its own control functions and displays faults and operating conditions.

B. A “FAULT LOG" shall record, store, display and print upon demand, the following data for the fifty (50) most recent events:

1. VFD mode (Auto/Manual)
2. Elapsed time (since previous fault)
3. Type of fault
4. Reset mode (Auto/Manual)

C. A "HISTORIC LOG" shall record, store, display and print upon demand, the following control variables at 2.7 millisecond intervals for the fifty (50) intervals immediately preceding a fault trip:

1. VFD mode (manual/auto/inhibited/tripped/etc.)
2. Speed demand
3. VFD output frequency
4. Drive inhibit (On/Off)
5. Motor amps
6. VFD output volts
7. Type of fault:

a. Inverter Over/Temp.
b. Over Voltage
c. Detection Error

d. Earth Leakage
e. Watchdog
f. PSU Power Fail
g. Manual Test
h. Out of Sat 1-6
i. Software Fault
j. Waveform Gen.
k. Remote Watchdog
l. Thermistor
m. Sustained Overload
n. Bypass SCR Trip

8. Drive inhibit (On/Off)

D. The fault log record shall be accessible via Ethernet or a+ RS232 serial link as well as line by line on the keypad display.

2.9 DRIVE OPTIONS

A. The VFD shall be provided with the following options/modifications to the basic VFD unit. All special features shall be factory mounted and wired within the VFD enclosure unless otherwise specified.

1. Internally mounted input circuit breaker interlocked with the enclosure door, with through-the-door handle to provide positive disconnect of incoming AC power. The circuit breaker shall be rated for 42,000 AIC.
2. Door-mounted meters shall be provided on all units as listed below:

a. Analog ammeter (0% - 110%) with phase selector switch to measure source current.
b. Analog speed/frequency meter (0 - 110% speed as well as Hertz).
c. Analog voltmeter (0 - 600 volt AC) with phase selector switch to measure source voltage.
d. 5-digit elapsed time meter.

3. Isolated 4-20mA DC output signals proportional to speed and current for remote monitoring of the VFD.

2.10 SPARE PARTS

A. The drives shall be supplied with one set of 100% spare parts of each type of replaceable power part and logic cards (except main circuit breaker).

2.11 ACCEPTABLE MANUFACTURERS

A. VFD’s shall be Allen Bradley, Danfoss, Robicon, or equal. Acceptable alternate Manufacturers must have a minimum of three (3) installations of VFD’s in California.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be the responsibility of the Contractor. The Contractor shall install the drive in accordance with the contract drawings and as recommended by the System Integrator, the VFD manufacturer, the harmonic filter equipment manufacturer, and as outlined in the installation manual.

B. Power and control wiring shall be completed by the Electrical Contractor. The Contractor shall complete all wiring in accordance with the recommendations of the System Integrator, the VFD manufacturer, the harmonic filter equipment manufacturer, and as outlined in the installation manual.

3.2 QUALITY ASSURANCE AND FACTORY TESTS

A. The controller shall be subject to tests including but not limited to the following quality assurance controls, procedures and tests:

1. Power transistors, SCRs and diodes shall be tested to ensure correct function and highest reliability.
2. All printed circuit boards shall be tested at 50°C for fifty (50) hours. The VFD Manufacturer shall provide certification that the tests have been completed.
3. Every controller will be functionally tested with a motor to ensure that the unit will run properly when the drive is started up according to the instruction manual provided.

3.3 START-UP

A. Certified factory start-up shall be provided for each drive by a factory authorized service center. A start-up test plan shall be submitted for review. A certified start-up form shall be filled out for each drive with a copy provided to the Engineer, to the Owner, and a copy kept on file at the Manufacturer. A blank copy of the certified start-up test form shall be included with the test plan submittal. Cost for this startup support shall be included in the VFD bid price. The Engineer shall be notified a minimum one (1) week in advance of the scheduled start-up.

B. The VFD’s shall be tested utilizing both utility and standby power sources. The VFD Representative shall make any and all adjustments and modifications to the VFD’s to operate within specified limits, without additional cost to the owner. The Manufacturer’s representative will be present during these tests.

C. No additional payments or time for completion of the project shall be allowed and no waivers of any penalties, liquidated damages, or other fees shall be provided as a result of system modifications or adjustments necessary to comply with harmonic distortion requirements as required to achieve IEEE-519 compliance.

3.4 OPERATION AND MAINTENANCE TRAINING

A. The Supplier shall conduct specifically organized training sessions in operation and maintenance of the VFD equipment for personnel employed by the Owner. The training sessions shall be conducted to educate and train the personnel in maintenance and operation of all components of the system. Training shall include, but not be limited to, the following:

1. Preventative maintenance procedures
2. Trouble-shooting
3. Setup and Calibration
4. Testing
5. Replacement of components.

B. At least two (2) training session, of at least four (4) hours in duration, shall be conducted after start-up of the system. The Supplier shall provide specific instruction materials for each training session and shall supply such materials to the Owner at least two (2) weeks prior to the time of the training.

END OF SECTION 16269

SECTION 16410

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplemental Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.

3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of NRTL listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Manufacturer's field service report.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: No fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NFPA 70.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2010 m).

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Owner's written permission.
4. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide [**Eaton Electrical Inc; Fusible Switch** or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. Type HD, Heavy Duty, Single Throw, 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: Mechanicaltype, suitable for number, size, and conductor material.

2.2 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide Eaton Electrical Inc; NST Series or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. Type HD, Heavy Duty, Single Throw, 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Hookstick Handle: Allows use of a hookstick to operate the handle.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Outdoor Locations: NEMA 250, Type 3R.
2. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Section 16074 "Vibration and Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 16075 "Electrical Identification."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges.

END OF SECTION 16410

SECTION 16442

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplemental Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Load centers.
4. Electronic-grade panelboards.

1.3 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. TVSS: Transient voltage surge suppressor.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Include evidence of NRTL listing for series rating of installed devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.
8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 16074 "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Twospares for each panelboard.
3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 1.

F. Comply with NFPA 70.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.11 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

   a. Ambient Temperature: Not exceeding minus 22 deg F (minus 30 deg C)] to plus 104 deg F (plus 40 deg C).
   b. Altitude: Not exceeding 6600 feet (2000 m).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.
3. Comply with NFPA 70E.

1.12 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.13 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five > years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 16074 "Vibration and Seismic Controls for Electrical Systems."

B. Enclosures: Surface-mounted cabinets.

1. Rated for environmental conditions at installed location.

   a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
   b. Outdoor Locations: NEMA 250, Type 3R
   c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4 >.
   d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
6. Finishes:

   a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
   b. Back Boxes: Same finish as panels and trim.
   c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

7. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.

C. Incoming Mains Location: Bottom.

D. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

E. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Mechanical type.
3. Ground Lugs and Bus-Configured Terminators: Mechanical type.

F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices. With exception of main service and derived sources, neutral and ground shall remain isolated within panels.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

H. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide Eaton Electric Inc; EZ Panel factory-assembled panelboards or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

D. Mains: Circuit breaker.

E. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide Eaton Electrical Inc; Series G Global Circuit Breakers > or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
3. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
4. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

2.4 PANELBOARD SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide Eaton Electrical Inc; SPD Series or comparable product by one of the following:

1. Current Technology; a subsidiary of Danahar Corporation.
2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
4. Liebert Corporation.
5. Siemens Energy & Automation, Inc.
6. Square D; a brand of Schneider Electric.

2.5 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Equipment Mounting: Attach panelboard to the vertical finished or structural surface behind the panelboard.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

D. Comply with mounting and anchoring requirements specified in Section 16074 "Vibration and Seismic Controls for Electrical Systems."

E. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.

F. Mount panelboard cabinet plumb and rigid without distortion of box.

G. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

H. Install filler plates in all unused spaces.

I. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

J. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 16075 "Electrical Identification."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 16075 "Electrical Identification."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Section 16075 "Electrical Identification."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
   b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
   c. Instruments and Equipment:

      1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as indicated.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 16442

SECTION 16443 - MOTOR-CONTROL CENTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplemental Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes MCCs for use with ac circuits rated 600 V and less and having the following factory-installed components:

1. Incoming main lugs and OCPDs.
2. Full-voltage magnetic controllers.
3. Reduced-voltage magnetic controllers.
4. Reduced-voltage, solid-state controllers.
5. Multispeed controllers.
6. VFCs.
7. Feeder-tap units.
8. TVSS.
9. Instrumentation.
10. Auxiliary devices.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. CE: Conformite Europeene (European Compliance).

C. CPT: Control power transformer.

D. EMI: Electromagnetic interference.

E. GFCI: Ground fault circuit interrupting.

F. IGBT: Insulated-gate bipolar transistor.

G. LAN: Local area network.

H. LED: Light-emitting diode.

I. MCC: Motor-control center.

J. MCCB: Molded-case circuit breaker.

K. MCP: Motor-circuit protector.

L. NC: Normally closed.

M. NO: Normally open.

N. OCPD: Overcurrent protective device.

O. PCC: Point of common coupling.

P. PID: Control action, proportional plus integral plus derivative.

Q. PT: Potential transformer.

R. PWM: Pulse-width modulated.

S. RFI: Radio-frequency interference.

T. SCR: Silicon-controlled rectifier.

U. TDD: Total demand (harmonic current) distortion.

V. THD(V): Total harmonic voltage demand.

W. TVSS: Transient voltage surge suppressor.

X. VFC: Variable-frequency controller.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: MCCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of controller and each type of MCC. Include shipping and operating weights, features, performance, electrical ratings, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each MCC, manufacturer's approval drawings as defined in UL 845. In addition to requirements specified in UL 845, include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Each installed unit's type and details.
b. Factory-installed devices.
c. Enclosure types and details.
d. Nameplate legends.
e. Short-circuit current (withstand) rating of complete MCC, and for bus structure and each unit.
f. Features, characteristics, ratings, and factory settings of each installed controller and feeder device, and installed devices.
g. Specified optional features and accessories.

2. Schematic Wiring Diagrams: For power, signal, and control wiring for each installed controller.
3. Nameplate legends.
4. Vertical and horizontal bus capacities.
5. Features, characteristics, ratings, and factory settings of each installed unit.

C. Harmonic Analysis Study and Report: Comply with IEEE 399 and NETA Acceptance Testing Specification; identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at the defined PCC to specified levels.

1.6 INFORMATIONAL SUBMITTALS

A. Standard Drawings: For each MCC, as defined in UL 845.

B. Production Drawings: For each MCC, as defined in UL 845.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around MCCs where pipe and ducts are prohibited. Show MCC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Seismic Qualification Certificates: For MCCs, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Product Certificates: For each MCC, from manufacturer.

F. Source quality-control reports.

G. Field quality-control reports.

H. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

I. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

J. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For MCCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:

1. Manufacturer's Record Drawings: As defined in UL 845. In addition to requirements specified in UL 845, include field modifications incorporated during construction by manufacturer, Contractor, or both.
2. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
3. Manufacturer's written instructions for setting field-adjustable overload relays.
4. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage, solid-state controllers.
5. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
6. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: No fewer than three of each size and type.
2. Control Power Fuses: No fewer than three of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.9 QUALITY ASSURANCE

A. Source Limitations: Obtain MCCs and controllers of a single type from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Section 16074 "Vibration and Seismic Controls for Electrical Systems."

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver MCCs in shipping splits of lengths that can be moved past obstructions in delivery paths.

B. Handle MCCs according to the following:

1. NEMA ICS 2.3, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600 Volts."
2. NECA 402, "Recommended Practice for Installing and Maintaining Motor Control Centers."

C. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside MCCs; install temporary electric heating, with at least 250 W per vertical section.

1.11 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
2. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
3. Humidity: Less than 95 percent (noncondensing).
4. Altitude: Exceeding 6600 feet, or 3300 feet if MCC includes solid-state devices.

B. Interruption of Existing Electrical Service or Distribution Systems: Do not interrupt electrical service to, or distribution systems within, a facility occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of electrical service.
2. Indicate method of providing temporary electrical service.
3. Do not proceed with interruption of electrical service without Owner's written permission.
4. Comply with NFPA 70E.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for MCCs, including clearances between MCCs and adjacent surfaces and other items.

1.12 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

B. Coordinate features of MCCs, installed units, and accessory devices with remote pilot devices and control circuits to which they connect.

C. Coordinate features, accessories, and functions of each MCC, each controller, and each installed unit with ratings and characteristics of supply circuits, motors, required control sequences, and duty cycle of motors and loads.

1.13 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace devices and components that fail in material or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB; Control Products.
2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. General Electric Company; GE Industrial Systems.
4. Rockwell Automation, Inc.; Allen-Bradley Brand.
5. Siemens Energy & Automation, Inc.; Power Distribution.
6. Square D; a brand of Schneider Electric.

B. General Requirements for MCCs: Comply with NEMA ICS 18 and UL 845.

2.2 FUNCTIONAL FEATURES

A. Description: Modular arrangement of main units, controller units, control devices, feeder-tap units, instruments, metering, auxiliary devices, and other items mounted in vertical sections of MCC.

B. Controller Units: Combination controller units.

1. Install units up to and including Size 3 on drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
2. Equip units in Type B and Type C MCCs with pull-apart terminal strips for external control connections.

C. Feeder-Tap Units: Through 225-A rating shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.

D. Future Units: Compartments fully bused and equipped with guide rails or equivalent, ready for insertion of drawout units.

E. Spare Units: Installed in compartments indicated "spare."

2.3 INCOMING MAINS

A. Incoming Mains Location: Contractor to coordinate based on field conditions.

B. Main Lugs Only: Conductor connectors suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Mechanical type.

C. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. MCCB Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    d. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2.4 COMBINATION CONTROLLERS

A. Full-Voltage Controllers:

1. General Requirements for Full-Voltage Enclosed Controllers: Comply with NEMA ICS 2, general purpose, Class A.
2. Magnetic Controllers: Full voltage, across the line, electrically held.

    a. Configuration: Non-reversing.

B. Reduced-Voltage, Solid-State Controllers:

1. General Requirements for Reduced-Voltage, Solid-State Controllers: Comply with UL 508.
2. Reduced-Voltage, Solid-State Controllers: An integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relay; suitable for use with NEMA MG 1, Design B, polyphase, medium-induction motors.

    a. Configuration: Standard duty, non-reversable.
    b. Starting Mode: field selectable.
    c. Stopping Mode: field selectable.
    d. Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
    e. Adjustable acceleration-rate control using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds.
    f. SCR bridge shall consist of at least two SCRs per phase, providing stable and smooth acceleration without external feedback from the motor or driven equipment.
    g. Keypad, front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:
    h. Adjusting motor full-load amperes, as a percentage of the controller's rating.
    i. Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
    j. Adjusting linear acceleration and deceleration ramps, in seconds.
    k. Initial torque, as a percentage of the nominal motor torque.
    l. Adjusting torque limit, as a percentage of the nominal motor torque.
    m. Adjusting maximum start time, in seconds.
    n. Adjusting voltage boost, as a percentage of the nominal supply voltage.
    o. Selecting stopping mode, and adjusting parameters.
    p. Selecting motor thermal-overload protection class between 5 and 30.
    q. Activating and de-activating protection modes.
    r. Selecting or activating communications modes.
    s. Digital display, front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:
    t. Controller Condition: Ready, starting, running, stopping.
    u. Motor Condition: Amperes, voltage, power factor, power, and thermal state.
    v. Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.
3. Controller Diagnostics and Protection:
    a. Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor overload alarm and trip; settings selectable via the keypad.
    b. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency over or under normal.
    c. Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component, or when the motor is stopped.
    d. Shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.
    e. Remote Output Features:

f. All outputs prewired to terminal blocks.
g. Form C status contacts that change state when controller is running.
h. Form C alarm contacts that change state when a fault condition occurs.

4. Optional Features:
   a. Analog output for field-selectable assignment of motor operating characteristics; 4 to 20-mA dc.
   b. Additional field-assignable Form C contacts for alarm outputs.
   c. Surge suppressors in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.

C. Disconnecting Means and OCPDs:

1. Fusible Disconnecting Means:

   a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J fuses.
   b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
   c. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.

2. MCP Disconnecting Means:

   a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
   b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
   c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
   d. NO alarm contact that operates only when MCP has tripped.
   e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

3. MCCB Disconnecting Means:

   a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
   b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   c. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
   d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
   e. NO alarm contact that operates only when MCCB has tripped.

4. Molded-Case Switch Disconnecting Means:

   a. UL 489, NEMA AB 1, and NEMA AB 3, with in-line fuse block for Class J or L power fuses (depending on ampere rating), providing an interrupting capacity to

comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.

b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
c. Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
d. NO alarm contact that operates only when molded-case switch has tripped.

D. Overload Relays:

1. Solid-State Overload Relays:

a. Switch or dial selectable for motor running overload protection.
b. Sensors in each phase.
c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
d. Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
e. Analog communication module.

2. Form C isolated overload alarm contact.
3. External overload reset push button.

E. Control Power:

1. Control Circuits: 24-V ac; obtained from integral CPT, with primary and secondary fuses of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

a. CPT Spare Capacity: 100 VA.

2.5 VARIABLE FREQUENCY DRIVE UNITS

A. Comply with provisions of Section 16269.

2.6 FEEDER-TAP UNITS

A. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.

c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.

B. Fusible Switch: NEMA KS 1, Type HD, clips to accommodate specified fuses with lockable handle.

2.7 INSTRUMENTATION

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

1. PTs: IEEE C57.13; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; bar or window type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. CPTs: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Instrument Switches: Rotary type with off position.

1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and phase-to-neutral voltages where a neutral is included.
2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.

2.8 MCC CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from CPT.

B. Control Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.9 ENCLOSURES

A. Indoor Enclosures: Freestanding steel cabinets unless otherwise indicated. NEMA 250, Type 12 unless otherwise indicated to comply with environmental conditions at installed location.

B. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.
2. Space-Heater Power Source: Transformer, factory installed in MCC.

C. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

D. Compartments: Modular; individual doors with concealed hinges and quick-captive screw fasteners. Interlocks on units requiring disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.

E. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC; same size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

F. Wiring Spaces:

1. Vertical wireways in each vertical section for vertical wiring to each unit compartment; supports to hold wiring in place.
2. Horizontal wireways in bottom and top of each vertical section for horizontal wiring between vertical sections; supports to hold wiring in place.

2.10 AUXILIARY DEVICES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oiltight type.

a. Push Buttons: Unguarded types; momentary contact unless otherwise indicated.
b. Pilot Lights: LED types; with push to test.
c. Selector Switches: Rotary type.

2. Elapsed-Time Meters: Heavy duty with digital readout in hours**;** resettable.

B. Reversible NC/NO contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

E. Space heaters, with NC auxiliary contacts, to mitigate condensation in enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

2.11 SOURCE QUALITY CONTROL

A. MCC Testing: Inspect and test MCCs according to requirements in NEMA ICS.

B. MCCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive MCCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 HARMONIC ANALYSIS STUDY

A. Perform a harmonic analysis study to identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at the defined PCC to specified levels.

B. Prepare a harmonic analysis study report complying with IEEE 399 and NETA Acceptance Testing Specification.

3.3 INSTALLATION

A. Coordinate layout and installation of MCCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Floor-Mounting Controllers: Install MCCs concrete base.

1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
3. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Seismic Bracing: Comply with requirements specified in Section 16074 "Vibration and Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in each fusible switch.

F. Install fuses in control circuits if not factory installed. Comply with requirements in Section 16491 "Fuses."

G. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

I. Comply with NECA 1.

3.4 IDENTIFICATION

A. Comply with requirements in Section 16075 "Electrical Identification" for identification of MCC, MCC components, and control wiring.

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label MCC and each cubicle with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.
4. Mark up a set of manufacturer's connection wiring diagrams with field-assigned wiring identifications and return to manufacturer for inclusion in Record Drawings.

B. Operating Instructions: Frame printed operating instructions for MCCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of MCCs.

3.5 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices and designated process control system.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches within enclosed controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.6 CONNECTIONS

A. Comply with requirements for installation of conduit in Section 16130 "Raceways and Boxes." Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Comply with requirements in Section 16060 "Grounding and Bonding."

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation.
2. Test and adjust controllers, components, and equipment.
3. Test insulation resistance for each enclosed controller element, component, connecting motor supply, feeder, and control circuits.
4. Test continuity of each circuit.
5. Verify that voltages at controller locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer before starting the motor(s).
6. Test each motor for proper phase rotation.
7. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
8. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
9. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multipole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multipole enclosed controller 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

10. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
11. Mark up a set of manufacturer's drawings with all field modifications incorporated during construction and return to manufacturer for inclusion in Record Drawings.

C. Enclosed controllers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.8 ADJUSTING

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

B. Adjust overload relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.

C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Engineer before increasing settings.

D. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage, solid-state controllers.

E. Program microprocessors in VFCs for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

3.9 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.

B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers, and to use and reprogram microprocessor-based, reduced-voltage, solid-state controllers.

END OF SECTION 16443

SECTION 16491

FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600-V ac and less for use in control circuits and enclosed switches .
2.
3. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

    a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
    b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
4. Coordination charts and tables and related data.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:

1. Ambient temperature adjustment information.
2. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Comply with UL 248-11 for plug fuses.

1.6 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.7 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following

1. Cooper Bussmann, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Feeders: Class RK5, time delay.
2. Motor Branch Circuits: Class RK5, time delay.
3. Control Circuits: Class CC, time delay.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s).

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 16075 "Electrical Identification" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 16491

SECTION 16511

INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplemental Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Interior lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

B. Related Sections:

1. Section 16140 "Wiring Devices" for manual wall-box switches.
2. Section 16145 "Lighting Control Devices" for automatic control of lighting, including photoelectric relays.

1.3 DEFINITIONS

A. BF: Ballast factor.

B. CCT: Correlated color temperature.

C. CRI: Color-rendering index.

D. LER: Luminaire efficacy rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting fixture, including ballast housing if provided.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of lighting fixture including dimensions.
2. Emergency lighting units including battery and charger.
3. Ballast, including BF.
4. Energy-efficiency data.
5. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
    a. Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Installation instructions.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

B. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.

C. Field quality-control reports.

D. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

1.8 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.9 WARRANTY

A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide product indicated on Drawings.

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

A. LED:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

3. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

4. CRI of 70. CCT of 3000 K or as indicated on the drawings.

5. Rated lamp life of 50,000 hours.

6. Internal driver.

B. Metal Parts: Free of burrs and sharp corners and edges.

C. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.

D. Diffusers and Globes:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

a. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.
b. UV stabilized.

E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp and ballast characteristics:

a. "USE ONLY" and include specific lamp type.

2.3 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:
1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.

a. Battery: Sealed, maintenance-free, nickel-cadmium type.
b. Charger: Fully automatic, solid-state type with sealed transfer relay.
c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
f. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.4 EMERGENCY LIGHTING UNITS

A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
6. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.
7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.5 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Section 16073 "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures:

1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
2. Install lamps in each luminaire.

B. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.

C. Suspended Lighting Fixture Support:
1. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
2. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

D. Connect wiring according to Section 16120 "Conductors and Cables."

3.2 IDENTIFICATION

A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 16075 "Electrical Identification."

3.3 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION 16511

SECTION 17010

INSTRUMENTATION AND CONTROL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Scope:

1. GENERAL: This section specifies general requirements applicable to process instrumentation systems consisting of process sensors, monitoring and control devices, and accessories required to provide a complete and fully functional monitoring and control system.
2. RESPONSIBILITY: The Contractor shall provide, configure, calibrate, program, test, and commission all components of the instrumentation, control, communications, and network systems supplied (UNO). The Contractor shall place the completed systems in operation, including tuning loops and making final adjustments to instruments as required during plant start-up. The Contractor shall provide the services of instrument technicians for testing and adjustment activities.
3. RELATED REQUIREMENTS: Division 17 is an extension of, and includes all of the requirements of Division 16, Electrical. All work performed under Division 17 shall also comply with the applicable sections of Division 16 as well as the general provisions of Divisions 0 & 1.

B. Contract Requirements:

1. General Conditions, Supplemental Conditions, and Division 1 apply to Work in this section.

C. DEFINITIONS:

1. General: The definitions of terminology used in these specifications shall be defined in ISA Standard S51.1, unless otherwise specified.
2. APPROVED EQUAL: Items that are accepted and approved by the owner, the owners designated project representative, or the engineer as being functionally equivalent for the application and acceptable substitutes for items specified in the contract documents.
3. Contractor: The general contractor is responsible for overall project construction. The party with whom the contract is executed.
4. CSI: Control System Integrator. An organization engaged in the business of detail design, component purchase, assembly, programming, and implementing process control and industrial electronic systems.
5. Data Sheets: Data sheets as used in this specification shall refer to ISA S20.
6. Galvanic Isolation: Pertaining to an electrical node having no direct current path to another electrical node. As used in this specification, galvanic isolation refers to a device with electrical inputs and/or outputs which are galvanically isolated from ground, the device case, the process fluid, and any separate power supply terminals, but such inputs and/or outputs are capable of being externally grounded without affecting the characteristics of the devices or providing path for circulation of ground currents.

7. GC : General Contractor
8. HMI: Human Machine Interface.
9. Integrated Circuit: A number of circuit elements inseparably associated on or within a continuous body to perform the function of a circuit.
10. NA: Not Applicable
11. Panel: An instrument support system which may be either a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Panels may provide mechanical protection, electrical isolation, and protection from dust, dirt, and chemical contaminants which may be present in the atmosphere. "Panel" shall be understood to include consoles, cabinets, and racks.
12. OIT: Touch screen Operator Interface Terminal. Used for HMI as specified.
13. PROJECT: In reference to a person the term project shall be used to refer to the owner or representatives of the owner designated by the owner. Synonymous with PROJECT REPRESENTATIVE.
14. PACKAGED SYSTEM: Integrated equipment systems that are specified in other divisions and sections of the specifications. These systems include process and mechanical equipment as well as electrical and controls equipment that conforms to the requirements of Division 16 and 17. These systems may include skid mounted and loose items. Some items provided with the equipment may require installation and connection by others. Some related items identified as "supplied by others" may not be supplied with the system but may nonetheless be required for some of the functions of the system.
15. SCADA: Supervisory Control and Data Acquisition.
16. Signal Types: The following types of signals are used in systems specified in this division.

    a. Low Level Analog: A signal that has a full output level of 100 millivolts or less. This group includes thermocouples and resistance temperature detectors.
    b. Digital Code: Coded information such as that derived from the output of an analog to digital converter or the coded output from a digital computer or other digital transmission terminal. This type includes those cases where direct line driving is utilized and not those cases where the signal is modulated.
    c. Pulse Frequency: Counting pulses such as those emitted from speed transmitters.
    d. High Level Analog: Signals with full output level greater than 100 millivolts but less than 30 volts, including 4-20 mA transmission.
    e. Modulated Signals: Signals emanating from modems or low level audio signals. Normal signal level is plus 4 dBm to minus 22 dBm. Frequency range is 300 to 10,000 hertz.
    f. Discrete Events: Dry contact closures monitored by solid-state equipment. If the conductors connecting to dry contacts enter enclosures containing power or control circuits and cannot be isolated from such circuits in accordance with NEC Article 725, this signal shall be treated as low voltage control.
    g. Low Voltage Control: Contact closures monitored by relays, or control circuits operating at less than 30 volts and 250 milliamperes.
    h. High Level Audio Signals: Audio signals exceeding plus 4 dBm, including loud speaker circuits.
    i. Radio Frequency Signals: Continuous wave, alternating current signals with fundamental frequency greater than 10 kilohertz.
    j. 120 VAC control: Contact closures monitored by relays, or control circuits operating at 120 volts AC.

17. Solid State: Circuitry or components of a type which convey electrons by means of solid material such as silicon or crystals, or which work on magnetic principles such as ferrite cores. Vacuum tubes, gas tubes, slide wires, stepping motors, or other devices are not acceptable substitutes for solid-state components or circuitry.
18. Two-wire Transmitter: A transducer which derives operating power supply from the signal transmission circuit and therefore requires no separate power supply connections. As used in this specification, two-wire transmitter refers to a transmitter which produces a 4 to 20-milliampere, current-regulated signal in a series circuit with a 24-volt direct current driving potential and a maximum circuit resistance of 600 ohms.
19. UNO: Unless specifically Noted Otherwise. All general requirements statements shall apply as stated except where specific exceptions are stated, in which case the general requirement shall be modified by the stated exception.

D. REFERENCE SECTIONS: Requirements of the sections listed below apply to and are related to the work of this Section. Other Sections, not referenced below, may also apply and be related to the proper performance of this work. The Contractor is responsible to perform all the work required by the Contract.
1. Division 16: all sections.
2. Division 17: all sections.

1.2 QUALITY ASSURANCE

A. REFERENCED STANDARDS: The latest edition of the documents listed below are included in the Contract where referenced.

1. American National Standards Institute (ANSI)
2. Institute of Electrical and Electronic Engineers (IEEE)
3. Underwriters' Laboratories (UL)
4. The Instrumentation, Systems, and Automation Society (ISA)
5. API RP550: Manual on Installation of Refinery Instruments and Control Systems, Part I – Process Instrumentation and Control Sections 1 Through 13
6. API RP 551: Process Measurement Instrumentation
7. API RP 552: Transmission Systems - first Edition
8. ANSI/ISA S5.4: Instrument Loop Diagrams
9. ISA S20: Specification Forms for Process Measurement and Control Instrumentation, Primary Elements, and Control Valves
10. ANSI/ISA S5.1: Instrumentation symbols and Identification
11. ANSI/ISA S51.1: Process Instrumentation Terminology
12. ISA S5.3: Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer systems
13. ISA RP12.2.02: Recommendations for the Preparation, Content, and Organization of Intrinsic Safety Control Drawings
14. NFPA 70 National Electric Code (NEC)
15. NFPA 79 Electrical Standards for Industrial Machinery
16. NFPA 820 Fire Protection in Wastewater Treatment and Collection Facilities
17. IBC 1632 International Building Code
18. UL 508 Industrial Control Equipment

B. LISTING:

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment shall be listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer's place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.3 SUBMITTALS

A. GENERAL: Submit information per Division 1.

B. MEDIA: All submittals shall be provided in hard copy (paper) in accordance with Division 1 and electronic format. Electronic format shall be PDF format on CD that is compatible with Microsoft Widows / Adobe Reader. One CD shall be provided for each hard copy required per Division 1.

C. ORGANIZATION AND FORMAT: Submittal organization shall be the same as the specifications. Provide submittals bound with section coversheets and tabbed dividers with specification section numbers for submittal organization. Bill of materials, cut sheets, shop drawings, schematics, panel layouts, schedules, etc., shall be cross-referenced, indexed, or otherwise related by unique identifier for each item. The project may reject improperly organized or notated submittals. Provide .pdf file page numbers in table of contents as well as bookmark links to section coversheets in pdf file.

D. REVIEWS AND RE SUBMITTALS: Suppliers shall provide re-submittals which include responses to all submittal review comments separately and at a level of detail commensurate with each comment. Supplier responses shall indicate how the supplier resolved the issue pertaining to each review comment. Responses that only indicate that the review comment was noted, will be looked into, etc., are not satisfactory. Re-submittals which do not comply with this requirement may be rejected and returned without review. Contractor shall be allowed no extensions of any kind to any part of their contract due to the rejection of non-compliant submittals. Submittal review comments not addressed by the contractor in re submittals 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.

E. PRODUCT DATA: Submit catalog cut sheets for all products. Identify all cut sheets by unique bill of material item number, index, or key. Notate catalog cuts to indicate only those items, models, options, or series of equipment to be furnished. Cross out or otherwise obliterate all extraneous materials and information. Clearly identify all configuration options for the equipment to be furnished.

F. BILL OF MATERIALS: Submit bill of materials including all items, products, and assemblies supplied. Documents shall be updated following submittal review, factory test, and commissioning. Updates shall be provided to the Project Representative in a timely manner. Bill of materials shall include the following information:

1. Item number, index, or key relating to submitted cut sheets, drawings, schedules, etc.
2. Item manufacturer's name, model, and part numbers. Supplier unique part numbers are not acceptable.
3. Description
4. Quantity supplied
5. Supplier contact information

G. NOTATED SPECIFICATIONS: Submit copies of all Division 17 specification sections with each paragraph notated to indicate compliance. A check mark shall indicate complete compliance. Explanations shall be provided for all non-compliant items in accordance with Division 1.

H. NOTATED P&ID DRAWINGS: Submit copies of all project Process and Instrumentation drawings with each drawing element notated to indicate compliance. A check mark shall indicate complete compliance. Explanations and markups shall be provided for all non-compliant items and in accordance with Division 1

I. NOTATED ELECTRICAL AND INSTRUMENTATION DRAWINGS: In the case of deviations from the contract documents, particularly related to the impact of the configuration of submitted packaged equipment supplied to the project, submit marked up copies of applicable Electrical and Instrumentation contract drawings notated to identify and explain all proposed deviations from the contract documents. Items not notated on the submitted marked up copies shall be assumed to be 100% compliant with the bid documents. This requirement applies to electrical one lines, MCCs, MCC control schematics, panel schedules, and control schematics. This requirement does not apply to plan drawings and conduit schedule which shall be marked up to reflect the as constructed project configuration and submitted as record drawings.

J. SEISMIC: Submit Seismic design information per 16010-2.01D. Include a list of equipment weighing 200 pounds or more.

K. O&M: Submit operation and maintenance information as specified in any Division 17 specification section. O&M manuals shall include product data for all materials and items supplied in compliance with the submittal requirements of this section.

L. DIV 17: Submit information as required by all Division 17 specification sections.

M. CSI: Submit information about proposed CSI including employee resumes, company information, etc, as required by any Division 17 specification sections.

N. DRAWINGS: Submit all drawings described in this and other Division 17 sections including elementary, loop, schematic, fabrication, installation, field wiring, panel layout and assembly, etc., drawings. Drawings shall be updated following submittal review, factory test, and commissioning. Updates shall be provided to the Project Representative in a timely manner. Cross reference drawing elements with BOM and catalog cut sheet unique references. Drawings shall use project tag formats and numbers. Unique and separate drawings shall be provided for each item supplied including but not limited to all panels and all MCC units. Typical drawings that apply to multiple panels or multiple MCC motor control units are not acceptable.

O. PACKAGED EQUIPMENT: All packaged equipment suppliers shall provide submittals in compliance with Division 17. This shall include packaged equipment purchased under the contract as well as any pre-purchased packaged equipment assigned to the contractor.

P. SOFTWARE AND PROGRAMMING: Per Section 17802

Q. COMPONENT DRAWINGS: Dimensional, installation, and wiring diagrams and drawings for all supplied components.

R. TESTING AND CALIBRATION: Test plans, calibration forms, test forms, test results, and test reports required by any Division 17 specification section. Per Section 17804.

S. SPARE PARTS: Spare parts lists

1.4 SERVICE REQUIREMENTS

A. ENVIRONMENTAL CONDITIONS: All equipment shall be suitable for operation in the following ambient conditions. Modify equipment if necessary as required to function in the specified environment.

1.	Atmospheric contaminants:	
	Hydrogen sulfide	0.1 mg/L
	Chlorine	0.01 mg/L
	Ammonia	0.5 mg/L
	Dust	50.0 ug/m3
2.	Electromagnetic radiation:	
	27/500 MHz	10 volts/m
3.	Control Rooms:	
	Temperature	60 to 95 degrees F
	Humidity	20 to 80 percent
4.	Pump Rooms	
	Temperature	40 to 120 degrees F
	Humidity	10 to 100 percent
5.	Outdoor Field Locations:	
	Temperature	-10 to 120 degrees F
	Humidity	10 to 100 percent

1.5 DESCRIPTION OF SYSTEM

A. GENERAL:

1. SYSTEM SCOPE: The instrumentation and control system shall include the instruments, control devices, programmable controllers, input and output devices, sensors, interfacing devices, communications devices, cabinets, enclosures, and other components, as required to implement the functional requirements of the Contract.
2. DESIGN AND ASSEMBLY: The instrumentation and control system shall be designed and assembled by the CSI to be an integrated system composed completely of components that are specifically designed and intended to be used for and in conjunction with the control and operation of motor-driven pumps and process equipment. The control system shall be designed and assembled by the CSI to provide:

    a. Control of motor driven pumps, equipment, and processes

b. Monitoring of operation of motor driven pumps, equipment, and processes
c. Indication of operating status of motor driven pumps, equipment, and processes
d. The capabilities indicated and implied by Contract documents.
e. Reliable communications with the plant SCADA system.

3. CUSTOM PARTS: System components shall be commercial, off-the-shelf (COS) components. Custom designed or manufactured components shall require Project Representatives approval.

B. FUNCTIONAL REQUIREMENTS:

1. BID DOCUMENTS: As defined in Division 17 specifications and the contract drawings.
2. MANUAL FUNCTIONS: The system shall readily enable manual operation of any and all equipment functions. Manual equipment operation shall not be reliant on any programmable electronic devices or equipment.
3. FAULT TOLERANCE: The system shall be immune to single point failures to the maximum extent practical.
4. LOCATION OF FUNCTIONS: The system shall include manual, automatic, programmed, and hardwired functions. The devices that provide these functions shall be located at field mounted control stations, packaged system local control panels, motor control equipment, process area control panels, and plant SCADA equipment.

C. HIERARCHICAL MONITORING AND CONTROL SYSTEM ARCHITECTURE:

1. Plant systems have been designed to include operator interfaces for all system functions. All systems have been designed to be manually operable via discrete devices and via programmed Human Machine Interface devices. Systems have been designed to be monitored and controlled in a hierarchical manner. Basic functions have been designed to be provided at field stations, local panels, and MCC’s by discrete panel switches, indicator lights, and displays. All programmable devices and systems have been designed to, and shall communicate over a TCP/IP plant Ethernet network. The CSI, the Contractor, and packaged equipment suppliers shall ensure that all components of supplied plant systems fully and seamlessly integrate into this system architecture.

1.6 CONTRACTOR AND SUBCONTRACTOR SCOPES OF WORK

A. SYSTEMS RESPONSIBILITY:

1. With the exception of packaged systems and third party programming, all instrumentation and industrial electronic systems and functions shall be provided under the supervision of a single Control System Integrator, chosen by the Contractor, who is regularly engaged in the design, programming, configuration, and installation of similar systems of equal or greater scope and complexity. The Control System Integrator shall be enjoined by the Contractor as a Subcontractor. The assignment of specific responsibilities herein to the Control System Integrator shall not, in any way or under any conditions, diminish the Contractor's full and complete responsibility for all work performed and all materials installed under the contract. The contract between the Contractor and the Control System Integrator shall specifically require that the Control System Integrator conform to and meet all requirements specified in

the contract documents. The assignment of the Control System Integrator as an equipment supplier shall not be acceptable.

B. INTENT OF DRAWINGS AND SPECIFICATIONS:

1. GENERAL: Due to the fact that the contract documents cannot dictate the use of specific brands or models of components and equipment unless there is a compelling reason to do so, the control system drawings are intended to primarily convey detailed functional and operational requirements of the control system rather than specific component selection, assembly, and interconnection information. The substantial interconnection information provided in the Contract Drawings is general in nature and is provided for the purpose of indicating the general scope of work and the aforementioned functional and operational requirements, and shall not be construed to represent detailed shop drawings or parts thereof.
2. ANCILLARY COMPONENTS REQUIRED: Components not explicitly indicated in the Contract Documents but none-the-less implied, required for the environment or area classification indicated, or required for the proper functioning of the system as indicated shall be considered required just as though they had been explicitly indicated. The aforementioned components shall be considered incidental to the Contract and shall not constitute a basis for claim by the Bidder for additional compensation or time allowed to complete the Work.

C. CONTROL SYSTEM INTEGRATOR'S RESPONSIBILITIES:

1. RESPONSIBILITY: In accordance with A and B above, the Control System Integrator (CSI) shall be solely and completely responsible for the detailed design, assembly, programming, and commissioning of the entire control system with the exception of control equipment provided as a part of packaged equipment systems or otherwise noted as exceptions.
2. DESIGN AND PERFORMANCE: The control system hardware and assemblies shall be designed by the CSI to provide the control capabilities and functions indicated in and implied by the drawings and these specifications and to provide trouble-free operation with a minimum of maintenance.
3. COORDINATION AND INTEGRATION: The CSI shall be directly responsible for the coordination and integration of the control system with motor controls, packaged equipment controls, and other related equipment. The CSI shall be responsible to obtain submittal information on equipment specified or provided by other suppliers or disciplines and to integrate all the equipment into the control system to form a complete working system as outlined by the Contract Documents.
4. PROACTIVE COMMUNICATION: The CSI shall communicate directly with the manufacturer(s) and supplier(s) of all related equipment to determine all details of the equipment that may influence or affect the control system. The CSI shall determine all requirements for and shall cause integration of the control system into a unified operating system. All correspondence shall include Carbon Copying (cc:) the General Contractor.
5. ITEMIZED RESPONSIBILITIES: The CSI shall be responsible for the following equipment and services:

    a. Detailed Design of Control Panels: The drawings depict the functional and operational requirements of the control system and are at times diagrammatic. The CSI shall provide detailed, scaled design of all components on and in control panels and determine specific physical, thermal, and electrical requirements.
    b. Detailed Design of Control Circuitry: The drawings depict the functional and operational requirements of the control system and are at times diagrammatic. The

CSI shall be responsible for the final selection of all control system components, except for components specified as "no equal", and all detailed circuit design and component interconnection required to meet the general and functional requirements indicated in or implied by the Drawings and Specifications. Where components are specified as "no equal", the CSI shall provide all detailed design, including specification of miscellaneous or interfacing components required to integrate the specified component into the CSI's control system design. It is the responsibility of the CSI to ensure that all devices selected, and the proposed interconnection of those devices, perform as intended to provide a complete and operable system meeting the requirements of the anticipated environment and area classifications. The CSI shall define all requirements for all interfacing components and shall supply all appurtenances, accessories, and all such devices which may be required for proper functioning and interfacing of components as part of the control system. An example of such appurtenances would be interposing relays or analog isolators. All such aforementioned necessary ancillary components not specifically indicated in the Contract Documents shall be considered incidental to the contract and shall be required just as if they had been specifically indicated.

c. INTERCONNECTING WIRING: The design of all interconnecting wiring of control equipment, including remote control panels, packaged equipment panels, mechanical equipment with control components, etc.
d. MOTOR CONTROL CENTERS: Supplying the Motor Control Equipment and/or Motor Control Centers (MCCs) in accordance with Division 16.
e. EQUIPMENT TESTING: Testing of the Motor Control Equipment in the CSI's shop. Testing of control panels in the CSI's shop under simulated operating conditions. Per Section 17804.
f. INTEGRATION TESTING: Integration testing of all system and related components simultaneously in the CSI's facility. This testing shall include all panels, instruments, process switches, test fixtures, MCCs, motor controllers, available equipment packages, communications and networking equipment, SCADA system hardware and software (UNO), PLC system hardware and software (UNO), etc. Per Section 17804.
g. COORDINATION WITH GC: Coordinate with the Contractor for specific requirements and locations of raceway penetrations and field wiring in control panels. The CSI shall supply the Contractor with all necessary detailed installation drawings and/or written instruction for installation of all control components and sensing devices as required for proper system operation.
h. CALIBRATION: Calibration of all new and connected existing field instruments UNO. Per Section 17804.
i. COMMUNICATIONS AND NETWORKS: Set up, configuration, test, and verification of all communications equipment, channels, and networks including new and reused telephone circuits.
j. STARTUP AND TESTING: System start up, commissioning, functional testing following installation. Per Section 17804.
k. INSTRUMENTS: Provide all instruments specified unless specifically noted otherwise. Some instruments shall be provided by packaged equipment vendors. The CSI shall integrate vendor provided instruments and equipment.
l. CONFIGURATION AND PROGRAMMING: Configure and program all supplied devices, equipment, and software unless specifically noted otherwise. Configuration and programming of devices and equipment supplied as a part of packaged systems shall be provided by the vendor of each packaged system. Per Section 17802
m. APPLICATION SOFTWARE DEVELOPMENT: Per Section 17802.

n. EQUIPMENT SUBMITTAL REVIEW: Review all equipment and packaged system submittals which include Division 17 items. Notify the Contractor of any and all needed modifications to submitted equipment, package system scope of services or supply, or CSI supplied equipment required to accommodate and integrate submitted equipment into the CSI's work. Specifically note how submittals which include variances from the contract documents will impact CSI provided control panels and MCC's if accepted by the contractor.

D. GENERAL AND ELECTRICAL CONTRACTOR'S RESPONSIBILITY: The General and Electrical Contractor shall be responsible for the following equipment and services:

1. CSI SUBMITTAL REVIEW: Review of the CSI's submittals and wiring diagrams for coordination with space requirements, raceway requirements of field wiring, etc.
2. EQUIPMENT SUBMITTALS: Supply the Integrator with information submittals on all equipment which impacts or connects to the control system, which the Integrator must incorporate into their shop drawings and integrate into the project. This includes items such as pumps, motors, packaged control panels, other equipment, valve actuators, etc.
3. INSTALLATION:

a. Installation of control panels provided by the CSI.
b. Installation of Motor Control Equipment (MCC) provided by the CSI.
c. Installation of interconnecting wiring in accordance with the contract documents and the CSI's wiring diagrams.
d. Installation of Instrumentation and Control System components in accordance with the contract documents and instructions of the CSI.

1.7 SHOP DRAWINGS

A. GENERAL: The CSI, suppliers of packaged control systems, and suppliers of MCCs shall develop all shop drawings required for design, fabrication, assembly, installation, operation, and maintenance of the supplied control system components. Drawings shall be prepared utilizing a computer aided drafting program. CAD shop drawings shall be updated and provided to the Project Representative prior to factory testing, prior to system installation, and with the O&M manuals. All drawings shall be supplied in hardcopy and electronic file formats per paragraph 1.3.B of this section.

1. DIAGRAMS: Submit detailed interconnection diagrams, wiring diagrams, elementary diagrams, communications diagrams, and loop diagrams with all electrical and electronic components clearly identified by project tag number consistent with the contract drawings and schedules. Diagrams for each circuit or element shall be separate and unique. Typical diagrams are not allowed. Diagrams shall carry a date and brief description of the revisions. Diagrams shall carry a uniform and coordinated set of wire and terminal block numbers in compliance with panel work wiring, Section 17110.
2. PANEL LAYOUTS: Submit detailed construction drawings for panel layouts and equipment enclosures with dimensions in inches. Show both exterior and interior views.
3. WIRE AND TB NUMBERS: Wiring and loop diagrams shall carry a uniform and coordinated set of wire numbers and terminal block numbers in compliance with Division 16 and Section 17110.

4. UNIQUE DRAWINGS: Each control circuit, control loop, control panel layout design, motor control schematic, etc., shall be presented on a unique drawing. Control circuits, loop diagrams, and panel layouts referenced to typical diagrams are not acceptable.
5. SYMBOLS: Drawing symbol format shall comply with NFPA 79, ISA 5.1, ISA 5.3 and where appropriate, ISA RP 12.2.02.
6. RECORD DRAWINGS: Provide record drawings per Section 17839.
7. FORMAT: Drawings shall be prepared utilizing a computer based drafting program and shall be formatted as follows:

    a. SIZE: Hardcopy plots shall be 11-inch by 17-inch (half-size).
    b. TEXT: Minimum Text size: 0.125 inch for 22 x 34 inch drawings, 0.063 inch for 11 x 17 inch drawings.
    c. BOARDERS: Drawings shall have borders and title blocks identifying the Contract, facility, system, revisions to the drawing, and type of drawing.
    d. REVISIONS: Each release of a drawing shall carry a revision number, date, and a brief description of the changes. All changes associated with a given release shall be indicated on the drawing by a revision flag. Changes on the latest revision shall be indicated by clouding.
    e. CAD: Drafting software shall be AutoCAD 2008 or latter. Bind all x-refs.

8. FIELD EQUIPMENT TERMINALS: All schematics, diagrams, and drawings showing connections to field equipment shall provide correct terminal block numbers for the connections at the field equipment. This includes packaged system control panels, MCCs, stand alone motor controls, valve actuators, instruments, switches, etc. The contractor, subcontractors, and suppliers shall coordinate as needed to accomplish this.

B. ELEMENTARY AND LOOP DIAGRAMS: Provide elementary diagrams for all discrete loops. Loop diagrams shall be prepared in compliance with ISA S5.4 and shall be provided for all analog loops. Elementary diagrams and loop diagrams shall show circuits and devices of a system. These diagrams shall be arranged to emphasize device elements and their functions as an aid to understanding the operation of a system and maintaining or troubleshooting that system.

1. Provide complete elementary diagrams for equipment control.
2. Comply with NFPA 79.
3. Show wire numbers, color codes, signal polarities, and terminal block numbers. Tables for wire numbers, signal polarity, and terminal block numbers are not acceptable.

C. SCHEMATIC DIAGRAMS: Provide schematic drawings showing all control panel components, the interconnection of all control panel components, all field devices, and the connection of all field devices to control panels. Schematic diagrams shall also show all communications components, their interconnection, and their interface with other control panel components. Provide wire and terminal block numbers in compliance with panel work wiring, Section 17110.

D. PANEL FABRICATION AND ARRANGEMENTS DRAWINGS: Provide arrangement drawings of all panel front and internal-mounted instruments, switches, devices, and equipment indicated. All panel mounting details shall be shown. Outer dimensions of all panels shall be included on the drawing. Deviations from approved arrangements shall require Project Representatives approval prior to installation. Arrangement drawings shall be drawn to scale using standard Architectural or Engineering scales.

E. RECORD DRAWINGS:

1. Also referred to as as-built drawings.
2. SHOP DRAWINGS: All submitted drawings shall be updated over the course of the construction project to reflect the installations and equipment as-built. A full set of record drawings shall be provided to the Project Representative upon completion of the project and shall be included in the O&M manuals. Record drawing requirements shall be the same as submittal drawing requirements.
3. CONTRACT DRAWINGS: The contractor shall maintain a set of record plan and P&ID markup drawings on site during construction. The contractor shall mark up the record drawing set to indicate any and all deviations of the installed systems from the contract documents. The marked-up drawings shall be provided to the project representative at project close out.

F. Wiring Diagrams:

1. Panels: comply with NFPA79.
2. Show components of a control panel in an arrangement similar to the actual layout of the panel.
3. Show internal wiring between devices within the panel.
4. Show all terminal blocks whether used for internal or field wiring. Those used for field wiring shall be clearly identified as such.
5. Wiring diagrams shall indicate insulation color code, signal polarities, wire numbers, and terminal block numbers.

G. Interconnection Diagrams:

1. Submit complete interconnection diagrams for field wiring.
2. Show each panel and field devices.
3. Show wire numbers, cable numbers, panel numbers, and field device tag numbers.
4. Comply with NFPA79.

H. Certifications:

1. Temperature: Provide test data certified by the manufacturer to demonstrate that field electronic devices are suitable for the specified ambient temperatures.
2. Corrosion: Provide test data showing design features of the electronic equipment provided to protect against damage by the specified atmospheric contaminants and specific evidence that similarly protected electronic equipment has operated in similar environments for a period of not less than five years without failure due to corrosion.

1.8 SEISMIC DESIGN:

A. Procedure and submittals: per Section 16010.

B. Structures and equipment shall be braced to prevent damage from specified forces.

C. Equipment shall not be required to function properly during periods of seismic disturbance, but shall be capable of manual restart without repair or modification following a disturbance.

1.9 ACCEPTABLE CONTROL SYSTEM INTEGRATORS

A. SYSTEM EXECUTION PERSONNEL: The Control System shall be designed, constructed, and commissioned by full time or contract employees with a minimum of 5 years of experience and a minimum of one year with Integrator. The CSI shall configure and program all devices and equipment supplied to perform the functions indicated in the contract documents unless specifically noted otherwise. Engineering and programming services shall only be provided by staff members directly employed by the CSI. Contract labor is not acceptable for engineering and programming services.

B. RECOMMENDED INTEGRATORS: CSI's recommended for this project include the following companies.

1. Calcon Systems, San Ramon, CA
2. Total Process Systems, San Jose, CA
3. Or approved equal.

C. APPROVAL OF PERSONNEL AND ALTERNATES:

1. WITHHOLDING OF APPROVAL: The Contractor and the proposed CSI shall anticipate that the Project Representative may withhold approval of a proposed CSI or employee if, in the opinion of the Project Representative, the CSI or employee does not have the experience, capability, or an acceptable performance and execution record of similar projects in the past. No Contractor, CSI, or employee denied approval by the Project Representative shall be entitled to any extension of time or to any claim for damages related to any consequences resulting from the withholding of approval for any reason whatsoever. Applicable consequences may include but are not limited to associated extra or unanticipated costs, hindrances, delays, or complications of any kind.

D. REQUIREMENTS FOR ALTERNATES: The acceptability of a proposed alternate CSI will be determined solely by the Project Representative. The CSI shall be an instrument and control system manufacturing company that conforms to the following requirements:

1. LOCATION: The CSI's manufacturing and assembly facility shall be located within 150 mile from the job site.
2. SPECIALTY: The CSI shall be specialized in the design, assembly, testing, installation, programming, commissioning, and service of municipal control and communication systems in the Bay Area for at least five years.
3. EMPLOYEE EXPERIENCE: The CSI shall employ technicians and engineers with documented experience in the design, assembly, testing, installation, operation, calibration, trouble-shooting, service, and repair of control and communication systems for municipal waterworks and sewerage facilities.
4. SIMILAR EXPERIENCE: The CSI shall have completed the design, assembly, testing, installation, and commissioning of control systems which include the instruments, components, equipment, and devices cited on the Plans by specific manufacturer's name.
5. SPARE PARTS STOCK: The CSI shall maintain a stock of spare parts for the instruments and devices cited on the Plans by specific manufacturer's name.
6. ALTERNATE SUPPLIER INFO: Prior to placement of purchase orders for services and equipment, the Contractor shall provide the following information about a proposed alternate CSI:

a. COMPANY INFO: Description of ownership and organization of Integrator.
b. RESUMES: Resumes of principals and/or key employees who will be working directly in the engineering, design, assembly, testing, and commissioning of the system for this project.
c. EXPERTISE: Description of expertise in design, assembly, testing, and installation of control systems for municipal waterworks and sewerage facilities.
d. PROJECT RESUME: Description of municipal control systems designed, assembled, and installed in the last five (5) years. Description shall include:

    1) Names of employees involved in each system.
    2) Detailed description and drawings of each system.
    3) Cost of each system.
    4) Names and telephone numbers of persons involved in operation and maintenance of each system.

e. SERVICE: Description of the service capabilities normally provided by the company including resumes of employees assigned to field service and listing of service equipment.
f. SPARE PARTS: Description of spare parts normally stocked and of restocking procedures.
g. ADDITIONAL INFO: Additional information that may assist the Project Representative in ascertaining the company's general ability to perform the work.
h. WARRANTY: Written agreement to the warrantee service terms of the contract documents.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. PRODUCTS: All products provided by the CSI shall be manufactured to comply with the listing requirements identified in Part 1 and other requirements as indicated in the Contract. System components shall be commercial, off-the-shelf components to the maximum extent possible. Custom designed or manufactured components shall require Project Representative’s approval.

2.2 MATERIALS

A. GENERAL: Material shall be new, free from defects, and of the quality specified. All equipment and materials utilized in the system shall be the products of Manufacturers with at least five (5) years experience in the manufacture of similar equipment. Similar items in the system shall be the products of the same Manufacturer. All equipment shall be of industrial grade and of standard construction, shall be capable of long, reliable, trouble-free service, and shall be specifically intended for control and monitoring of operation of motor-driven pumps and process equipment. All equipment shall be of modular design to facilitate interchangeability of parts and to assure ease of servicing.

B. ELECTRONIC COMPONENTS: Unless otherwise specified, electronic equipment shall be of solid-state construction. Components of standard electronic assemblies shall not be replaced with

components of different characteristics in order to meet the performance requirements of the specification. Parts shall be as shown in the instruction manuals and shall be replaceable with standard commercial components of the same description without degrading the performance of the completed assembly.

2.3 INSTRUMENTS

A. INSTRUMENT SCHEDULE: Application requirements are specified in the Instrumentation Schedule, individual specification sections, and/or on the drawings. The Instrumentation Schedule lists major instruments required to implement the process instrumentation and control systems. Instruments listed with equipment specification number references other than Division 17 shall be supplied by equipment suppliers. All instrument functions specified on this list with Division 17 specification references shall be provided by the CSI. Any additional instruments or devices required to complete the instrument loops because of unique characteristics of the particular equipment selected by the CSI (such as isolation I/Is) shall be provided. Such additional instruments shall be considered incidental to the contract and shall be provided and included in the original contract price even when not specified in the instrument index or on the contract drawings.

2.4 SPARE PARTS

A. In addition to spare parts mentioned elsewhere in Division 16 & 17 specification sections, the CSI shall supply the following spare parts for use by the Owner:

1. Qty 1 Relay of each type used or 10%, whichever is the greater amount
2. Qty 10 lamps of each type used or 100%, whichever is the greater amount.
3. Qty 200% spare fuses, two spare fuses for each type of fuse supplied minimum

PART 3 - EXECUTION

3.1 DESIGN AND ASSEMBLY

A. GENERAL: With the exception of any packaged equipment control systems, the supplied control systems shall be designed by the CSI per paragraph 1.6. The supplied control system shall be completely assembled in the shop of and by the CSI. All components and equipment shall be prewired to the maximum extent possible.

B. INTEGRATION: The CSI shall determine all requirements for and shall cause integration of the supplied control systems, MCCs, and any supplied packaged equipment control systems into a complete and unified system. The CSI shall be responsible for the coordination and integration of the supplied control system with motor controls and other related equipment.

C. REVIEW OF SUBMITTALS: The CSI shall be directly responsible to obtain submittal information on related equipment supplied by others and to integrate this information as required with the overall control system to form a complete working package.

D. COORDINATION: The CSI shall communicate directly with the Manufacturer(s) and Supplier(s) of all related equipment to determine all details of the equipment that may influence or affect the supplied control system components. The CSI shall make any and all adjustments or revisions required to integrate the submitted equipment into the job at no additional expense to the owner and with no extension of the schedule.

3.2 DELIVERY, STORAGE, AND HANDLING

A. Shipping:

1. Anchor, brace, and protect equipment during shipping handling.
2. No internal wiring shall be disconnected for transportation.

B. Delivery Inspection: Notify the Project Representative and provide access for inspection upon arrival of any material or equipment to be incorporated into the work. Remove protective covers when required.

C. Supplied Control Panels:

1. Completely wired and tested in the factory prior to being shipped to the job site.
2. Shipped as a single unit to job site after testing is complete.
3. No internal wiring shall be disconnected for transportation.

3.3 INSTALLATION

A. GENERAL

1. INSTALLATION BY CONTRACTOR: The control system and associated instruments and connections shall be installed by the contractor.
2. INSTALLATION INSTRUCTIONS: The control system shall be installed in accordance with the installation drawings and instructions provided by the CSI, packaged system suppliers, and other equipment suppliers.
3. SUPERVISION: The CSI's instrumentation and controls project engineer shall supervise and coordinate all activities related to the installation of Division 17 requirements.
4. EXPERTISE OF INSTALLER: Installation shall be performed by the workers who are skilled and experienced in the installation of electrical instrumentation and control systems. Installation shall include all elements and components of the control systems and all conduit and interconnecting wiring between all elements, components, sensors, valve operators, etc.
5. LOCATION: Equipment shall be located so that it is readily accessible for operation and maintenance.
6. INSTRUMENT TECHNICIAN: The CSI shall provide the services of skilled instrument technicians for testing, calibration, and adjustment activities per 17804.

B. SIGNAL CONNECTION AND TRANSMISSION:

1. Unless otherwise specified, analog signal transmission between electric or electronic instruments not located within a common panel shall be 4 to 20 milliamperes and shall have a loop compliance of at least 500 ohms.

2. Two-wire loop transmitters shall operate at 24 VDC.
3. Unless otherwise shown, milliampere signals from the field shall be converted to 1 to 5 VDC signals at the field terminal block of each panel. Conversion error shall not exceed 0.1%. All instruments within a panel shall be parallel wired with 1-5 VDC signals.
4. Loops shall be grounded at the field terminal block by bonding to the instrument panel signal ground bus. Separate grounded conductors shall be provided for each loop. Daisy chaining of grounded conductors from one loop to another is not allowed.
5. Provide isolating amplifiers for field equipment possessing a grounded input or output, or having a common mode voltage other than system ground.
6. Convert high frequency (greater than 50 Hz) pulse rate signals from field transmitters to analog 1- 5 VDC signals at the panel.
7. Convert platinum resistance temperature detector (RTD) outputs to 4-20 milliampere signals at the RTD, or where shown on the Drawings. The temperature milliampere signal may be brought from the field to the panel and converted to a 1-5 Volt DC signal.
8. All other transmission systems, such as impulse duration, low frequency pulse rate, and voltage regulated, will not be permitted. When transmitters with non-standard outputs are specified, their output shall be converted to 4 to 20 milliamperes at the field instrument.
9. Equipment located in classified areas shall be explosion-proof or intrinsically safe. Provide intrinsic safety barriers approved by UL, CSA, or FM.

C. TAGGING: All field devices shall be labeled with tag number indicated in the bid documents or consistent with project tagging conventions when not shown in the bid documents. Comply with project naming and numbering conventions. Tag shall be 10ga, 316 stainless steel with stamped letters and numbers attached to device with 12ga, 316 stainless steel wire.

D. FIELD EQUIPMENT:

1. INSTALLATION: Equipment shall be provided as specified on the drawings such that ports and adjustments are accessible for in-place testing and calibration. Where possible, equipment shall be located between 48 inches and 60 inches above the floor or a permanent work platform. Instrumentation equipment shall be mounted for unobstructed access, but mounting shall not obstruct walkways. Equipment shall be mounted where shock or vibration will not impair its operation. Support systems shall not be attached to handrails, process piping or mechanical equipment except for measuring elements and valve positioners. Instruments and cabinets supported directly by concrete or concrete block walls shall be spaced out not less than 5/8 inch by framing channel between instrument and wall.
2. SUPPORT SYSTEMS: Steel used for support of equipment shall be hot-dip galvanized after fabrication. Support systems including panels shall be designed in accordance with the applicable building code and seismic zone and shall prevent deformation greater than 1/8 inch under the attached equipment load and an external load of 200 pounds in any direction.

E. Electrical Power Connections:

1. DIVISION 16: Electric power wiring and equipment shall be in compliance with Division 16.
2. DISCONNECT SWITCHES: Power disconnect switches shall be provided within sight of equipment and shall be labeled to indicate opened and closed positions and specific equipment served. “Within sight of” is defined as having a clear unobstructed view from the equipment served and within 50 feet of the equipment served. Disconnect switches shall be mounted between 36 inches and 72 inches above the floor or permanent work platform. Where equipment location is such that the above requirements cannot be met by a single

disconnect switch, two switches, one at the equipment and one at the work platform, shall be provided.

3. SURGE ARRESTORS: Each disconnect switch serving equipment located outdoors shall be provided with a surge arrestor, General Electric 9L15CCB001, or equal. The surge arrestor shall be bonded to the plant ground grid with a No. 8 AWG bare copper conductor.
4. CONTROL PANELS: All control panels shall be provided with a main power disconnect equipped with auxiliary contacts as required to disconnect all power sources to the panel or shall be labeled to indicate the multiple power sources not disconnected by the main disconnect. Field wiring for all power sources not disconnected by the main disconnect shall land on fused disconnect type terminal blocks.

3.4 TESTS AND INSPECTIONS:

A. Per Section 17804

3.5 CALIBRATION, START-UP, AND COMMISSIONING:

A. Per Section 17804

3.6 SYSTEM MAINTENANCE AND WARRANTY

A. CSI SOLELY RESPONSIBLE: The CSI shall be solely and completely responsible for all maintenance of control systems they supply from time of installation to the date of substantial completion of all work under the contract. The CSI shall correct all deficiencies and defects and make any and all repairs, replacements, modifications, and adjustments as malfunctions or failures occur. The CSI shall perform all such work required or considered to be required by the owner to properly maintain the system.

B. DEFECTS AND REPAIRS: The CSI shall make any and all repairs, replacements, modifications, and adjustments required to eliminate any and all defects in design, materials, and workmanship which are discovered within the one year guarantee period. The CSI shall begin all repairs, replacements, modifications and adjustments within twenty-four (24) hours of notification by telephone by the owner and shall complete such repairs, replacements, modifications and adjustments within forty-eight (48) hours of notification.

C. ACCEPTANCE OF WORK: The CSI shall anticipate that the Owner may delay acceptance of all work under the contract if, in the judgment of the Owner, malfunctions or failures in operation of the supplied control system repeatedly occur after start-up to an unacceptable extent. The CSI shall not be entitled to an extension of time or to any claim for damages because of hindrances, delays, or complications caused by or resulting from delay by the owner in accepting the work because of malfunctions or failures in operation of the supplied control system.

D. PACKAGED SYSTEMS: Packaged system suppliers shall provide warranty support meeting the above stated requirements for their supplied systems.

3.7 OPERATION AND MAINTENANCE DATA

A. O&M MANUALS: The CSI shall prepare and assemble six (6) sets of operation and maintenance (O&M) manuals in accordance with the project general requirements and Paragraph 1.3 of this section. These manuals shall be submitted two weeks prior to training. O&M manuals shall include, but not be limited to, the following:

1. Trouble-shooting procedures
2. Calibration procedures
3. Testing procedures
4. Component replacement procedures
5. Preventative maintenance procedures
6. Listing of recommended spare parts
7. Listing of recommended maintenance tools and equipment
8. Catalog data for all equipment and devices supplied, organized per submittal requirements
9. Configuration, setup, and programming manuals for all programmable devices supplied including PLC, VFD, instruments, etc.
10. Communication channel test forms
11. Calibration and test forms for all field switches, instruments, PLC IO, VFD IO, etc, per Section 17804
12. Configuration files for all configurable or programmable electronic devices and equipment supplied for this project
13. Application software program documentation for all programs and configurations developed or supplied by the contractor for this project
14. System user's manual covering all functions supplied by the contractor for this project as described below

B. RECORD DOCUMENTS: All contract P&ID drawings and control strategy specification sections and all submittal drawings shall be revised to reflect as-built conditions at the end of the project. Record drawings and documents shall be submitted in accordance with the project general requirements and Paragraph 1.3 of this section. Record drawings and documents shall be submitted with the O&M manuals. Record drawings and documents shall include the following:

1. Shop drawings per 1.7 of this section.
2. Wiring diagrams of cabinet and enclosure contained assemblies
3. Wiring diagrams of all system connections and interconnections including all loops, field equipment, communications interfaces, networks, etc.
4. All other submitted shop and installation drawings and details not listed
5. Bill of Material
6. Contract P&ID drawings
7. Contract control strategy specification sections

3.8 SYSTEM USERS MANUAL

A. SCOPE: The CSI shall develop and submit a detailed user manual covering all aspects of the operation and use of the components and systems they supply. The manual shall cover the following

1. OVERVIEW: An overview of the architecture of the control system including control panels, MCC's, field devices, PLC, OIT, SCADA, data historian, remote alarm notification, communications, networks, remote access, etc.
2. FUNCTIONS: All hardware/hardwired, programmed, manual, automatic, display, control, alarming, communications, networking, etc. features and functions of the systems and components they supply.
3. HARDWIRED ELEMENTS: Descriptions of the meaning and function of all hardwired panel, MCC, and field mounted discrete operator interface monitoring and control devices. Correlate functions to the control strategies.
4. PROGRAMMED ELEMENTS: The presentation and use of all elements of all OIT and SCADA HMI screens provided by the contractor for this project. Relate to control strategies. Include screen shots of all screens provided by the contractor with narrative descriptions of use, function, meaning, color conventions, animation, etc., of all screen elements.
5. TAG LISTS: PLC, OIT, SCADA, remote alarm notification system, and process data historian tag data base lists.
6. CONFIGURATION SETUP: Configuration screens for all PLC, OIT, SCADA, historian, remote alarm notification, communications, and network system components.
7. Network schema: Provide IP address listing
8. SECURITY: System, application, data base, remote access, etc., security. Provide all configured user and administrator user names and passwords.
9. START UP: System start up procedures for SCADA systems supplied and configured by the contractor for the project.

B. USED IN TRAINING: The system users manual shall be completed prior to and shall be used for required training. The manual shall be updated to incorporate comments received during training and re submitted for inclusion in the O&M manual. Submit 2 weeks prior to training.

C. PACKAGED EQUIPMENT: Packaged equipment suppliers shall supply user's manuals per the above requirements for the systems they supply.

D. THIRD PARTY PROGRAMMING: Third parties other than the contractor or packaged equipment suppliers who provide PLC, OIT, SCADA, or other programming shall provide users manuals for the programming they provide.

3.9 TRAINING

A. GENERAL: The CSI shall conduct specifically organized training sessions to educate and train the owner's personnel in the maintenance and operation of all aspects and components of the control system they supply. Training on all system components shall include, but not be limited to, the following subjects:

1. All O&M manual items
2. All system users’ manual items

B. TRAINING SESSIONS: The CSI shall provide a minimum of 16 hours of on-site instruction to the owner's employees after start-up and commissioning of the system. The owner shall be allowed to video tape all or any part of the training sessions. The CSI shall prepare and assemble specific instruction materials for each training session and shall supply such materials to the Project

Representative at least two (2) weeks prior to the time of the training. The O&M manuals and the system users' manual shall be complete and shall be used in the training sessions.

C. VFD TRAINING: Training shall cover details of operation of VFD's from the HIM (Human Interface Module). Training shall provide detailed instructions on the modification of VFD operating parameters typically requiring adjustment by operators. The contractor shall develop and provide "cheat sheets" which provide step by step instructions required to accomplish the following:

1. Copy VFD configuration to HIM
2. Copy HIM configuration to VFD
3. Switch between auto and manual modes
4. Manually adjust speed
5. Adjust minimum and maximum speed limits
6. Adjust acceleration and deceleration ramp times
7. Access parameters and fault codes

END OF SECTION 17010

SECTION 17110

PROCESS CONTROL PANELS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for panels for instrumentation and communication equipment. Additional requirements are specified in sections specifying the various instrumentation and communication systems.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.

1. Section 17010: Instrumentation and Control Systems.

C. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below.

1.	FED STD 595A	Federal Standard Colors
2.	IEC 60947-7-1	Low Voltage Switchgear and Control gear - Terminal blocks for copper conductors
3.	NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
4.	NFPA 79	Electrical Standards for Industrial Machinery
5.	UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
6.	UL 508A	Industrial Control Panels

B. Listing:

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special

inspection at the manufacturer's place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.3 SUBMITTALS

A. Per Section 17010

B. Dimensioned front view drawings

C. Dimensioned internal equipment layout drawings

D. Panel assembly drawings shall include sections showing clearances between face and rear mounted equipment with items keyed to the bills of materials

E. Nameplate engraving schedule showing engraving by line, character size, and nameplate size

F. Enclosure manufacturers' drawings

G. Panel seismic calculations

H. Panel wiring diagram for each panel. The diagram shall meet the requirements as set forth in the NFPA 79 Electrical standards for industrial machinery.

I. Calculations of percentage wire fill for wire ways including factory wiring and allowance for field wiring

J. Panel load calculations

K. UPS hold up time calculations

1.4 DESIGN REQUIREMENTS

A. Enclosures shall be limited to the following NEMA 250 types:

1.	NEMA 12	Control rooms, switchgear rooms, MCC rooms
2.	NEMA 4X SS	All other locations and applications except outdoor
3.	NEMA 7D	Classified Locations
4.	NEMA 3R/12	Outdoor locations

B. Panel Design:

1. No panel mounted operator interface devices, such as selector switches, will be mounted greater than 72" or less than 36" above the finished plant floor, with the exception of annunciators.

2. No panel mounted instruments, such as recorders, will be mounted greater than 66” or less than 40” above the finished plant floor, with the exception of the annunciator panel as described below.
3. Panelboards: each panel containing 120-volt powered equipment with an aggregate load greater than 1200 watts shall be provided with a panelboard per Section 16470.
4. Annunciators: Annunciators shall not be mounted with the top frame in excess of 90” above the finished plant floor.
5. Power supplies:

    a. The control panels shall contain a dual redundant DC power supply system.

6. Touch screen operator interface panels and panel mounted computers shall be mounted at 60” AFF to the center of the screen.

C. Labeling:

1. Panels shall be manufactured and labeled in accordance with UL 508A and shall bear the UL label.
2. Design shown on Drawings is functional in nature and is for reference and shall be altered as required to make the panels UL 508A compliant.

PART 2 - PRODUCTS

2.1 MATERIALS AND QUALITY

A. General:

1. Panel work shall be designed for seismic requirements per Section 016100.
2. Cutouts for future equipment shall be blanked off with suitable metal covers.
3. Instrument tag numbers shall be identified on the panel rear.
4. Nameplates shall identify face-mounted instruments.
5. Instruments shall be mounted in a manner that allows ease of access to components and ease of removal.
6. Face-mounted instruments that are more than six inches deep, weigh more than 10 pounds, or exert more than a 4 ft-lb moment force on the face of the panel shall be supported underneath at the rear by a 1-inch x 1/8-inch thick steel angle.
7. Face-mounted equipment shall be flush or semi-flush with escutcheons.
8. Floor mounted cabinets without touch screen operator interface panels or panel mounted computers that are less than 60 inches high shall be provided with floor stands to raise the top of the panel to at least 60 inches above the floor or work platform. Wall mounting may be used in lieu of a floor stand if panel weighs less than 100 pounds and wall space is available.
9. Panels with touch screen operator interface or panel mounted computers shall be configured and installed so that center of screen is 60” AFF.

B. Fabrication of NEMA Type 12 Industrial Use, Indoor Cabinets with Front Doors:

1. Enclosure fabricated from 16-gauge minimum thickness sheet steel for enclosures smaller than 24"x24", and 14-gauge minimum for larger enclosures. Face-mounted instruments shall be mounted in the door.
2. Interior frame or otherwise formed so as to provide a rigid structure
3. Doors shall be hung on full-length continuous (piano-type) hinges and equipped with vault-type latch capable of accepting a 3/8-inch-shackle padlock
4. Three-point latch hardware shall be provided for doors exceeding 48 inches height. Door width shall not exceed 34 inches.

C. Fabrication of NEMA Type 4X Cabinets:

1. NEMA 250, Type 4X requirements
2. Fabricated from 14 gauge (minimum thickness) Type 316L stainless steel (or fiberglass when specifically specified) and provided with an interior frame or otherwise formed to provide a rigid structure.
3. Where face-mounted instruments are specified mount on an interior sub-panel
4. Doors:

    a. Vault-type latch and, if greater than 48 inches high, three-point latch hardware
    b. Latch shall accept a 3/8-inch shackle padlock.
    c. Unless shown otherwise, door width shall not exceed 36 inches.

5. For cabinets located outdoors, equip with rain and sun shields

D. Fabrication of NEMA 7D Cabinets: NEMA 250, Type 7 suitable for Class 1, Division 1, Group D classified area and assembled and installed to maintain this rating.

E. Outdoor, Door-in-Door Cabinet: NEMA 250, Types 3R and 12 requirements except dust test. Cabinet shall be force-ventilated and provided with a sun shield. Cabinet shall be fabricated from 1/8-inch minimum thickness sheet steel and shall be provided with an interior frame or otherwise formed to provide a rigid structure. Where face-mounted instruments are specified, they shall be mounted on an interior hinged subpanel arranged to swing completely out of the enclosure. Hinges shall be full-length piano-type. Door and subpanel shall be provided with vault-type latch and, if greater than 30 inches high, three-point latch hardware. Door latch shall accept a 3/8-inch shackle padlock. Door width shall not exceed 36 inches.

2.2 HEATING AND VENTILATING

A. Cooling shall be provided to maintain the internal panel temperature below 104 degrees F (40 °C) when all equipment is operating at its maximum heat load and the ambient temperature is 86 degrees F (30 °C). Filtered forced air ventilation shall be provided for NEMA 12 cabinets and either closed glycol loop heat exchange system or a mechanical refrigeration system for NEMA 4X and NEMA 7 enclosures.

B. Fans shall be equipped with UL-approved washable filters and provide at least 240 CFM. Noise level at three feet from exterior wall and 30 degrees off axis shall not exceed 60 db.

C. Outdoor or below grade cabinets shall not be insulated and shall be provided with thermostatically controlled space heaters.

D. Heater wattage shall to maintain the air temperature inside the cabinet above the dew point or 50 degrees F (10 °C), whichever is higher, at all times.

E. If space heater surface temperature exceeds 122 degrees F (50 °C), an expanded metal guard shall be provided.

F. When a strip type heater is used, the heater shall be a 240 VAC heater and connected to 120 VAC and sized to produce the required heat at 120 VAC.

G. Thermostat Acceptable Manufacturer:

1. Honeywell T631B1013
2. Penn Controls A28AA-4
3. Approved equal

2.3 NAMEPLATES

A. Machine engraved laminated white phenolic nameplates with black lettering shall be provided for panel mounted equipment.

B. Nameplate engraving shall be as specified and shall carry the instrument tag number in 3/32-inch (2.4 mm) minimum size lettering on the bottom line, or engraved as shown on the Drawings.

C. Nameplates shall be attached to the panel with a minimum of two self-tapping 316 stainless steel screws.

D. Wording may be changed if changes are made prior to commencement of engraving.

E. Machine-printed laminated adhesive labels shall identify tag number of instruments and equipment inside panels.

F. Attach nameplates and labels to panel surfaces, not to instruments.

G. Machine embossed, adhesive backed nameplates shall identify the tag number of equipment inside cabinets.

2.4 INTERCONNECTION WIRING AND ELECTRICAL DEVICES

A. Interconnection Wiring:

1. Power, control, and signal wiring inside panels:

a. Conductor insulation shall be rated for 600 volts and 90 degrees C in dry locations.

b. All conductors shall be stranded copper.
c. Power and control conductors in panels shall have insulation type MTW, minimum 16 AWG.
d. Wiring for instrumentation analog signals shall be minimum 18 AWG; aluminum foil twisted shielded pairs, Belden type 8760, or approved equal. Wiring for instrumentation analog signals shall be run continuously from measuring instrument to control cabinet terminal strips without splices.
e. Conductor size vs. fuse rating for conductors inside panels shall be as follows UNO:

18 AWG	<1 AMP
16 AWG	5 AMPS
14 AWG	15 AMPS
12 AWG	20 AMPS

2. Support wiring independent of terminations by slotted flame retardant plastic wiring channels
3. Wiring channels shall comply with UL94, Type V. Wiring channel fill shall not exceed 40 percent.

B. Wire Naming and Tagging

1. Wiring shall be tagged at terminations with machine printed plastic sleeves.
2. Wire numbers shall consist of three parts, or as shown on the Drawings.
3. Unless shown otherwise, the prefix of the wire number shall be the instrument loop number.
4. If an instrument loop number is not available, the lowest mechanical equipment number of all final drives in the circuit shall be used.
5. Following the prefix shall be a code letter. The third part of the wire number shall be a number that identifies wires in a circuit that are electrically identical.
6. Label each control and instrumentation wire as follows:
   LLL-CC-NNN, Where:
   LLL = equipment, panel or loop number
   CC = wire code from table
   NNN= wire number

C. Color Coding

1. Color coding of wires within control panels shall be as follows (subject to restriction by UL 508A):

WIRE COLOR CODES				
Code	Type	Color	Use	Volts
S1	TSP	BLACK	SIGNAL (+)	5-24 VDC
S2	TSP	WHITE or CLEAR	SIGNAL (-)	5-24 VDC
SG	TSP	BARE	SHIELD DRAIN	5-24 VDC
S1	TRIAD	BLACK	SIGNAL	0-24 VDC
S2	TRIAD	WHITE	SIGNAL	0-24 VDC
S3	TRIAD	RED	SIGNAL	0-24 VDC
SG	TRIAD	BARE	SHIELD DRAIN	0-24 VDC
24P	SINGLE	BLUE	POWER (+)	24 VDC

24C	SINGLE	WHITE/BLUE	COMMON (-)	24 VDC
D	SINGLE	BLUE	CONTROL	24 VDC
125P	SINGLE	BLUE	POWER	125 VDC
125C	SINGLE	WHITE/BLUE	COMMON	125 VDC
B	SINGLE	BLUE	CONTROL	125 VDC
L	SINGLE	BLACK	POWER	120 VAC
N	SINGLE	WHITE	NEUTRAL	120 VAC
C	SINGLE	BLACK	CONTROL	120 VAC
PG	SINGLE	GREEN	POWER GND	EARTH GND
SG	SINGLE	GREEN/YELLOW	SIGNAL GND	EARTH GND
UL	SINGLE	BLACK/WHT	UPS POWER	120 VAC
UN	SINGLE	WHITE/GREY	UPS NEUTRAL	120 VAC
EX	SINGLE	YELLOW	EXTERNAL	120 VAC
EXN	SINGLE	WHITE/YELLOW	EXTERNAL NEUTRAL	120 VAC GND'D
A	SINGLE	BLACK OR BLUE	ANNUNCIATOR	120 VAC/24VDC
IO	SINGLE	BLACK OR BLUE	ISOL I/O	120 VAC/24VDC
R	SINGLE	BLUE	RTU	12 VDC
IS	SINGLE	LIGHT BLUE	INTRINSIC SAFE	<12 VDC

2. Power and control wiring shall be carried in covered wiring channels separate from low voltage analog signal circuits.
3. All control wiring in control panels or other enclosures that is powered from an external source and is not disconnected by the control panel disconnect shall be terminated at a disconnecting terminal block (with energization indicator light upon entering the enclosure.) The color of the wire shall then be changed to yellow to identify it as being powered from an external source. Provide identification nameplate on exterior of enclosure to indicate sources of external power.

D. Terminal blocks and accessories:

1. UL listed
2. DIN rail mounted. Compliant with IEC 60947-7-1
3. Compression clamp type terminal rated for 600 volts and 30 Amperes
4. 22 AWG to 12 AWG copper wire size range
5. Mark using marker carrier and preprinted marker bars for the terminal numbers
6. Acceptable manufacturers:

    a. Entrelec Series: Typical Entrelec catalog numbers are the following:

        1) Terminal Block: Type MS 4/6
        2) Switch Block: Type M 4/6.SNT
        3) Fuse Block: Types M 4/8.SFL, M 4/8.SFD, M 4/8.SFD1

    b. Phoenix Contact Series UK IEC Terminal Blocks
    c. Allen-Bradley Series 1492 IEC Terminal Blocks
    d. Approved equal

7. Field connections shall be to separate terminal blocks. Terminal blocks for field terminations shall be in a separate part of the panel close to where the field cables enter the panel.
8. External circuits shall be fused. Fuses shall include blown fuse indicator lamps.
9. Comply with UL 508A requirements in construction.

2.5 PANEL GROUNDING

A. Each panel shall be provided with two copper ground bars. One bar shall be bonded to the panel frame or sheet metal and to the station ground system. The second (signal) ground bar shall be mounted on insulated stand-offs and shall be bonded to the frame ground bar at one point only.

B. Signal circuits, signal cable shields, and low-voltage DC power supply commons shall be bonded to the signal ground bar.

C. Surge protectors and separately derived AC power supplies shall be bonded to the frame ground bar.

2.6 FUSES

A. Circuits shall be fused. Fuses shall be 1/4 x 1-1/4 inch. Fuses on 120V AC circuits shall be ceramic tube type with 25,000 amperes interrupting capacity at 125 volts and neon blown fuse indicator lamps. Fuses for 24V DC circuits shall be fast acting glass tube type rated 1/8 or 1/10 amp for 4-20 mA loops and 1/2 amp for the power supply to individual instruments. Fuse holders for 120V AC shall be drawout type and molded from melamine plastic.

2.7 SURGE PROTECTION

A. Surge Protection: Per section 17130

2.8 PANEL LIGHT, SWITCH, AND CONVENIENCE OUTLET

A. Provide a light with a door actuated switch in control panels that contain a PLC rack , relays, or other equipment that would require troubleshooting or operator access for normal operation. Provide a duplex outlet, 120VAC 15A, in all panels that require a computer or other maintenance tools that may need a power source. These shall be on a separate dedicated circuit.

2.9 PANEL DISCONNECT SWITCH

A. All control panels shall be provided with a main power disconnect switch. Label panels with multiple power sources and identify power sources.

PART 3 - EXECUTION

3.1 GENERAL

A. Wired as shown on the wiring diagrams.

B. Control room cabinets:

1. Mount on channel iron sills as specified.
2. Sills shall be leveled so panel structures will not be distorted.
3. Panels shall be shimmed to precise alignment so doors operate without binding.
4. Sealant shall be provided under panels not located in dry control or electrical equipment rooms.
5. Floor-mounted cabinets except in dry control rooms or electrical equipment rooms shall be mounted on 3-1/2-inch minimum height concrete pads or grouted bases as specified
6. Mount record drawings for wiring, connection and interconnection diagrams behind a piece of Plexiglas on the inside of one (or more) door(s).

C. Terminals and terminal blocks shall be sprayed with a silicone resin, similar to Dow Corning R-4-3117 conformal coating, after all terminations have been completed.

3.2 COATING

A. Except for stainless steel and fiberglass panels, all panels and cabinets shall be painted inside and out. Exterior finish shall be an enamel meeting ANSI 61 gray. Interior panel finish shall be an enamel meeting Federal Standard 595: 27880 white.

B. Treat cutouts to prevent corrosion.

END OF SECTION 17110

SECTION 17130

POWER SUPPLY AND CONDITIONING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for power supply and conditioning equipment required to power instrumentation and communication devices and systems.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.

1. Section 17010: Instrumentation and Control Systems.

C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete.

D. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below. In case of conflict between the requirements of this Section and those of the listed documents, the more stringent requirements shall govern.

1.	NFPA 70	National Electrical Code (NEC)
2.	UL 1012	Power Units other than Class 2
3.	UL 1283	Electromagnetic Interference Filters
4.	UL 1449	Transient Voltage Surge Suppressors

B. LISTING

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer’s place of assembly or as a completed assembly in the

field. All costs and expenses incurred for such inspections shall be included in the original contract price.

C. Labeling: power supply equipment shall bear a UL or other label acceptable to the inspection authority having jurisdiction for the specified application.

1.3 SUBMITTALS

A. Product data.

1.4 PLANT ELECTRICAL SUPPLY SYSTEM

A. Electric power for instrumentation and communication systems shall be obtained from the power distribution system specified in Division 16. This power is not regulated, waveforms may be distorted, and significant amounts of electrical noise may be present.

B. Unless otherwise specified, provide all necessary power supply and conditioning equipment for all required voltages and current capacities and of adequate quality to ensure reliable operation of the instrumentation and communication systems.

C. Unless otherwise specified, assume that the power supply for instrumentation systems is 120 volts plus or minus 15 percent, 60 hertz plus or minus 3 hertz, and 5 percent harmonic distortion.

PART 2 - PRODUCTS

2.1 GENERAL

A. Except for power supply units that form an integral part of an individual piece of equipment:

1. Comply with UL 1012.
2. Approved by UL, CSA, or FM for the application.

B. Power supply equipment serving multiple instrument loops shall be provided in hot-standby configurations such that failure of a single unit will not disable all or any part of the instrumentation and communication systems.

C. Provide diode isolation for redundant direct current supply units.

D. Connect the DC power supply negative output terminal to the signal ground bus at a single point.

2.2 DIRECT-CURRENT POWER SUPPLIES

A. Dual (Redundant) DC Power Supply:

1. UL labeled, regulated redundant power package with the following features:
2. Dual and identical DC power supplies
3. Dual (redundant) isolation diodes or "N+1" redundant design allowing forced current sharing among individual supplies
4. Barrier block terminals for all wiring connections
5. Connections for two 120 VAC power sources
6. 24 VDC output voltage with accessible adjustment for a minimum of plus or minus 0.5 volts; floating output
7. Output voltmeter and output ammeter for each internal power supply
8. Control for automatically selecting one of the two power supplies as master
9. SPDT (minimum) alarm contact for external alarm circuit tripped for power supply failure
10. Line regulation: shall not exceed plus or minus 0.05 percent for line voltage variation from 93 to 132 volts
11. Load regulation: full load and no load shall not exceed plus or minus 0.05 percent.
12. Ripple shall not exceed 15 mV rms.
13. Electronic current limiting to provide short circuit protection and recovery on the output.
14. Enclosure: 19-inch rack mount or wall-mount enclosure suitable for locating on mounting panel inside a control panel
15. Automatic adjustable output over-voltage shutdown with alarm and over-temperature protection shall be provided. EMI filtering of both AC input and DC output shall be provided.
16. Output current: Output current rating shall provide 50% spare capacity at peak load.
17. Acceptable manufacturers:

    a. Acopian Series RWL24
    b. Kepco series MST
    c. Lambda series ZUP
    d. Approved equal

2.3 UNINTERRUPTIBLE POWER SYSTEM (UPS)

A. UPS shall provide continuous duty protection and complete power conditioning. UPS shall consist of a power conditioner, a battery charger, a battery, an inverter, system control, and a surge suppression network. UPS shall be UL or CSA labeled and shall meet IEEE 587-80 standards. UPS capacity shall be a minimum of 150% of full load. UPS shall provide the following functions and features:

1. Performance when the power line is absent:

    a. Output voltage: 120VAC ± 3%, sinewave
    b. Total harmonic distortion: 5% maximum
    c. Battery: Provide sufficient batteries for 20 minutes of full load operation

2. Performance when the power line is present:

    a. Input voltage range: 120V ± 20%
    b. Total harmonic distortion: 2% maximum added to incoming line distortion

c. Surge protection: Per ANSI C62.41-80 (6000V peak, 500 nanosecond rise time, 100kHz damped ring wave)
d. Output regulation band: +6% to -8% of nominal for all conditions of line and load
e. Correction time: 2 cycles maximum
f. Common mode noise attenuation: 100dB at 100 kHz
g. Normal mode noise attenuation: 70dB at 100 kHz
h. Efficiency: 93% minimum
i. Transfer time AC line to inverter: 4 milliseconds maximum
j. Transfer time inverter to AC line: No interruption
k. Transfer points power conditioning to inverter: -8% or +6% of nominal voltage
l. Transfer points inverter to power conditioning: -11% or +13% of nominal voltage
m. Input Frequency tolerance: ±5%
n. Load Power Factor: 0.9 leading to 0.9 lagging, linear load, 0.6 non-linear load
o. Operating Temperature: -29 to +40 degrees C

3. Acceptable Manufacturers:

a. APC
b. Topaz
c. Approved equal

2.4 SURGE PROTECTION

A. For protection against line generated transients for both normal and common mode protection: The unit shall be a non-degrading, solid state, series low pass filter with transient protection having the following features:

1. UL compliant for UL categories 1283 and 1449
2. Input voltage: 120 VAC single-phase, 47-63 hertz
3. Load current: 20 amperes minimum
4. Barrier type terminal blocks for line and load hard-wired connections
5. Response time: less than 1 nsec normal mode and 5nsec common mode
6. HF noise suppression: -25 dB at 100 KHz and -55 dB at 5-10 MHz
7. Transient suppression (per IEEE C62.41): Line-neutral, line-ground, neutral-ground - 15,000 Amps (8 x 20 usec); Category A Ringwave: Normal mode: 6V, Common mode: 330V.
8. Operating temperature: -40 degrees C to +45 degrees C
9. Acceptable manufacturer and model:

a. Control-Concepts Islatrol IC+130
b. Control-Concepts Islatrol IE+120
c. Eaton/Cutler Hammer AEGIS HW
d. Approved equal

B. For Isolation Transformers: Surge arrestors and capacitors shall be provided on the primary winding of isolation transformers supplying power to solid state systems. Surge protectors shall be mounted in a separate, NEMA 1 enclosure adjacent to the transformer and the incoming line passed through this enclosure. Surge arrestors shall be General Electric 9L15EC or equal. Surge capacitors shall be General Electric 9L18B, or equal.

C. For Panel External Terminal Blocks: Surge protectors shall be provided at panel external terminal blocks and according to the equipment manufacturer's instructions for types c,d,e,f,g ,and i signal circuits as defined in Section 17010, which extend outdoors. Surge protectors shall be:

1. For Panel : MTL Zone Defender or MTL Zone Sentinel or equal
2. For 2 wire transmitters: MTL TP48 or equal
3. For 4 wire transmitters: MTL SD Series or MTL 375/377 or equal
4. For Antennas: Polyphaser or equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Unless otherwise specified, mount and connect in compliance with the manufacturer's instructions.

B. Provide line side disconnect switches.

C. Provide line and load side overcurrent protection in compliance with NFPA 70.

D. Disconnect switches per Section 16175

E. Small power supply and conditioning equipment may be mounted in the panel served. Larger units shall be mounted adjacent to the equipment served.

F. Where unconditioned power is brought into control panels, it shall be enclosed in metallic raceways within the panel.

G. When larger than 5 KVA load capacity supported from surfaces other than concrete provide with sound isolators.

H. Final raceway connections shall be a flexible conduit in compliance with Section 16110.

I. When not designed for exposed mounting, house in panels per Section 17110.

END OF SECTION 17130

SECTION 17211

PROCESS TAPS AND PRIMARY ELEMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories. The Contractor is responsible for all aspects of required process taps including but not limited to modification of existing piping, installation of weldolets, etc,, as required to connect specified instrumentation to process media and process parameter measurement points.

B. Related Section: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.

1. Section 17010: Instrumentation and Control Systems.

C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete.

D. Listed products: Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below.

1.	API RP550	Manual on Installation of Refinery Instruments and Control Systems, Part 1 - Process Instrumentation and Control
2.	ASTM A269	Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
3.	ASTM A276	Specification for Stainless Steel Bars and Shapes
4.	ASTM D1248	Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable
5.	SAMA PMC 17-10	Bushings and Wells for Temperature Sensing Elements

B. Listing:

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer's place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.3 SUBMITTALS

A. Per 17010

B. Flow calculation for each differential-type flow element

PART 2 - PRODUCTS

2.1 GENERAL:

A. Requirements primary elements are specified in this Section and in INSTRUSPEC sheets in Part 3.

2.2 VALVES

A. Isolation Valves:

1. Full port ball valves with ASTM A276, 316 stainless steel trim and body.
2. Teflon seats and packing.
3. Acceptable manufacturer:

    a. Parker Hannifin
    b. Whitey
    c. Hoke
    d. Approved equal

B. Gage Valves:

1. Machined from ASTM A276 bar stock.
2. Use with 1/2-inch NPT connections and integral bleed valve.
3. Acceptable manufacturer:

    a. Anderson Greenwood M9530
    b. Hoke 6801L8Y
    c. Approved equal

C. Root Valves:

1. ASTM A276, Type 316 stainless steel bar stock
2. 1/2-inch NPT male process connection and three 1/2-inch NPT female instrument connections
3. One instrument connection shall be provided with an ASTM A276, Type 316 stainless steel bleed valve.
4. ASTM A276, Type 316 stainless steel plugs for unused ports
5. Lagging type units shall be provided for insulated vessels and pipes.
6. Acceptable manufacturer:

    a. Anderson Greenwood M5 AVS-44
    b. Hoke 6802L8Y
    c. Approved equal

D. Manifolds:

1. Three-valve bar-stock type
2. Body: machined from ASTM A276, Type 316 stainless steel bar stock
3. Valves shall be globe configuration with 316 stainless steel ball seats and Teflon stem packing.
4. Designed for direct mounting to differential pressure transmitters in place of the flanges normally furnished
5. Fabricated manifolds or manifolds employing needle or soft seat valves are not acceptable.
6. Purge taps, 1/8-inch NPT shall be furnished on manifolds where water purge is specified.
7. Acceptable manufacturer:

    a. Anderson Greenwood M4TVS
    b. Hoke 8123F8Y
    c. Approved equal

2.3 TUBING AND TUBING FITTINGS

A. Instrument tubing:

1. 1/2-inch x 0.065-inch seamless annealed ASTM A269 Type 316 stainless steel between the process connection and instruments.

B. Tubing fittings:

1. Type 316 stainless steel
2. Swage ferrule design with components (nut, body and ferrule system) interchangeable with those of at least one other manufacturer.
3. Flare and ball sleeve compression type are not acceptable.
4. Acceptable manufacturer:

    a. Parker Hannifin
    b. Swagelok

c. Hoke
d. Approved equal

2.4 CHEMICAL SEALS

A. Diaphragm:

1. Unless otherwise specified, seal shall be the diaphragm type with flushing connection, Type 316 stainless steel body and Type 316L diaphragm.
2. Unless otherwise specified, fill fluid shall be DC200 silicone oil.
3. Acceptable manufacturer:

   a. WIKA Series 990. TC
   b. Ashcroft Type 101
   c. Approved equal

B. Annular:

1. Seal shall be the in-line full stream captive sensing liquid type.
2. Metallic wetted parts shall be 316 stainless steel.
3. Unless otherwise specified, flexible cylinder shall be Buna-N.
4. Rated 200 psig with not more than 5-inch WC hysteresis.
5. Unless otherwise specified, fill fluid shall be DC200 silicone oil.
6. Acceptable manufacturer

   a. Red Valve Series 40
   b. Ashcroft Series 80
   c. Approved equal

2.5 BUSHINGS AND THERMOWELLS

A. Comply with SAMA PMC17-10.

B. Unless otherwise specified, machined from 316 stainless steel bar stock.

C. On insulated vessels or pipes, temperature taps with1/2-inch NPT, and lagging extensions.

2.6 PURGE ASSEMBLIES

A. Air purge assembly:

1. Constant-differential relay, needle valve, check valve and 0.2 to 2.0 SCFH rotameter.
2. Acceptable manufacturer:

   a. Bailey / Fischer & Porter 10A6100 Purgemaster
   b. Approved equal

B. Water purge assembly:

1. Strainer, constant-differential regulator, needle valve, check valve, and 20 to 200 cc/m rotameter.
2. Acceptable manufacturer:

a. Assembly:

1) Moore Products 63BD4A
2) Fischer & Porter 10A3137N-53BR2110
3) Approved equal

b. Strainer: 155 micron wye-type

1) ASCO 8600A2
2) Crane
3) Approved equal

2.7 FLOW STRAIGHTENING VANES

A. Acceptable manufacturer and Models:

1. Daniel Industries
2. Model 1106F
3. Approved equal

2.8 TEMPERATURE SENSORS, THERMOCOUPLES (T/C, RTD)

A. Acceptable Manufacturers and Models:

1. Weed Instruments Co.
2. Model Series: 305 with ½-H260, with 2A or 1A
3. Approved equal

2.9 SEALS

A. Acceptable Manufacturers and Models:

1. Ashcroft
2. Model Series: Diaphragm and ISO-Ring
3. Approved equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Process Connections:

1. Unless otherwise specified, process taps shall comply with API RP550.
2. Root valves shall be provided at taps, except temperature taps and pump discharge pressure taps.
3. Arrange, where possible, such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels.

    a. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
    b. Where process taps are not readily accessible from instrument locations, a block valve shall be provided at the instrument. Block valves shall also be provided for each instrument where multiple instruments are connected to one process tap.

B. Electrical Connections: Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of two feet.

3.2 IDENTIFICATION

A. Tagging: All field instruments shall be labeled with function and instrument number, i.e. (FIT-301/EFFLUENT FLOW METER). Tag shall be 10ga 316 stainless steel with stamped letters and numbers attached to device with 12ga 316 stainless steel wire.

3.3 TESTING

A. Testing requirements per Section 17010.

END OF SECTION 17211

SECTION 17221

FIELD INSTRUMENTS GENERAL

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies general requirements for field instruments. This section applies to instrumentation elements that quantitatively convert sensed process energy into a form/signal compatible with process measurement, control, and display devices and accessories.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.

1. Section 17010: Instrumentation and Control Systems.

C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

D. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below.

1.	ANSI B16,5	Pipe Flanges and Flanged Fittings
2.	API RP550	Manual on Installation of Refinery Instruments and Control Systems, Part 1- Process Instrumentation and Control
3.	ASTM A276	Stainless Steel Bars and Shapes
4.	NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)

B. Listing:

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer's place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.3 SUBMITTALS

A. Per 17010

B. Submit product data complete with ordering numbers.

PART 2 - PRODUCTS

2.1 TRANSMITTERS:

A. Unless otherwise specified, transmitters shall comply with the following requirements:

1. Two-wire type with operating power derived from the signal transmission circuit, unless otherwise specified.
2. Output shall be 4 to 20 mA, current regulated DC.
3. Load variations within the range of 0 to 500 ohms with the power supply at 24 VDC
4. Output shall be galvanically isolated.
5. Time constant of transmitters used for flow or pressure measurement, including level transmitters used for flow measurement, shall be adjustable from 0.0 to 5.0 seconds.
6. Output shall increase with increasing measurement.
7. Unless otherwise specified, enclosures shall be rated NEMA 250, Type 4X.
8. Provide with surge protectors when located outdoors:
9. Where two-wire transmitter is located in a classified area, use intrinsic safety barrier as specified below.
10. DIGITAL COMMUNICATIONS: Provide HART or approved equal digital communications where available. Only one instrument communications protocol will be allowed.
11. Provide programming device and software utilities for communications capable devices.
12. Acceptable manufacturer:

    a. Rosemount Model 470A
    b. Control concepts model TMR
    c. Approved equal

2.2 OUTPUT INDICATORS

A. Provide with any transmitter that does not include an integral indicator.

B. Output indicator shall be a loop powered current-to-digital display indicator.

C. Input current shall be 4-20 mA and display shall be a 3 1/2 active digit liquid crystal display with black numerals at least 0.35 inches high.

D. Display scalable with decimal point to read process engineering units.

E. Enclosed in a hockey puck type housing with glass window, classified as appropriate for the area in which the output indicator is installed.

F. A diode shall be provided to maintain loop continuity in case of indicator failure or removal.

G. Accuracy shall be +/- 0.1 percent of reading.

H. Indicators, whether integral or separate, shall be calibrated in process units.

I. The units shall be engraved on the indicator scale plate.

J. The installed orientation of the output indicator shall enable operators to easily read the display from the operating floor.

K. Acceptable Manufacturer:

1. Action Instruments models V561/V565
2. Precision Digital models 697/698
3. Moore Industries models PSD/SPD
4. Approved equal

2.3 DETAILED INSTRUMENT REQUIREMENTS

A. Detailed requirements for specific instruments are specified in other Division 17 specification sections.

2.4 INTRINSIC SAFETY BARRIERS

A. Shall be two-wire, active, isolating, loop powered type.

B. Mounting: DIN Rail

C. Acceptable Manufacturer:

1. Measurement Technology LTD, type MT3042
2. Stahl 9005/01-252/100/00
3. P + F SafeSnap Plus Z728 series
4. Approved equal

2.5 SIGNAL CURRENT ISOLATOR (FIELD MOUNTED)

A. Provides Galvanic isolation of milliampere transmission signals from transmitters with inadequately isolated output circuits. House in a NEMA 250, type 4X/7 conduit body. Derive its operating power from the signal input circuit.

B. Input and output signals shall be 4 to 20 mA and error shall not exceed 0.1 percent of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

C. Acceptable Manufacturer:

1. Action Instruments model T700
2. Moore Industries model SCX
3. Acromag model 150i
4. Approved equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation requirements per Section 17010.

B. Electrical Connections: Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of two feet.

C. Tagging: All field instruments shall be labeled with function and instrument number, i.e. (FIT-301/EFFLUENT FLOW METER). Tag shall be 10ga 316 stainless steel with stamped letters and numbers attached to device with 12ga 316 stainless steel wire.

3.2 TESTING

A. Testing requirements per Section 17010.

END OF SECTION 17221

SECTION 17231

ANALYTICAL INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for analytical instruments. This section applies to instrumentation elements that quantitatively convert sensed process parameters into a form/signal compatible with process measurement, control, and display devices and accessories.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.

1. Section 17221: Field Instruments General

C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

D. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Per 17221 Field Instruments General

1.3 SUBMITTALS

A. Per 17010

B. Submit product data with complete ordering numbers.

PART 2 - PRODUCTS

2.1 DETAILED INSTRUMENT REQUIREMENTS

A. Requirements for instruments are specified in this section and on INSTRUSPEC sheets in Part 3.

B. Installation and application requirements are specified in this section, section 17901, and/or on the contract Drawings.

PART 3 - EXECUTION

3.1 INSTRUSPEC SHEETS

A. INSTRUSPEC sheets provide detailed requirements for the instruments listed below.

INSTRUSPEC Symbol	Instrument Description	Instrument Function
AIT1	Dissolved Oxygen Analyzer	DO Measurement

Instrument Identification: AIT1

Instrument Function: DO measurement
Instrument Description: DO Analyzer
Power Supply: 9-30VDC
Signal Input: NA
Signal Output: 4-20 ma DC, HART
Process Connection: Probe, submersible, 1" NTP
Product Requirements:

Sensor:

1. Optical Fluorescent Type, digital output.
2. Range: 0 to 20 ppm (mg/L) as O2.
3. Accuracy shall not exceed: 0.05ppm for values < 1ppm; 0.10ppm for values < 5ppm; 0.20ppm for values >5ppm.
4. Repeatability: +/- .01 ppm
5. Response time: 60 seconds to 95%; 40 seconds to 90% of final reading.
6. Temperature range: 32 to 140 degrees F.
7. Drift shall be less than: 1% per year
8. Resolution: 0.01ppm, 0.1% DO saturation.
9. Pressure range: 0 to 50 psi.
10. Power supply: Transmitter.
11. Provide Integral cable with quick disconnect, length as required by field conditions.
12. Approval: FM.
13. Hazard Rating: Not Applicable for this project.
14. Self Cleaning Feature: Sensor shall not rely on self-cleaning features to maintain accuracy.
15. Minimum Flow Rate: Flow rate shall not be a requirement for accuracy.

Transmitter:

1. Range: 0 to 20 ppm (mg/L) O2, 0 to 200% saturation.
2. Resolution: 0.01 ppm.
7. Temperature range: -20 to 60 degrees C.
8. Temperature accuracy using RTD: +/- 0.5 degrees C between 0 and 50 degrees C, +/- 1 degree C above 50 degrees C.
9. Enclosure: NEMA 4X, IP65, NEMA 7B, as required by the area classification.
10. Display: Backlit LCD display.
11. Configuration: Provide software configuration tools and all required connection accessories.
13. Relative humidity: 0 to 95% non condensing.
14. RFI/EMI: EN-61326, CE.
15. Internal diagnostics.
16 Mounting: panel, pipe or back-mount as required by field conditions.

Acceptable Manufacturer:

1. Hach LDO Model 2 Series with SC200 Transmitter
2. Rosemount/Emerson RDO Sensor with 94030 Analyzer
3. Yokogawa Model DO70G Sensor with DO402G Converter
4. Sensor and transmitter shall be provided by the same manufacturer
5. Or Approved equal.

Installation:

1. Install in accordance with manufacturer's instructions and recommendations

Calibration:

1. Calibrate per the Manufacturer's instructions and recommendations.

END OF SECTION 17231

SECTION 17241

FLOW TRANSMITTERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for flow transmitters. This section applies to instrumentation elements that quantitatively convert sensed process flow energy into a form/signal compatible with process measurement, control, and display devices and accessories.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.

1. Section 17221: Field Instruments General

C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

D. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Per 17221 Field Instruments General

1.3 SUBMITTALS

A. Product Data per 17010.

B. Operations and Maintenance material per 17010.

PART 2 - PRODUCTS

2.1 DETAILED INSTRUMENT REQUIREMENTS

A. Requirements for instruments are specified in this section and on INSTRUSPEC sheets in Part 3.

B. Installation and application requirements are specified in this section, and/or on the contract Drawings.

PART 3 - EXECUTION

3.1 INSTRUSPEC SHEETS

A. The following INSTRUSPEC sheets provide detailed requirements for the listed instruments.

INSTRUSPEC Symbol	Instrument Description	Instrument Function
FM1	Magnetic flow meter	Flow measurement

Instrument Identification: FM1

Instrument Function: Flow measurement
Instrument Description: Magnetic flow metering system
Power Supply: 120 VAC (transmitter)
Signal Input: Induced Voltage
Signal Output: 4-20 mA DC, Digital
Process Connection: Flange, ANSI B16.5 Class 150, raised face
Product Requirements:

General:

1. Magnetic flow meter shall be provided as a system consisting of a flow tube and remotely mounted converter/transmitter complete with all necessary interconnecting cables for the flow tube to transmitter separation shown.
2. System shall be suitable for measuring raw river water.
3. Provide grounding rings when required by Manufacturer.
4. Provide mechanical protection for the flow tube flanges and liner during installation or removal of the flow tube.
6. Flow tube size shall match adjacent process piping without need for reducers.
7. Flow Tube and transmitter shall be the products of the same manufacturer recommended for use together by the manufacturer.

Flow Tube:

1. The inside diameter of the flow tube shall match process piping.
2. Flow tube features: measuring tube material 304 stainless steel; liner material will be Teflon-PTFE for sizes less than 1", polypropylene for 1” - 6”, and hard rubber for sizes larger than 6”.
3. Pulsed DC field excitation with automatic zero point correction.
4. Field coil insulation class E.
5. Field replaceable electrodes replaceable when flow tube is under operating pressure.
6. Electrode material 316 stainless steel
7. Housing: NEMA 4X.

Transmitter:

1. Signal converter/transmitter shall be suitable for an adjustable full-scale flow within the limits of from 1 to 30 feet per second.
2. Indoor Dry areas: Signal converter / transmitter to be integrally mounted with flow tube.
3. Outdoor areas and in-vault locations: Signal converter / transmitter to be remote mounted in control panel or nearest outdoor control enclosure.
3. Bi-directional flow and totalization measurement.
4. Integral high-contrast LCD display, integral control panel.
5. Accuracy of 0.3% of Rate.
6. Signal output 4-20 mA DC, galvanically isolated and internally powered 500 ohm driving capability.
7. Low-flow cutoff: adjustable from 1% to 3% of range
8. Terminals and signal converter modules plug in and replaceable without recalibration or resetting and upgradeable to comply with future communication standards.
9. Adjustable dampening: 0.2 to 256 seconds
10 Power 120 VAC.
11. Enclosure: NEMA 4X wall mount.

Acceptable manufacturer:

1. McCrometer Ultra Mag Flow Tube
2. McCrometer M-Series Converter
3. Krohne AQUAFLUX Flanged Flow tube
4. Krohne IFC 090K Flow Transmitter

5. Rosemount Series 8705T Flanged Flow Tube
6. Rosemount series 8712 Flow Transmitter
7. Or Approved equal.

Installation:

1. Install in accordance with manufacturer's instructions, API RP550, and the specified functional requirements.
2. Install ground rings upstream and downstream of the flow tube.
3. Install the transmitter on the wall near to but remotely from the flow tube.
4. Provide signal cable between the primary element and transmitter by the system manufacturer.
5. Provide a sufficient length of cable for installation of a continuous run between the primary element and the remotely mounted transmitter.

Calibration:

1. Range shall be 0 to 1,500gpm
2. Instrument shall be calibrated and certified at the factory by the manufacturer.

END OF SECTION 17241

SECTION 17242

LEVEL TRANSMITTERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for level transmitters. This section applies to instrumentation elements that quantitatively convert sensed process level into a form/signal compatible with process measurement, control, and display devices and accessories.

B. The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.

1. Section 17221: Field Instruments General

C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

D. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Per 17221 Field Instruments General

1.3 SUBMITTALS

A. Product data per 17010.

B. Operations and Maintenance Materials per 17010.

PART 2 - PRODUCTS

2.1 DETAILED INSTRUMENT REQUIREMENTS

A. Requirements for instruments are specified in this section and on INSTRUSPEC sheets in Part 3.

PART 3 - EXECUTION

3.1 INSTRUSPEC SHEETS

A. The following INSTRUSPEC sheets provide detailed requirements for the listed instruments.

INSTRUSPEC Symbol	Instrument Description	Instrument Function
LT1	Submersible Pressure Transmitter	Level Measurement

Instrument Identification: LT1

Instrument Description: Submersible Venter Gage pressure transmitter
Instrument Function: Level measurement (Wet-Well Level)
Power Supply: 14-33 VDC
Signal Input: NA
Signal Output: 4-20 mA DC
Process Connection: NA
Product Requirements:

Sensor:

1. The transducer shall incorporate a miniature, silicon piezoresistive pressure sensor with excellent resistance to shock and vibration.
2. Accuracy: ±0.1% best fit straight line (BSL)
3. Totally submersible, molded integral cable, supply cable suitable for well depth.
4. Overpressure capability: <6X rated pressure
5. Thermal stability: ±0.5% thermal error band (TEB) 30°F to 86°F (-2°C to 30°C)
7. Body: All titanium, with diameter less than 0.7 inches
8. The transducer shall be available in vented gauge (standard) and sealed gauge (option) ranges from 0 to 1 to 900 psi.
9. Range: 0 – 7 mH2O (gage) for river wet-well, 0 – 3.5mH2O (gage) for other locations
10. Zero offset: +- 5 mV
11. Span: +- 10 mV
12. Mounting: Provide Manufacturer's accessory cable grip.

Transmitter:

1. Enclosure: NEMA 4X
2. Material: PVC base and clear halogen free, self extinguishing polycarbonate cover.
3. Cable Glands: Located at base of enclosure, shall accept cable diameters of 0.23 inch to 0.39 inch.
4. Desiccant Module: Status colors Blue-dry; pink saturated, replaceable, with moisture status indicator.
5. Micro Filter: Located at base of enclosure, Gore-Tex
6. Excitation Voltage: 14 to 33 Vdc, loop powered
7. Output: 2-wire, 4-20mA (Rloop max(Kohm)=(Vloop-14) ÷ 20 mA) 32mA max
8. Zero Adjustability: ±20% FS
9. Span adjustability: 3 to 100% FS
10. Bridge Excitation Voltage: 6.2 Vdc
11. Storage Temperature: -55 to +220 F
12. Accuracy: With PDCR 1830 ±0.1% FS
13. Compensated Temperature Range: With PDCR 1830 ±0.5% FS from 22 to 122 F

Acceptable Manufacturers:

1. Transducer: GE/Druck PDCR 1830/1840 Series
2. Amplifier/Transmitter: Druck SCU 220
3. Or Approved equal.

Installation:

1. Install transducer in stilling well tube. Coordinate installation depth with owner.
2. Install in accordance with manufacturer's instructions and the recommendations of API RP550.
3. Outdoor locations: Install transmitter in a suitably sized NEMA 4X enclosure.

END OF SECTION 17242

SECTION 17251

PROCESS SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for process and non process activated switches.

B. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

C. Not all products listed are required for all applications. Submit only products required for the application.

1.2 REFERENCED SECTIONS

A. The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.

1. Section 17010: Instrumentation and Control Systems.

1.3 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below.

1.	API RP550	Manual on Installation of Refinery Instruments and Control Systems, Part 1 - Process Instrumentation and Control
2.	NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
3.	NEMA ICS 2	Industrial Control Devices, Controllers and Assemblies
4.	NEMA ICS 6	Industrial Control and Systems: Enclosures

B. Listing

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the

manufacturer's place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.4 SUBMITTALS

A. Product data per 17010

PART 2 - PRODUCTS

2.1 GENERAL

A. SWITCHES: Unless otherwise specified, switches shall comply with the following requirements:

1. Contact outputs used for alarm actuation shall be ordinarily closed and shall open to initiate the alarm.
2. Contact outputs used to control equipment shall be ordinarily open and shall close to start the equipment.
3. Contacts monitored by solid-state equipment such as programmable logic controllers or annunciators shall be hermetically sealed and designed for switching currents from 20 to 100 mA at 24 VDC.
4. Contacts monitored by electromagnetic devices such as mechanical relays shall be rated NEMA ICS 2, designation B300.
5. Double barriers shall be provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
6. Switch electrical enclosures shall be rated NEMA 250, Type 4X minimum.
7. Provide suitable intrinsic-safety barriers for contacts in hazardous areas that are monitored by equipment in safe areas.
8. BUSSED INSTRUMENTS: Provide Device Net, Foundation Field Bus, or approved equal for digital communications of process switch signals. Only one digital protocol for process switches communications shall be allowed.

B. Requirements for instruments are specified in this section and on INSTRUSPEC sheets in Part 3.

C. Installation and application requirements are specified in this section, and/or on the contract Drawings.

2.2 INTRINSIC SAFETY BARRIERS AND RELAYS

A. Intrinsic safety barriers for process switches:

1. Dual input, passive type.
2. Shunt diode barrier construction with non-replaceable fuse and internal current limiting resistor
3. Listings: UL, FM or CSA certified for use in Class I Groups A, B, C, D; Class II Groups E, F, G.
4. Acceptable manufacturers:

a. Ronan X57 Series
b. Turck MZ-61 Series
c. Approved equal

B. Intrinsic safety relays:

1. Isolates field contacts in classified location from control circuits in non-classified location.
2. Input:

a. Maximum field contact current/voltage: 10 mA/11 VAC
b. Turn-on sensitivity: < 100K Ohms
c. Turn-off sensitivity: > 1 Megaohm

3. Output:

a. SPST N.O./N.C. switching action field programmable
b. Rating: 1 A resistive at 24 VDC or 120 VAC

4. Power: 100 to 130 VAC, 50-60 Hz, 4 VA maximum
5. Listings: UL of FM approval for use in Class I Groups A, B, C, D. Class II Groups E, F, G
6. Enclosure: NEMA 1
7. Acceptable manufacturers:

a. Gems SafePak model 54820
b. Stahl IS Isolator Type 9170
c. Square-D series 8501 TO or NY2
d. Warrick series 17 or 27
e. Approved equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation requirements per Section 17010.

B. Electrical Connections: Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of two feet.

C. Tagging: All field instruments shall be labeled with function and instrument number, i.e. (FIT-100/RIVER WATER FLOW METER). Tag shall be 10ga 316 stainless steel with stamped letters and numbers attached to device with 12ga 316 stainless steel wire.

3.2 TESTING

A. Testing requirements per Section 17010.

3.3 INSTRUSPEC SHEETS

A. The following INSTRUSPEC sheets provide detailed requirements for the listed devices.

INSTRUSPEC Symbol	Instrument Description	Instrument Function
LS1	Level Switch, float	Level measurement
TS	Temperature switch	Motor Winding Overtemp

Instrument Identification: LS1

Instrument Function: Level measurement
Instrument Description: Float level switch
Power Supply: N/A
Signal Input: N/A
Signal Output: Contacts
Process Connection: N/A
Product Requirements:

1. SPST tilt actuated switch
2. Switch shall not contain mercury
3. High buoyancy, foam filled, durable, corrosion resistant float housing
4. 14-AWG wire type SO cable with PVC outer jacket
5. Tilt switch shall be rated for two amps at 120 VAC minimum
6. Cable length as needed, field verify
7. Contacts: 1 NO or 1 NC

Acceptable manufacturer:

1. US Filter Model 9G-EF
2. Anchor Scientific Solo-Float
3. Approved equal

Installation:

1. Install per the manufacturer's instructions.

Calibration:

1. Per Manufacturer recommendations

Instrument Identification: TS

Instrument Function: Temperature monitor
Instrument Description: Temperature switch, bi-metallic type
Power Supply: NA
Signal Input: NA
Signal Output: Contacts
Product Requirements:

1. Construction: bi-metallic strip or solid-state with temperature rating for protection of motor windings.
2. Switch:
   a. General purpose SPDT, unless otherwise specified.
   b. Rated 10 A at 120 VAC; 0.5 A at 120 VDC

Acceptable Manufacturers:

1. Provide as an integral accessory to pump motor.

Installation:

1. Factory installed.

Calibration:

1. Factory calibrated and tested.

END OF SECTION 17251

SECTION 17272

MISCELLANEOUS PANEL INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for panel mounted devices for operator interface and internal controls.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.

1. Section 17010: Instrumentation and Control Systems.

C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

D. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below.

1. EIA RS-310C Racks, Panels, and Associated Equipment
2. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)
3. UL 508 Industrial Control Equipment

B. Listing

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer's place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.3 SUBMITTALS

A. Product data per 17010

PART 2 - PRODUCTS

2.1 GENERAL

A. Unless otherwise specified or shown, devices covered by this Section shall comply with all requirements for installation in a control panel bearing the UL 508 label.

B. Unless otherwise specified, all like equipment specified in this Section shall be the product of a single manufacturer.

C. Requirements for devices are specified in this Section are listed on INSTRUSPEC sheets in Part 3.

D. All operator interface devices mounted on the panel front shall be rated for the environment in which they will be located. Unless specified otherwise devices mounted on indoor panels shall be NEMA 13 rated. Operator devices mounted outdoors, or in wet or corrosive environments, shall be NEMA 4X rated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Devices shall be installed in panels per Section 17110 and in compliance to EIA RS-310C.

3.2 TESTING

A. Testing requirements per Section 17010

3.3 INSTRUSPEC SHEETS

A. INSTRUSPEC sheets provide detailed requirements for the listed devices. The following INSTRUSPEC sheets are included in this Section.

INSTRUSPEC Symbol	**Instrument Description**	**Instrument Function**
XXS	Selector Switch Assembly	Operator Interface
XXL	Pilot Light Assembly	Operator Interface
PB	Push Button	Operator Interface
SS	Selector Switch	Operator Interface
PL	Pilot Light	Operator Interface
POT	Potentiometer	Operator Interface
CR	Control Relay	Control Logic

TR	Timer Relay	Control Logic
TCM	Totalizer-Counter meter	Event Counter
AH	Alarm Horn	Alarm Horn
ETM	Elapsed Time Meter	Duration Measurement

Instrument Identification: XXS

Instrument Description: Selector Switch Assembly
Instrument Function: Operator Interface
Power Supply: 120 VAC, 60 Hertz
Signal Input: N/A
Signal Output: Contact
Process Connection: N/A
Product Requirements:

1. Switches shall be four-quadrant style as described.
2. Up to four control positions that can be configured as: (1) selector switches, (2) selector push-type switches, (3) pushbuttons, and/or (4) segmented indicating light units.
3. Provide up to four separate energized indicating lights with legend plates and colored lenses as shown on the Drawings.
4. Indicating lights, pushbuttons and selector switches shall be oil tight heavy-duty units, conforming to NEMA 250 Type 4 or better.
5. Contacts in signal circuits for electronic solid-state dry circuits shall be gold, rated for 28 VDC one-ampere resistive, and125 VAC 0.5-ampere resistive.
6. Contacts in control circuits shall be silver and rated for 125 VDC 5-amperes inductive and 120 VAC 5 amperes.
7. Indicating lights for 120 VAC shall be transformer type using a LED lamp.
8. Indicating lights for 24 VDC shall be resistive type using a LED lamp.
9. Lights shall be capable of being changed from the front of the panel without special tools.
10. Unit shall be UL/CSA listed.
11. Acceptable Manufacturer:
    a. Senasys Inc., Series CMC
    b. Approved equal

Installation:

1. Mount and connect in panels per Section 17110 and in accordance with manufacturer's instructions to the specified functional requirements.

Application/Calibration:

1. NA

Instrument Identification: XXL

Instrument Description: Pilot Light Assembly
Instrument Function: Operator Indicator (Pilot) Light
Power Supply: 120 VAC, 60 Hertz or 24VDC as applicable
Signal Input: N/A
Signal Output: N/A
Process Connection: N/A
Product Requirements:

1. Each assembly shall have up to four positions that can be configured as segmented indicating light units.
2. Provide indicating lights, legend plated and colored lenses as shown on the Drawings.
3. Indicating lights shall be oil-tight heavy-duty units, conforming to NEMA 250 Type 4 or better.
4. Indicating lights for 120 VAC shall be transformer type using a LED lamp.
5. Indicating lights for 24 VDC shall be resistive type using a LED lamp.
6. Lights shall be capable of being changed from the front of the paned without special tools.
7. Units shall have UL/CSA listing.
8. Acceptable Manufacturer:
   a. Senasys, Inc. Series CMC
   b. Approved equal

Installation:

1. Mount and connect in panels per Section 17110 and in accordance with manufacturer's instructions to the specified functional requirements.

Application/Calibration:

1. NA

Instrument Identification: PB

Instrument Description: Push Button Switch
Instrument Function: Operator Interface
Power Supply: NA
Signal Input: N/A
Signal Output: Contacts
Process Connection: N/A
Product Requirements:

1. 30.5 mm diameter mounting hole, flush head, heavy-duty, water-tight/oil-tight, NEMA rated to match enclosure type.
2. Operators: Red for stop functions and black for all other functions.
3. Provide pushbuttons designated "Lock-Out-Stop" (LOS) or "Emergency Stop" (E-stop) with red mushroom head and maintained-operation contacts.
5. Contacts: unless otherwise indicated, momentary action
   a. NEMA ICS 2 designation Type A600 except when switched circuits are monitored by PLC or other solid state circuits
   b. For Solid state circuits: Hermetically sealed reed contacts
6. Acceptable Manufacturers:
   a. Allen-Bradley Series 800T
   b. Square-D class 9001 Type K
   c. Approved equal

Installation:

1. Mount and connect in panels per Section 17110 and in accordance with manufacturer's instructions to the specified functional requirements.

Application/Calibration:

1. NA

Instrument Identification: SS1, SS2

Instrument Description: Selector Switches
Instrument Function: Process control
Power Supply: 120 VAC or 24 VDC
Signal Input: NA
Signal Output: Contact
Process Connection: NA
Product Requirements:

1. Selector switches shall be Heavy-duty NEMA 13, or NEMA 4X as required by mounting location, and enclosure type.
2. Selector switches shall be 2, 3, or 4 position as required by the application.
3. Selector switches installed outdoors shall have knob lever operator handle.
4. Selector switches installed indoors shall have standard knob operator.
5. Units shall be heavy duty type
6. Escutcheon legend: As indicated on the Drawings.
7. Acceptable Manufacturer - SS1:
   a. Allen-Bradley 800H or 800T
   b. G.E. Series CR104P
   c. Approved equal.
5. Acceptable manufacturer SS2: Where solid state loads are switched, and the indicated contact development cannot be obtained with logic-read type contacts:
   a. Blue Line with Type D contacts
   b. Approved equal

Installation:

1. Mount and connect in panels per Section 17110 and in accordance with manufacturer's instructions to the specified functional requirements.

Application/Calibration:

1. NA

Instrument Identification: PL

Instrument Description: Pilot light, Indicating light
Instrument Function: Process status indication
Power Supply: 120 VAC or 24 VDC
Signal Input: NA
Signal Output: NA
Process Connection: NA
Product Requirements:

1. Indicating lights shall be NEMA 12 oil tight and dust tight, or NEMA 4X heavy duty type
2. Provide with detachable contact blocks.
3. Indicating lights shall be press-to-test 24 VDC or 120VAC transformer/LED type.
4. Lens colors: white – ready/on-line; red – running/energized, green – stopped/de-energized.
5. Approved Manufacturer:
   a. Allen-Bradley 800T
   b. Square D
   c. Approved equal

Installation:

1. Mount and connect in panels per Section 17110 and in accordance with manufacturer's instructions to the specified functional requirements.

Application/Calibration:

1. NA

Instrument Identification: POT

Instrument Description: Rotary Potentiometer
Instrument Function: Operator Interface
Power Supply: 0-15 VDC, as specified
Signal Input: N/A
Signal Output: 0 - Full Scale Volts
Process Connection: N/A
Product Requirements:

1. 30.5 mm diameter mounting hole, heavy-duty, water-tight/oil-tight, NEMA 13 or 4X, rated to match enclosure type.
2. Single-turn operation with 312-degree rotation
3. Electrical rating: 300 VAC/DC, 2 Watts, resistance as specified.
4. Escutcheon legend: 0 - 100; or as shown on drawings
5. Acceptable Manufacturers:
   a. Allen-Bradley Series 800T
   b. Square-D class 9001 Type K
   c. Approved equal

Installation:

1. Mount and connect in panels per Section 17110 and in accordance with manufacturer's instructions to the specified functional requirements.

Application/Calibration:

1. Calibration, and set points shall be as required for intended application.

Instrument Identification: **CR1, CR2, CR3, CR4**
Instrument Description: Control Relay
Instrument Function: Control Logic
Power Supply: Dependent on application
Signal Input: 120 VAC or 24 VDC
Signal Output: Contacts
Process Connection: N/A
Product Requirements:

1. General: All relays shall have indicator lights and 4 Form C contacts except for Types 3 & 4, which shall have 3 Form C contacts. Submit relay types appropriate to the application.
2. CR1: Dry circuit relay. (0 to 100 mA DC). Hermetically sealed with miniature blade terminals.
   a. Potter Brumfield KHS Series with bifurcated gold crossbar
   b. Omron model MY4ZH
   c. Approved equal.
3. CR2: Low level relay (10 mA DC to 1A DC). Miniature blade terminals
   a. Potter-Brumfield KHA series with gold-silver-nickel contacts.
   b. Allen-Bradley Bulletin 700-HC14
   c. Approved equal.
4. CR3: Intermediate level relay (50 mA DC to 5 amps AC). Octal tube base.
   a. Idec series RR with silver contacts.
   b. Allen Bradley Bulletin 700-HA.
   c. Approved equal.
5. CR4: Low power relay (10 amps at 120 VAC). Square base with blade terminals.
   a. Potter-Brumfield KU Series with silver cadmium-oxide contacts
   b. Allen-Bradley Bulletin 700-HB
   c. Approved equal

Installation:

1. Mount and connect in panels per Section 17110 and in accordance with manufacturer's instructions to the specified functional requirements.

Application/Calibration:

1. NA

Instrument Identification: TR1, TR2
Instrument Description: Timer Relay
Instrument Function: Control Logic
Power Supply: NA
Signal Input: 120 VAC or 24 VDC
Signal Output: Contacts
Process Connection: N/A
Product Requirements:

1. TR1: Time delay “on” relay.
   a. DPPT contacts rated 3 A at 30 VDC or 220 VAC
   b. Repeatability: +- 0.2% maximum
   c. Setting error +- 10% maximum
   d. Temperature error: +- 3% maximum
   e. Range: As specified, 0.1 - 3600 seconds
   f. Lifetime:
      i. electrical: 200,000 operations
      ii. mechanical: 50,000,000 operations
   g. Coil voltage: As specified
   h. Approved Manufacturers:
      i. Allen-Bradley 700-HR series
      ii. Omron H3CR-A series
      iii. Approved equal.
2. TR2: Time delay "off" relay.
   a. "True off" delay: timed contact remains energized after power is removed from coil terminals up to 600 seconds.
   b. DPDT contacts rated 24 VDC or 240 VAC at 5A
   c. Repeatability: +- 0.4% maximum
   d. Setting error: +- 10% maximum
   e. Temperature error: +- 0.2% maximum
   f. Range: As specified, 0.1 - 600 seconds
   g. Lifetime:
      i. electrical: 100,000 operations
      ii. mechanical: 20,000,000 operations
   h. Coil voltage: As specified
   j. Approved Manufacturers:
      i. Idec GT-3F series
      ii. Allen-Bradley 700-HRQ series
      iii. Omron H3CR-H series
      iv. Approved equal.

Installation:

1. Mount and connect in panels per Section 17110 and in accordance with manufacturer's instructions to the specified functional requirements.

Application/Calibration:

1. NA

Instrument Identification: **TCM**

Instrument Description: Totalizing/Counting Meters
Instrument Function: Event counter
Power Supply: Battery
Signal Input: contact or voltage pulse
Signal Output: NA
Process Connection: NA
Product Requirements:

1. Totalizing meters and counters shall be 8 digit Liquid Crystal Display (LCD) type.
2. They shall receive a contact closure or voltage pulse and increment one count every pulse.
3. They shall have an integral battery and be completely self contained.
4. Reset button shall be inaccessible or On/Off switchable.
5. Acceptable Manufacturer:
   a. Unit shall be Veeder-Root mini LX series
   b. Red Lion
   c. Approved equal

Installation:

1. Mount and connect in panels per Section 17110 and in accordance with manufacturer's instructions to the specified functional requirements.

Application/Calibration:

1. NA

Instrument Identification: AH

Instrument Description: Alarm Horn
Instrument Function: Audible alarm
Power Supply: 120 VAC
Signal Input: NA
Signal Output: NA
Process Connection: NA
Product Requirements:

1. Electronic type
2. 120 volt AC powered
3. 2900 hertz
4. Continuous operation rated
5. Acceptable Manufacturer:
   a. Sonalert
   b. Edwards
   c. Approved Equal.

Installation:

1. Mount and connect in panels per Section 17110 and in accordance with manufacturer's instructions to the specified functional requirements.

Application/Calibration:

1. NA

Instrument Identification: ETM

Instrument Description: Elapsed Time Meter
Instrument Function: Run Time Totalization
Power Supply: 120 VAC or 24 VDC
Signal Input: 120 VAC or 24 VDC
Signal Output: NA
Process Connection: NA
Product Requirements:

1. Panel-mounted, non-resetable, hour indicator.
2. 2” X 1” nominal size, rectangular case type for flush panel mounting.
3. The meter face shall be of the style that most closely resembles other panel mounted indicating instruments.
4. The meters shall have a 7-digit non-resetable register with the last digit indicating hundredths of an hour.
5. Acceptable Manuufacturer
   a. HECON GO series
   b. Approved equal

Installation:

1. Mount and connect in panels per Section 17110 and in accordance with manufacturer's instructions to the specified functional requirements.

Application/Calibration:

1. NA

END OF SECTION 17272

SECTION 17800

PROGRAMMABLE LOGIC CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies Programmable Logic Controller (PLC) hardware, programming software, system configuration, and testing requirements. Each PLC system shall consist of a PLC processor, input/output modules, communication modules, and accessories which form a system. Each PLC system shall be programmable in industrial standard relay ladder logic symbols and be delivered fully programmed for the functions required per Section 17802. Each PLC system shall be delivered fully configured to process bi-directional communication with a plant SCADA system if specified. Each PLC system shall be provided with and Graphical HMI (Human Machine Interface) in the form of a touch screen operator interface panel or a SCADA HMI.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.

1. Section 17010: Instrumentation and Control Systems.

C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

D. Not all products listed are required for all applications. Submit only products required for the application.

E. Contractor Responsibilities include but are not limited to the following:

1. Coordinate installation of the PLC equipment with the plant SCADA system.
2. Perform Control system startup, testing and commissioning
3. Coordinate the Work defined by this Section with other work defined under this Contract.

F. Small and medium capacity PLC's shall meet all of the requirements of this section unless specifically indicated as applying to only small or medium capacity PLC's, in which case the requirement shall apply only to the indicated class of PLC. PLC shall be as specified elsewhere in the contract documents or as required by the application. Application of small capacity PLC's not specifically specified as such shall require project approval following submittal review. Medium capacity PLC's are acceptable for all project PLC requirements.

G. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

H. Programming not provided by the Contractor: Unless noted otherwise the Contractor shall program all PLC's on the project except as noted below:

1. Suppliers of packaged control systems shall program PLC equipment they supply.
2. These parties shall provide all services related to PLC program development, documentation, and testing including coordination, submittals, program development, documentation, etc.
3. The Contractor shall support these programmers as requested by the Project Representative as required to support the testing and integration of the programs supplied by others to the extent that the programs supplied by others interact with contractor supplied equipment.

1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revisions of the following documents. It is a part of this Section as specified and modified.

1. NEMA ICS 1 General Standards for Industrial Controls and Systems
2. NEMA ICS 1.1 Safety Guidelines for the Application of Industrial Control Systems
3. NFPA 70 National Electrical Code (NEC)

B. Listing: Equipment shall be listed for the purpose for which it is used by UL, FM or CSA.

1. All equipment, materials, and the design, construction, installation, and application thereof shall comply with all applicable provisions of the National Electrical Code (NEC), the Occupational Safety and Health Act (OSHA), and any applicable federal, State, and local ordinances, rules and regulations. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing label.
2. Equipment listed/labeled by an NRTL shall be as dictated by the latest printing of the Electrical Testing Laboratories Accreditation Report available from the State of Washington Department of Labor and Industries, Electrical Inspection Division, or applicable document and agency in other states. Any NRTL listing/labeling shall be acceptable to and approved by the local authority having jurisdiction.
3. When a product is not available with a testing laboratory listing for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the Manufacturer’s place of assembly. All costs and expenses incurred for such inspections shall be included in the original Contract price.

C. Accessories: Manufacturer recommended accessories are acceptable only when not available directly from the PLC Manufacturer.

1.3 SUBMITTALS

A. Per Section 17010

1.4 DESIGN REQUIREMENTS

A. Each PLC system shall consist of one PLC Central Processing Unit (CPU) and one or more I/O chassis populated with I/O modules as shown in the Contract Drawings. PLC systems shall be mounted in the control panels.

B. Each PLC system shall receive input signals and transmit output signals to circuits and components as needed to perform required process control and monitoring functions.

C. Each PLC system shall be programmed in industry standard relay ladder symbols and shall be delivered fully programmed for the functions required per Section 17802.

D. Each PLC system shall be fully configured to process bi-directional serial communications with the plant SCADA system.

E. Power Supply Requirements: Each PLC I/O rack shall contain a power supply to provide DC power necessary for the CPU, and/or input and output modules. Power shall be from 100 to 130 volts AC, 60 Hz source.

F. Plant SCADA Interface: The PLC system will include small or medium capacity PLC's that will control plant processes and communicate with the plant SCADA system. The PLC system and associated accessories shall be compatible with and shall provide direct communications with G.E. Proficy iFix, Rockwell Automation Factory Talk View SE and ME, or Wonderware Intouch SCADA software, most current versions at the time of purchase. The PLC's shall communicate peer to peer and with the SCADA systems via Ethernet network.

G. PLC's shall be capable of on-line programming remotely over their communication connection. Remote on-line programming shall not interfere with communication to/from network connected PLC's (which are not being programmed) and the SCADA system.

PART 2 - PRODUCTS

2.1 ACCEPTABLE PRODUCTS

A. Provide complete PLC Systems in accordance with the Contract Documents or in the case of packaged system as required to monitor and control the submitted equipment and processes.

1. Include all hardware required to provide a complete and operable PLC system.
2. Ensure hardware is fully compatible with the software that is to operate on the hardware.
3. Provide components from the same manufacturer, model, part number, and revision for any specified component.
4. Provide products compatible with plant SCADA System.
5. Acceptable Manufacturers and product line:

    a. Allen-Bradley Compact Logix
    b. Siemens S7-300 Series
    c. Schneider Electric Modicon M340
    d. Or Approved Equal.

e. PLC systems at the plant shall be standardized. All PLC's at the plant shall be the products of the same manufacturer and shall consist of the same product lines. Contractor and suppliers shall coordinate to ensure consistency.

2.2 PROGRAMMING SOFTWARE

A. Programming software shall be a product of the PLC Manufacturer specifically intended for the submitted PLC system. Programming software shall be as specified in Section 17802.

2.3 PLC SYSTEM REQUIREMENTS

A. The processor models, I/O quantities and I/O configurations shall comply with the following general control requirements:

1. PLC CPUs shall not be required to be redundant unless specifically noted otherwise.
2. Processes shall be tolerant of the removal or failure of any individual I/O module.
3. Each control panel containing a PLC shall have a touch screen Operator Interface terminal, or a SCADA Human Machine Interface system for displaying and modifying specific PLC program parameters.
4. All programs loaded into the PLCs shall comply with Section 17802 and shall be written in Ladder Logic or other approved program languages. Use of programming techniques other than approved program languages is prohibited without written approval from the project.

B. PLC Failure Relay:

1. Provide at least one Relay Output module in each PLC System to provide a hard-wired indication of PLC failure. Locate the relay output card in the rack containing the CPU module.
2. Program the PLC and configure the Relay Output card so that the PLC failure relay is normally energized and shall de-energize on detection of a fatal PLC error or upon PLC power failure. Fatal error detection shall include all diagnostics available in the PLC and custom error detection programming as required.
3. Submit detailed description of the PLC Fail program functions that will control the contact to the Project for approval.

C. I/O Card Connections:

1. Provide connections utilizing cables and wiring arm connectors.
2. Provide all discrete and analog field wiring loops with individual fuses. Provide terminal blocks with integral fusing.

D. Operator Interface Panel:

1. Provide a touch-screen Operator Interface Terminal for each PLC System. Install as shown on the Drawings.

E. Programmable Logic Controller Equipment

1. Provide all appurtenant hardware required to support the installation, operation and maintenance of the PLC.
2. Rack Communications: Provide modules to communicate with I/O subsystem racks as required.
3. Wire spare I/O on installed cards to terminal blocks

2.4 SPARE PARTS AND CAPACITY

A. Provide at least 10% installed spare I/O points for each type and voltage of installed IO as follows:

1. Analog Inputs (1-5 VDC or 4-20 ma)
2. Analog Outputs (4-20 ma)
3. Discrete Inputs (120 VAC and/or 24VDC, as required)
4. Discrete Outputs (120 VAC, 24 VDC, and/or Relay Outputs, as required)

B. Provide spare rack capacity for 4 additional I/O modules.

C. Provide one spare of every PLC system component supplied. This set of spares shall include one of everything that is required for the full functionality and process mission of the PLC system including communications and media converter devices and process network switch.

2.5 Environmental Conditions

A. The environmental conditions are specified in Sections 17010 and 17110 unless noted otherwise.

B. General: Equipment provided under this section shall be suitable for operation under the ambient conditions listed below.

C. All Areas:

1. Atmospheric contaminants:

a.	Hydrogen sulfide	0.1 mg/1
b.	Chlorine	0.01 mg/1
c.	Ammonia	0.5 mg/1
d.	Dust	50.0 ug/m3

2. Electromagnetic radiation: 27/500 MHz, 10 volts/m

D. RAS Building:

1.	Temperature	40 to 120 degrees F
2.	Humidity	10 to 95 percent

E. Outdoor Field Locations:

1.	Temperature	0 to 120 degrees F
2.	Humidity	5 to 95 percent

F. The Programmable Controller processor shall be able to withstand conducted tests as outlined in the following:

1.	Temperature	IEC 60068-2-1 IEC 60068-2-2 IEC 60068-2-14
2.	Humidity	IEC 60068-2-30
3.	Vibration	IEC 60068-2-6
4.	Shock	IEC 60068-2-27
5.	Emissions	ISPR 11: Group 1, Class A
6.	ESD Immunity	IEC 61000-4-2
7.	Radiated RF Immunity	IEC 61000-4-3
8.	EFT/B Immunity	IEC 61000-4-4
9.	Surge Transient Immunity	IEC 61000-4-5
10.	Conducted RF Immunity	IEC 61000-4-6

G. Ambient temperature rating for storage shall be –40 to +85 degrees C (- 40 to +185 degrees F).

H. The programmable Controller system shall be described and tested to operate in a high electrical noise environment.

2.6 SYSTEM OVERVIEW

A. General

1. PLC System: PLC systems shall be modular in design and shall permit but not require a rack mounting configuration. The system shall provide a simple method of module interconnection that does not require custom wiring or cable fabrication.
2. PLC systems Include an operator interface terminal or alternate SCADA HMI unless specifically noted otherwise.

B. Major Components: The PLC Systems shall consist of the following major components:

1. Power Supply
2. Central Processor Unit (CPU)
3. Input/output modules.
4. Programming accessories.
5. Communications modules (Ethernet, DeviceNet, Operator Interface, and Expanded (Remote) I/O).
6. Operator Interface Terminal

2.7 POWER SUPPLY

A. PLC(s) (including all hardware) shall be capable of operating from a 120 VAC, 60 Hz unregulated power source (85-132 VAC, 47 to 63 Hz). One power source will be provided for each I/O rack. Power supplies shall be capable of powering all racks fully populated. Power supply shall be fused for short circuit protection.

B. The Manufacturer shall be able to provide as standard equipment a system power supply capable of converting AC standard low voltage line power to the DC power required to operate the Programmable Controller system.

C. A single main power supply shall have the capability of supplying power to the CPU and local input/output modules. Other power supplies shall provide power to remotely located racks.

D. The power supply shall automatically shut down the Programmable Controller system whenever its output power is detected as exceeding 125% of its rated power.

E. The power supply shall monitor the incoming line voltage for proper levels. When the power supply is wired to utilize AC input, the system shall function properly within the range of 85 to 265 VAC. In addition, the power supply shall provide surge protection, isolation, and outage carry-over up to 2 cycles of the AC line.

F. Design features of the Programmable Controller power supply shall include a diagnostic indicator mounted in a position to be easily viewed by the user. This indicator shall provide the operator with the status of the DC power applied to the backplane.

G. At the time of power-up, the power supply shall inhibit operation of the processor and I/O modules until the DC voltages of the backplane are within specifications.

H. In addition to the electronic protection described above the power supply shall offer a failsafe fuse that is not accessible by the customer.

2.8 SYSTEM DESIGN

A. The CPU shall be programmable in ladder logic. CPU shall be capable of executing relay logic commands (i.e. contacts, coils, master control relays), timing and counting functions, binary and BCD manipulation, logical functions (i.e. if, and, or), math function (plus, minus, multiplication, etc.), and subroutine executions (i.e. jump).

B. Memory shall be programmable locally or remotely. Program and Data Memory shall be non-volatile regardless of power disturbances and shall have a minimum retention time of one month without power applied.

C. CPU shall support discrete I/O points and analog/word I/O points. CPU shall support timers/counters, PID loops, drum sequencers, and free-form math subroutines callable from ladder logic. Processing time shall be .5 millisecond or less per 1 Kbytes of Boolean scan.

D. The PLC system shall execute status check upon power up and continuously during operation. PLC status information shall be accessible by the Programmer. Information shall indicate running or failure status of the PLC system (i.e. communication port error, scan time error, I/O failure location). The system shall have error indication for parity check. Upon proven parity error, all outputs shall be capable of “last condition” lock in or “all off”. I/Os shall have indicator lamps to determine status.

E. Modules are defined herein as devices that plug into a chassis and are keyed to allow installation in only one direction. The design shall prohibit upside down insertion of the modules as well as

safeguard against the insertion of a module into the wrong slot or chassis via an electronic method for identifying a module. Electronic keying performs an electronic check to insure that the physical module is consistent with what was configured.

F. The Programmable Controller shall have downward compatibility whereby all new module designs can be interchanged with all similar modules in an effort to reduce obsolescence.

G. The Programmable controller shall have the ability to be updated electronically to interface with new modules.

H. The Controller shall have the capability of addressing up to 960 local discrete points or 240 local analog points.

I. Up to 30 local I/O modules can be installed in up to 3 local I/O banks. Each bank will be a seamless extension to the local bank but will be electrically isolated from the other banks.

J. The Programmable Controller shall use multiple independent, asynchronous scans. These concurrent scans shall be designated for processing of input and output information, program logic, and background processing of other processor functions. Input and output devices located in the same backplane (local I/O) as the CPU will produce at the rate of configured RPI (Requested Packet Interval), and for discrete input modules enabled for Change Of State (COS), at the time any point changes state.

K. The Programmable Controller shall have the ability to communicate with multiple distributed I/O racks or devices configured with multiple I/O modules. CIP Networks that allow distributed I/O shall include EtherNet, and DeviceNet.

L. It shall be possible to communicate with remote (expanded) I/O racks or other PLC’s via fiber optic cable by inserting fiber optic converters into the links. The fiber link shall support distances between converters up to 6500 cable feet on “RIO”

M. The Programmable Controller shall have the ability to support multiple data communications links by using DeviceNet, Ethernet, and RS-485 networks.

N. The Programmable Controller shall have one dedicated serial port, which supports RS-232-C signals. It shall be accessible in control logic and provide support for, DF1 Point to point, and DH-485 (messaging only, no programming) communication protocols. Alternatively, it shall be usable for programming and data monitoring purposes. The serial port will also provide support for ASCII communications.

O. Connections can be made to other remote PLC inputs and outputs by bridging through Devicenet, or EtherNet

P. Connections can be made to up to 256 remote (expanded) input and output points over Devicenet, or EtherNet.

Q. Connections can be made to remote PLC inputs and outputs over Devicenet, or EtherNet.

R. Real Time data Producer/Consumer Connections can be made and data seamless exchanged between multiple large and small capacity PLC's

2.9 CONTROLLER DESIGN

A. The CPU shall be a self-contained unit, and will provide control program execution and support remote or local programming. This device will also supply I/O scanning and inter-processor and peripheral communication functions.

B. The user program and data shall be contained in battery backed memory. The operating system firmware shall be contained in non-volatile memory.

C. The operating system firmware can be updated via a separate update tool to allow for easy field updates. The controllers shall allow the operating system to be updated using a suitably configured CompactFlash card.

D. The controller user memory shall be available in increments between 64 Kbytes and 1.5 Mbytes

E. The CPU within the system shall perform internal diagnostic checking and give visual indication to the user by illuminating a “green” (OK) indicator when no fault is detected and a “red” (FAULT) indicator (Blinking or Solid) when a fault is detected.

F. The front panel on the Controller shall include color indicators showing the following status information:

1. Program or Run mode of the controller
2. The fault status of the controller
3. I/O status
4. RS-232 activity
5. Battery status
6. Force LED

G. The Controller shall include a face-mounted mode switch. The switch shall select the following Controller modes: RUN – No control logic edits possible, program always executing; PROGRAM – Programming allowed, program execution disabled; and REMOTE – Programming terminal can make edits and change processor mode, including test mode, whereby the logic executes and inputs are monitored, but edits are not permanently active unless assembled.

H. The Controller shall include a holder and a connector for a lithium battery. The battery shall provide power backup for user programs and data when the main power supply is not available

I. The front panel of the Controller shall include a 9-pin D-shell serial RS232 port, which supports DF1, DH-485 (messaging only no programming) and ASCII protocols.

J. All system modules and local and remote chassis shall be designed to provide for free airflow convection cooling. No internal fans or other means of cooling, except heat sinks, shall be permitted.

2.10 COMMUNICATIONS MODULES

A. Communications modules shall enable the PLC system to communicate between PLC CPU's and with other devices such as the SCADA system, Operator Interface Terminals, expanded I/O, etc. Modules shall be powered from the PLC backplane.

B. PLC's shall have integrated EtherNet, RS-232, and communication interface modules for DeviceNet and RS-485.

C. Operator Interface Communications module: Each PLC shall have a high-speed serial interface for communication with the Operator interface associated with that PLC. The Operator Interface communications module may support any high-speed serial protocol capable of throughput in excess of 100 Kbps. This interface may be combined with the Ethernet Communications module, provided that a throughput to the Operator Interface of at least 100 Kbps can be maintained. The operator interface shall not need to be disconnected from the PLC communications interface to allow the PLC to be programmed.

D. The Ethernet interface shall support the following:

1. Standard TCP/IP communications
2. Standard Ethernet media (10base2, 10base5, 10baseT, fiber)
3. CSMA/CD access method
4. Subnet masking
5. Standard repeaters, bridges, routers, host computers, peer PLC's
6. RJ-45 and AUI ports
7. Manual configuration using standard off the shelf software
8. Programmable controller messaging to peer controllers and workstations
9. I/O Control
10. Common Industrial Protocol (CIP), the protocol that provides real-time I/O messaging and information/peer-to-peer messaging
11. 10/100M/Baud auto sensing and auto switching
12. DHCP Utility
13. I/O data, Real- time interlocking, and Information
14. Full or Half-Duplex communication
15. Built-in web server capability
16. Built-in Email capability
17. Supports the open, standard EtherNet Protocol. EtherNet uses the producer/consumer network model, like DeviceNet which also use CIP.
18. The Ethernet interface shall not support bridging between Ethernet links within a PLC chassis.
19. The Ethernet interface shall support bridging to DeviceNet. Bridging allows for configuration (program up/download) and data collection.
20. The Programmable Controller shall have a standard programming instruction that allows peer-to-peer messaging with other controllers over the EtherNet network. The instruction shall be able to address any valid EtherNet node and also provide a simple path input for messages that need to be routed to other networks.

E. The DeviceNet interface shall support the following:

1. The Manufacturer shall offer industry standard 125/250/500 Kbaud DeviceNet Producer/Consumer communication capabilities as defined by the Open DeviceNet Vendor's Association (ODVA).
2. The DeviceNet Bridge module shall be able to connect to standard DeviceNet cabling and ODVA specified connectors.
3. The DeviceNet bridge module shall support Linear, Tree and Star bus topologies. Trees and Stars can be a max of 20 feet. All points of a tree or star are considered drops.
4. There shall be a software protocol layer that uses DeviceNet as the transport mechanism to deliver packets of data to peer devices.
5. The DeviceNet bridge module shall be certified as DeviceNet compliant by ODVA or one of it's approved certification agents.
6. The DeviceNet bridge module shall support a maximum of 64 addressable nodes.
7. The DeviceNet bridge module shall allow access to a DeviceNet network from programmable controllers and host computers on Ethernet.
8. The Manufacturer shall offer MMI (Man Machine Interface) software for data acquisition, supervisory control, operator interface, and information management that obtain data from the programmable controller over the DeviceNet network or by explicit messaging from Ethernet.
9. The DeviceNet bridge module shall allow Auto-Device-Replacement (ADR) capability
10. The DeviceNet bridge module shall allow Manual and Auto mapping of device data.
11. The DeviceNet bridge module can act as a Master to slave devices, Slave to a master device, or combination of master/slave.
12. The DeviceNet bridge module shall provide a visual display on the module providing Node Address, Baud Rate, and Module Status.
13. The DeviceNet bridge module shall allow a user to change the node address and/or baud rate without programming software.
14. The DeviceNet bridge module shall allow messaging from the local Controller to end nodes on Devicenet.

2.11 INPUT/ OUTPUT (I/O) SYSTEM

A. General: The system shall consist of individual modular plug-in input and output modules or cards. Any number of remote discrete and analog I/O points (up to the system capacity) shall be available.

B. Analog Input/Output

1. Analog I/O modules shall be available to convert analog control signals to minimum 12 bit binary numbers and vice-versa. Resolution shall be 1 part in 1,000 or smaller. Accuracy shall be 1.25 percent or better for Analog Inputs.
2. Analog input modules shall have 8 inputs capable of being configured as either 4-20 mA or 1-5 VDC. Isolated inputs shall be available.
3. Analog output modules shall have 4 outputs capable of driving a 4-20 mA signal into a maximum of 500 ohms. Isolated outputs shall be available.

C. Discrete Input/Output

1. Each discrete input and output shall be capable of accepting two #14 AWG stranded wires under a single terminal screw on the front of the chassis mounted I/O card. Front of card

mounted LED indicator lights shall indicate I/O point status (light on when point is energized).

2. Discrete input modules (120 VAC and 24 VDC) shall have 16 inputs in two groups of 8 with a common neutral or return. Inputs shall be "on" when voltage is supplied to the input point.
3. Discrete voltage outputs shall have 16 sourcing outputs in two groups of 8 with a common power bus, and have a minimum output rating of 1 Amp at 120 VAC, 24 VAC, or 24 VDC.
4. Relay outputs shall have 8 Form C (1 – NO, 1 – NC) outputs, and shall be individually isolated, and have a minimum output rating of 0.5 amps continuous at 24 VDC or 120 VAC.

D. Expanded (remote) Input/Output

1. The system shall be available with an expanded (remote) input/output arrangement capable of operation up to minimum of 1,000 feet from the CPU. The expanded I/O arrangement shall employ the same hardware components as the local I/O arrangement, except possibly those components that provide communication to the remotely located I/O. Communication shall be executed with dedicated remote communication equipment and shall not interrupt on-line troubleshooting with the Programmer. Communication speed shall be selectable, with a minimum throughput of 19200 bps.

E. I/O Diagnostics

1. Diagnostic lights shall be provided for the I/O communication system. Lights shall be available to indicate power, and operation status for the I/O system.

2.12 PLC PROGRAMMING SOFTWARE AND CABLES

A. Software shall be a standard programming, documentation, and diagnostics tool for the PLC. Software shall be capable of uploading and downloading programs to the PLC as well as allowing the user to monitor and troubleshoot the program while in operation. The software shall also be able to make "on-line" edits to the PLC program without compiling and downloading the entire program. Software shall be used for entering and editing programs as well as accessing programming utilities such as "cut and paste" block operations and entering program comments. Software shall enable the Programmer to enter relay ladder logic, special functions, and PID loop programs.

B. One copy of the PLC programming software with license and any necessary programming cables shall be provided for the overall plant. Programming software licenses shall not be required to be provided for packaged systems.

2.13 PLC PROGRAM DEVELOPMENT AND STORAGE

A. The program storage medium shall be battery backed RAM type.

B. Memory shall provide battery back-up capable of retaining all stored program data through a power failure. A low battery condition shall be detectable in ladder logic, but shall not automatically generate a major fault that will halt the execution of a running program. A low battery condition will generate a minor fault and will be detectable in ladder logic. Processor shall provide a low battery LED.

C. Provide Compact Flash card option for nonvolatile memory storage. The user can manually trigger the controller to save or load from Compact Flash and also configure the controller to load from Compact Flash on power up or when an issue is detected with the data in RAM. Additionally when memory is restored, a user selectable option to be restored in Run mode or Program mode shall be provided

D. The operator should be able to backup volatile memory, including data and program logic onto a personal computer storage disk.

E. All user memory in the processor not used for program storage shall be allocable from main memory for the purpose of data storage. Any data can be displayed in ASCII, Binary, Octal, Hexadecimal, or Decimal radices. Function-specific data types such as PID, Axis, Axis Group or Message shall have dedicated displays available annotating the meaning of specific control bits and words within them and allowing for selective control where appropriate.

F. If contacts or entire rungs are intentionally deleted from an existing logic program, the remaining program shall be automatically repositioned to fill this void. Whenever contacts or entire rungs are intentionally inserted into an existing program, the original program shall automatically be repositioned to accommodate the enlarged program. All rung comments shall maintain their original links.

G. It shall be possible to program application logic more than once into memory.

H. The number of times a normally open (N.O.) and/or normally closed (N.C.) contact of an internal output can be programmed shall be limited only by the memory capacity to store these instructions.

I. The number of times a timer or counter can be programmed shall be limited only by the memory capacity to store these instructions.

J. Control logic programs shall have immediate access to the sub elements of control structures by address and sub element mnemonic, such as timer accumulator value, timer done bit, or PID Process Variable value.

K. Data in the controller should be user defined and tag based and not restricted to any fixed data register format

2.14 PLC PROGRAMMING UTILITIES AND TECHNIQUES

A. The programming format shall be IEC 1131-3 compliant Ladder Diagram (LD), Function Block Diagram (FBD), Sequential Function Chart (SFC), and Structured Text (ST) languages.

B. The controller shall organize user applications as Tasks, which can be specified as continuous, periodic, or event based.

C. Periodic tasks shall run via an interrupt at a user-defined interval in one microsecond increments from 1 millisecond to 2000 seconds.

D. The interrupt mechanism of periodic and event tasks shall adhere to the IEC 1131-3 definition of pre-emptive multitasking.

E. The controller shall be able to accommodate a maximum of 32 individual tasks of which one can be continuous.

F. The periodic and event tasks shall have an associated, user assignable priority from one to fifteen (one being the highest priority), which specifies that task's relative execution priority in the multitasking hierarchy.

G. The event task can be triggered by hardware events (an input point) or software events (event instruction).

H. Each task shall have a user settable watchdog timeout which is unique to that task.

I. Each task can include a maximum of 32 programs, which can be ordered for execution within the task.

J. Each program can include routines programmed in LD, FBD, SFC, or ST languages. One of the routines can be specified as the main routine and one can be specified as an optional fault routine. All routines shall be capable of being edited when on-line. The number of routines which can be contained in a program is limited only by memory.

K. Variables within the controller shall be referenced as unique, default or user defined tags.

L. Tag naming convention shall adhere to specifications in IEC 1131-2.

M. Tags may be created off-line, on-line and at the same time the routine logic is entered.

N. The system shall have the capability to store a description for each tag.

O. Tags shall be available to all tasks in the controller (Controller Scoped) or limited in scope to the routines within a single program (Program Scoped) as defined by the user.

P. Any tag shall have the ability to be aliased by another tag, which is defined and has meaning to the user.

Q. The ability to program control logic via tags of the Programmable Controller shall exist.

R. It shall be possible to program ladder diagram rungs with the following restrictions:

1. Series instruction count limited only by user memory
2. Branch extensions limited only by user memory
3. Branch nesting to six levels

S. The capability shall exist to interleave input and output instruction types on the same contiguous rung in the ladder diagram rungs.

T. The capability shall exist to change a contact from normally open to normally closed, add instructions, change referenced tags, etc. It shall not be necessary to delete and reprogram the entire ladder diagram rung.

U. It shall be possible to insert ladder diagram rungs anywhere in the program, even between existing rungs, insofar as there is sufficient memory to accommodate these additions.

V. A single program command or instruction shall suffice to delete an individual ladder diagram rung from memory. It shall not be necessary to delete the rung contact by contact.

W. A clock/calendar feature shall be included within the CPU. Access to the time and date shall be from the programming terminal or user program.

X. Latch functions shall be internal and programmable.

Y. The system shall have the capability to address software timers and software counters in any combination and quantity up to the limit of available memory. All management of these instructions into memory shall be handled by the CPU. Instructions shall permit programming timers in the "ON" or "OFF" delay modes. Timer programming shall also include the capability to interrupt timing without resetting the timers. Counters shall be programmable using up-increment and down-increment.

Z. Timer instructions shall have a time base of 1.0 milliseconds. The timing range of each timer shall be from 0 to 2,147,483,648 increments. It shall be possible to program and display separately the timer's preset and accumulated values.

AA. The Programmable Controller shall use a signed double integer format ranging from -2,147,483,648 to +2,147,483,648 for data storage of the counter preset and accumulated values.

BB. The Programmable Controller shall store data in the following formats:

1. Boolean values (0 or 1).
2. Short Integer Numbers ranging from -128 to +127.
3. Integer Numbers ranging from -32,768 to +32,767.
4. Double Integer Numbers ranging from –2,147,483,648 to +2,147,483,647.
5. Floating Point Numbers consisting of eight significant digits. For numbers larger than eight digits, the CPU shall convert the number into exponential form with a range of plus/minus 1.1754944 E -38 to plus/minus 3.402823 E +38.

CC. The capability shall exist to organize data in the form of User Defined Data Structures. All aforementioned data types, as well as others, can be used in such structures along with embedded arrays and other User Defined Structures.

DD. The Programmable Controller shall have support for integer and floating point signed math functions consisting of addition, subtraction, multiplication, division, square root, negation, modulus, and absolute value.

EE. Trigonometric instructions supported shall include Sine, Cosine, Tangent, Inverse Sine, Inverse Cosine, and Inverse Tangent. These instructions shall fully support floating-point math.

FF. Additional floating point instructions supported shall include Log 10, Natural Log, and Exponential.

GG. It shall be possible to complete complex, combined calculations in a single instruction, such as flow totalizing or equations of the format ((A+((B-C)*D))|E).

HH. File function instructions supported shall also include Sort, Average and Standard Deviation.

II. Value arrays shall be limited in size only by the amount of available memory.

JJ. Arrays shall be configurable with one, two or three dimensions.

KK. The CPU shall support indexed addressing of array elements.

LL. Array element manipulation instructions shall be provided to execute "array copy", "array fill", "array to array move", "element to array move", "array to element move", and "first in-first out" (FIFO) operations shall be supported by the system. Math instructions and instructions for performing "logical OR", "logical AND", "exclusive OR", and comparison instructions such as "less than", "greater than", and "equal to" shall be provided. All instructions shall execute on either single words or array elements.

MM. For any module specifically associated with the Programmable Controller, it shall be possible to query the current status of all channels through controller scoped tags without any programming.

NN. The system shall contain instructions, which will construct word shift registers. Additional instructions shall be provided to construct synchronous bit shift registers.

OO. The Programmable Controller shall have a jump instruction which will allow the Programmer to jump over portions of the user program to a portion marked by a matching label instruction.

PP. It shall be a function of the CPU to automatically manage all data types. For example, if a word stored in an Integer tag is transferred into a Floating Point tag, the CPU shall convert the integer value into floating point prior to executing the transfer.

QQ. In applications requiring repeatable logic it shall be possible to place such logic in a subroutine section. Instructions which call the subroutine and return to the main program shall be included within the system. It shall be possible to program several subroutines and define each subroutine by a unique program file designator. The processor will support nesting of subroutines up to available stack capacity at the moment of the call. It shall be possible to pass selected values (parameters) to a subroutine before its execution. The number of these parameters is limited only by available memory. This allows the subroutine to perform mathematical or logical operations on the data and return the results to the main program upon completion. These subroutines will be accessed by jump-to-subroutine instructions.

RR. The program format shall display all instructions on a programming panel with appropriate mnemonics to define all data entered by the Programmer. The system shall be capable of providing a "HELP" utility which when invoked by the Programmer will display on the programming panel a list of instructions and all data and keystrokes required to enter an instruction into the system memory.

SS. At the request of the Programmer, tags contained in system memory shall be displayed on the programming panel. This monitoring feature shall be provided for all tags regardless of format or scope.

TT. The system shall have the capability to enter rung comments above ladder diagram rungs. These comments may be entered at the same time the ladder logic is entered.

UU. The capability shall exist for adding, removing, or modifying logic during program execution in routines of LD, FBD, SFC, and ST languages. When changes to logic are made or new logic is added it shall be possible to test the edits of such logic before removal of the prior logic occurs.

VV. It shall be possible to manually set (force) either on or off all hardwired discrete input or output points from the programming panel. It shall also be possible to manually set (force) an analog input or output to a user specified value. Removal of these forced I/O points shall be achieved either individually or totally through selected keystrokes. The programming terminal shall be able to display forced I/O points.

WW. A means to program a fault recovery routine shall exist. When a major system fault (Controller Fault) occurs in the system, the controller fault recovery routine shall be executed and then the system shall determine if the fault has been eliminated. If the fault is eliminated, program execution resumes. If the fault still exists, the system will shut down.

XX. The capability shall exist for each program to have its own fault routine for program fault recovery. Each having the same features as the controller based fault routine.

YY. An instruction shall be available to give the control program diagnostic information, state control, and sequencing of a process simultaneously, while allowing the capability of user-friendly state programming techniques.

ZZ. An instruction shall be supported to incorporate closed loop control systems. The "proportional", "integral", and "derivative" elements shall be accessible to the user in order to tune a closed loop system. This instruction shall fully support floating-point math.

AAA. The system shall support both bit and word level diagnostic instructions.

BBB. To facilitate conditional event detection programming, output instructions shall include "one shot" instructions, which may be triggered on either low-to-high (rising) or high-to-low (falling) rung conditions.

CCC. To facilitate debugging, an "always false" instruction shall exist which may be utilized to temporarily inhibit the execution of control logic.

DDD. The processor shall support Master Control Reset (Relay) type functionality to selectively disable sections of logic.

EEE. The processor shall include direct support of FOR-NEXT loop constructions.

2.15 INTERFACING AND PERIPHERALS

A. The programming software shall operate on a Windows XP workstation, service pack 2 or later. To be further known as “workstation”.

B. The workstation shall have the capability to be remotely located from the PLC processor. The workstation shall connect via Ethernet or RS232 for remote access.

C. The means to indicate contact or output status shall be by intensification of the contact or output on the computer display. Each element's status shall be shown independently, regardless of circuit configuration.

D. The Programmable Controller system shall be able to interface with a data terminal, which is RS-232-C compatible (up to 38400 baud) to generate hard copy messages.

E. The PLC system shall provide the capability to load a user program into, or record the contents of the processor's memory to a floppy disk and/or a hard disk on the programming workstation. It shall be possible to load or record the entire contents of memory.

F. The workstation should be able to edit and modify logic without having to take the controller off-line. Provide the ability for changes to be tested and verified prior to merging with existing logic.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install PLC Systems complete with ladder logic programming based on control strategy specifications 17802, or in the case of vendor defined systems as required for control and monitoring of the process and equipment.

B. Program the PLC System to provide local equipment monitoring, local equipment control and serve as an interface between the facility systems and the plant Mission RTU System.

C. Install all equipment in strict accordance with the manufacturer’s recommendations. Installation requirements shall include, but are not limited to, the following:

1. Maintain a minimum 6-inch vertical spacing between the bottom of the enclosure and the bottom-most PLC chassis.
2. Maintain a minimum 6-inch vertical spacing between the top of the enclosure and the top-most PLC chassis.
3. Maintain a minimum 6-inch vertical spacing between PLC chassis.
4. Maintain a minimum 4-inch horizontal spacing between power supply and side of enclosure.
5. Center wiring ducts between the PLC chassis.
6. Provide a grounding wire for each PLC chassis. Connect the grounding wire between one of the chassis grounding screws and the main grounding bus of the power system. This wire shall be green and the AWG rating shall be sized to meet the fuse rating of the supply circuit.
7. Ground each power supply mounted in the PLC chassis to one of the chassis grounding screws

D. Install the PLC equipment in new and existing enclosures as shown on the Drawings.

E. Program each Operator Interface panel for monitoring and control as described in Section 17802.

F. Install, configure and test the interface to the plant SCADA system.

3.2 TESTING

A. Perform testing as specified in Sections 17010, and 17804.

3.3 SERVICE

A. The Contractor shall provide manufacturers literature pertaining to the following:

1. System specifications
2. Electrical power requirements
3. Application considerations
4. Assembly and installation procedures
5. Power up procedures
6. Troubleshooting procedures
7. Programming procedures
8. Explanation of internal fault diagnostics
9. Shut down procedures
10. Recommended spare parts list

B. The PLC manufacturer shall provide field support personnel located within 100 miles of the owner. The PLC manufacturer shall also provide a field service department with experienced representatives stationed within 100 miles of the owner with the capability to provide telephone consultation, prompt on-site service, and field replacement stock.

C. The PLC manufacturer shall provide product application assistance by trained and experienced engineers to assist the customer with developed programs and systems through telephone consultation, on-site check-out, debug, and start-up assistance.

D. The PLC manufacturer shall provide a customer training program designed to teach the customer's personnel in the understanding and application of the programmable controller. The training program shall include training manuals and "hands-on" programming experience on a Programmable Controller of a type similar to that provided by the Contractor.

E. The PLC manufacturer shall have the capability to conduct on-site training programs at a location provided by the customer.

F. The PLC manufacturer shall be capable of providing troubleshooting software.

G. The PLC manufacturer shall be able to provide 24-hour technical support within 150-miles of the project site, including training and service support. The Contractor shall submit a list that includes PLC manufacturer’s business name, telephone numbers and addresses of technical support personnel in California.

H. The PLC manufacturer may provide the above mentioned services under this Contract through its vendor’s, Suppliers, or Subcontractors but the Contractor remains responsible for the execution of these services.

END OF SECTION 17800

SECTION 17802

PROGRAMMING

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: This Section specifies requirements for programming software, programmable devices, and programmable systems. Provide fully operational, fully programmed, and fully tested programs for all supplied programmable devices, software, and systems unless specifically noted otherwise. Programming for controlled processes shall operate as specified in the Contract Drawings, and needs of the application and equipment in the case of packaged systems. This section applies to but is not limited to the components listed below:

1. PLC's
2. OIT's

B. Related Sections: The work of the Sections listed below is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to comply with all of the requirements of all of the Contract Documents.

1. Section 17010: Instrumentation and Control Systems.

C. Experience: Programmers responsible for performing the detailed software design and programming of programmable equipment on the project shall have a minimum of five (5) years experience in similar projects. The Contractor shall assume full responsibility for software system design, programming, and operation unless specifically noted otherwise.

D. ACCEPTABLE PROGRAMMERS: All programming on the project shall be provided by either a direct employee of the CSI, or the packaged equipment control system suppliers as applicable. CSI employees providing programming services to the project shall have a minimum of 1 year of employment with the CSI. Packaged equipment suppliers shall provide programming for supplied programmable packaged control system components. Contract programmers hired by the Contractor or the CSI are not acceptable

1.2 SUBMITTALS

A. GENERAL: Per 17010

B. PROGRESS SUBMITTALS: All programming elements shall be submitted to the Project Representative for review at all required submittal levels.

C. FORMAT: Submit as hard copy printed program and configuration listings as well as programming software file format on CD-ROM.

D. SUBMITTALS: Submittals shall include the following as they apply to this project and the submittal level:

1. PLC logic block diagrams
2. PLC I/O and data file listings
3. PLC program listings
4. PLC program files
5. OIT screen samples from recent similar projects
6. OIT Tag database listing
7. OIT screen shots
8. OIT program files
9. Proposed color code for OIT screen presentation
10. Proposed common graphic elements and functions for OIT screen presentation
11. P&ID drawings with programmed elements check marked up too indicate element is programmed. Provide explanations for unchecked elements. Provide progress updates at 30, 60, 90, and 100% progress submittal level.

E. PLC programs: Provide block diagrams of logic sequence referenced to the control strategy specifications. PLC programs shall provide fully commented ladder logic. All instructions and all rungs shall be commented. Provide overall control sequence comments at the start of each program file and at the start of each major logic block. Reference logic descriptions to the control strategy specifications. Indicate registers used to communicate between PLC's and operator interface.

F. OIT: Submit color "screen shot" images of each proposed operator interface screen. Describe color schema, mouse button use, function key controls, animation, and communication protocol with PLC's. Provide screen navigation flow diagram. Include sample event and alarm log screens. All HMI screen elements shall be identified by tag number, equipment description, and system description.

1.3 PLC PROGRAMMING

A. GENERAL: All programmed process and equipment control logic shall be executed in PLC’s. The Contractor shall have full and complete knowledge of ladder logic programming.

B. LADDER LOGIC: Program all PLC functions in Ladder Logic. Submit requests to program functions in any other language. Function Block, Structured Text, and Sequential Function Chart programming may be allowed on an exception basis with written permission from the project representative. Time spent by the Contractor to correct programming that is not compliant with the programming software and programming language defined in this section will be at the Contractor's expense and shall not affect the project schedule or milestone dates.

1.4 SOFTWARE REVISIONS

A. REVISION TRACKING: Provide a formal revision tracking procedure for all software being developed and submitted to the Project Representative. The revision tracking procedure shall contain information necessary to track all changes, and ensure revisions are properly tested, documented, and incorporated into the final program. The revision tracking procedure shall track submitted programs, reference Project Representative's comments, show date program was saved,

date of all revisions, and reference to material used for the program revisions. The revision tracking procedure shall ensure that only fully tested, fully documented, and properly revised software is loaded into the PLC for delivery. Track incorporation of reviewers comments.

1.5 COMMUNICATIONS

A. None required except as needed for local programming.

1.6 PROGRAM DEVELOPMENT AND COMMISSIONING RESPONSIBILITY

A. GENERAL: The contract documents include depictions and descriptions of the functional requirements of control system component programming. Unless specifically noted otherwise the contractor shall configure and program all programmable equipment on the project. The contractor shall in all cases be responsible for the proper functioning or all programmable hardware they supply. The contractor shall in all cases be responsible for the process control network, communication systems, media, and infrastructure on which proper process control programming functionality depends.

B. PROGRAMMING ELEMENTS NOT SUPPLIED BY THE CSI: The project includes control system equipment and programming provided by the CSI, and packaged system suppliers. Where specifically noted, programs shall be developed, installed, and tested by responsible entities other that the CSI. The CSI shall not be required to provide supervision, development, submittal, installation, testing, documentation, commissioning, delivery, and warrantee support for programs provided by others except as noted in the SUPPORT paragraph below. Integration and overall project commissioning responsibilities shall be shared by the Contractor, packaged equipment suppliers, and third party programmers as directed by the Project Representative or the Owner. Applicable packaged systems and programming elements supplied by others on this project shall include the following:

1. UV system
2. Drum Filter Systems

C. PACKAGED EQUIPMENT: Suppliers of packaged equipment control systems shall configure, program, test, commission, and provide thorough documentation for all equipment they supply. Packaged equipment shall be understood to include preselected as well as contractor supplied packaged systems. Suppliers of these systems shall provide all services related to programming development, documentation, and testing including coordination, submittals, user manuals, training, warrantee support, etc. These system suppliers shall provide all programming and related services for all equipment they supply including but not limited to the items listed below:

1. PLC’s supplied with packaged equipment
2. Operator interface terminals supplied with packaged equipment
3. Final configuration and commissioning of VFD’s associated with vendor provided equipment
4. Configuration and calibration of all instruments supplied by the vendor
5. Configuration and programming of all devices required to support communications between the Vendors PLC and other devices at the site as required by the contract documents

D. CONTRACTOR SUPPORT: The Contractor and CSI shall provide coordination and support to packaged equipment vendor programmers. The CSI and the Contractor shall support these other parties in the development, submittal, testing, integration, and commissioning of their individual scopes of supply to the extent that the programs supplied by others interface with or otherwise interact with contractor supplied equipment and functions. The Contractor shall be responsible to provide services, support, and assistance to support the testing and verification of responses of their supplied equipment to the programming provided by others. The contractor shall provide this coordination and support at the request of, in the manner, and on the schedule dictated by the project representative.

PART 2 - PRODUCTS

2.1 PROGRAMS

A. GENERAL: Provide fully functioning programs that are without error, do not perform abnormal stops or actions, and are fully documented.

B. OVERVIEW: With exception of Manufacturer programmed package controllers, the plant PLC is not intended to perform automated adjustment of process parameters; these will be adjusted manually by plant Operators. The intent of the PLC is to provide for data collection and transmission between field devices and equipment, calibrate and process these values into appropriate engineering units, and make this information available to the local OIT display. Additionally, the PLC shall generate local alarms based on analog values and user-adjustable setpoints. Selective Alarms and process parameters will also be output to the adjacent Mission Control RTU via hard-wired interface.

C. Security: Provide three levels of access to OIT screen functions. Secure two of the levels with login requiring user name and password. The three access levels shall allow the following:

1. READ ONLY USER: This user will be able to navigate and view all system data but will not be able to enter any data. This user shall automatically log in on system startup or inactivity time out for higher level users.
2. FULL READ WRITE USER: This user will have full access to all administrative and data entry functions. This user shall automatically log out after 30 minutes of inactivity.
3. READ LIMITED WRITE USER: This user will not have access to administrative functions. This user will have access to a subset of the data entry functions. Write capabilities for this user will be defined during development. This user shall automatically log out after 30 minutes of inactivity.

D. GRAPHIC SCREEN CONTENT: Operator Interface display screens shall provide the following types of information:

1. System Overview
2. Sub process detailed information
3. Equipment Status
4. Set point and Data Entry
5. Alarm History with time/date stamp
6. Control Modes and logic state

7. Navigation

E. GRAPHIC SCREEN LAYOUT: Graphic displays shall include static and animated text and graphical representations of the facility, the equipment, and the process. Graphic HMI displays shall be logical, well organized, and intuitive to the operators. Do not overpopulate and congest screens. Create a sufficient number of screens to provide easy to read and understand screens which logically separate process information. Graphic elements shall resemble the facilities, equipment, and devices they represent. Use manufacturer provided graphic elements where available. All items on the process flow diagram drawings shall be represented on graphics screens. The general layout and content of graphics screens shall correlate with the process drawings however duplication of the process drawings in the graphic screens will not meet presentation requirements. Provide a minimum number of process graphics screens equivalent to the number of process drawings in the contract documents, in addition to any needed pop up's, trends, alarm lists, process overview screens, navigation screens, text data screens, numeric data entry screens, etc.

2.2 SOFTWARE FUNCTIONS

A. Provide features, characteristics, functions, and presentations

1. For VFD controlled pump motors and chiller fan motor, display

   a. Speed setpoint

   b. Status indication by animation including running, fault, unavailable/off-line

   c. Active mode (i.e. hand, off, auto, local, remote, etc.)

2. For Flow meters, display

   a. Real-time flow rates

   b. Instrument status by animation including fault or signal loss

3. Temperature display measured value and alarm status for each measured process location (i.e. Control box, Head Tank, etc.)

4. Dissolved Oxygen display measured value and alarm status for each measured process location

5. Packaged Equipment, display run and alarm status.

B. PLC PROGRAMS: Provide PLC programs capable of performing the following general functions at a minimum:

1. Analog input processing and conversion to engineering units
2. Discrete input processing for alarms and interlocks
3. Discrete output processing for Alarm generation
4. Equipment Sequence selection
5. Equipment Start/Stop and Speed control

6. Proportional + Integral + Derivative (PID) control algorithm processing, with setpoints entered locally or transmitted from the OIT or SCADA system
7. Analog Output processing for control loop outputs
8. Real-time clock for scheduling of control functions and tasks
9. Display of process data on Operator Interface and SCADA HMI
10. Provide alarm timers for all required alarms.

C. HMI: Provide Operator Interface programming that allows adjustment of loop set points, timer and counter presets, loop tuning parameters, etc.

D. PACKAGED EQUIPMENT: Provide monitoring of run status and alarms.

2.3 PROGRAM DOCUMENTATION

A. GENERAL: Provide complete documentation of all programs. Utilize all available documentation services available through the Programming Software. All application programs shall be fully documented. Program databases shall be fully expanded and documented and shall include a populated comments field. Documentation shall be sufficiently thorough to enable reviewers to review and understand all submitted programs without extensive reverse engineering efforts, and to enable trained staff of the owner to review, understand, maintain, and modify all programs supplied without extensive reverse engineering efforts. All programming components required to be complete for each progress submittal level shall be fully documented.

B. PLC PROGRAMS: All PLC programs shall be fully documented. All program blocks, sub programs, ladder rungs, and instructions shall be commented. Provide descriptive program block, sub program, and rung comments which relate the programming to the control sequence specifications. Provide sufficiently detailed comments to enable reviewers to understand the logic flow and functions of the programs. Use sub program and rung comments to explain how the code performs the all functions including those specified in the control strategy specification sections. Provide revision history of programs. Submit complete printouts and files demonstrating compliance to documentation requirements. PLC documentation shall include:

1. Log Book of revisions and their authors
2. Tags
3. Descriptors
4. Program, sub program, Task, Routine, rung, and instruction Comments
5. Titles
6. CPU Memory Configuration
7. I/O Rack configuration

C. TAG NAMES: Provide consistent tag names in PLC, OIT, SCADA, process data historian, and remote alarm notification software. Tags shall be descriptive and correlate to the loop, equipment, or function to which they are associated per the P&ID drawings and control strategy specifications. Include device or equipment tag number in register tag names, instruction comments, and rung comments at every available opportunity where the application of the element is specific to an individual tag number.

D. DESCRIPTOR FIELDS: Fully utilize all descriptor fields provided by the programming software including the following:

1. Tags and Aliases
2. Descriptions
3. Comments
4. Titles

E. DATA COMMUNICATIONS:

1. PACKAGED EQUIPMENT: Provide documentation detailing data structures communicated between vendor and contractor provided PLC's. Provide correlated tag lists from vendor provided PLC's which exchange data with contractor provided PLC's.
2. OTHER DATA COMM IO: Submit instrument and device configurations for all instruments, devices, scanners, modules, etc., which exchange IO data with PLC's via communications protocols such as devicenet, Foundation Fieldbus, Profibus, Modbus, Remote I/O, etc. Provide all instrument, scanner, and other communications device tag lists and configurations.

2.4 OWNERSHIP OF SOFTWARE LICENSES AND PROGRAMS

A. All operating software, programming software, etc. shall become the property of the Owner upon completion of the project. Suppliers and contractors shall make no claims of ownership, copyright, or other licenser upon final acceptance of the system. All “Commercial” software licenses required shall be licensed to the Owner at the time of the original purchase.

PART 3 - EXECUTION

3.1 PROGRAM DEVELOPMENT

A. SCHEDULE: Provide a schedule showing program development tasks including milestones. Include all software programs developed by the contractor. The schedule shall include the following steps as a minimum:

1. Predevelopment coordination submittal
2. Intermediate Software Submittal (60%)
3. Factory Acceptance Test software (100%)
4. Final Software Submittal with O&M manuals
5. Submittal review meetings

B. Predevelopment coordination: The programmer shall coordinate with the project prior to the start of detailed program development. The programmer shall provide the project with examples of proposed conventions, function implementation, and data presentations as requested by the project. The Project may at their discretion provide the programmer with samples of software functions and data presentations, conventions, etc. The programmer shall incorporate requested software functions, data presentations, conventions, etc into the programs they develop.

C. SUBMITTALS: Provide submittals listed below. Submit in programming software configuration and program file format and hardcopy format. Hard copy shall be produced with utilities provided with the programming software. All program and configuration files shall be represented at each

submittal level and shall be submitted simultaneously for each submittal level. Resubmittal of any programming submittal level may be required or may be deferred to the next submittal level at the discretion of the owners Project Representative. Resubmittals shall be provided upon the request of the owners Project Representative until the owners Project Representative approves all elements of the programming and configuration submittals.

1. Predevelopment submittal: Submit OIT screen samples from recent similar projects. Submit proposed standard screen element color code and proposed standard graphic elements for interface screen presentations.
2. 60% Software Submittal: Submit all items listed under submittals developed to a 60% level of completion. All unique functional and presentation elements shall be identified. All functional and presentation elements shall be identified and associated with a defined unique functional element. Tag databases shall be complete for all unique functional and presentation elements at the 60% level. A list shall be provided which identifies the duplication of the developed tags required to complete the tag databases. Programming for 60% of all unique functional and presentation elements shall be complete at the 60% submittal level. A list shall be provided which indicates all remaining functional and presentation elements to be developed and identifies which block of common tags and programming will be duplicated to complete the programming. Include tag lists and communications device configurations for data acquired via DeviceNet, Foundation Fieldbus, vendor-provided PLC's or SCADA, etc.
3. 100% Submittal: Submit completed programs to be used for factory acceptance testing.
4. O&M Submittal: Submit final programs and documentation as part of O&M manuals.

D. Submittal Review: The programmer shall provide progress submittals listed above to the project in the specified formats, color screen shots, and as requested by the project for review by the project. The project will provide review comments to the programmer. The programmer shall incorporate all project submittal review comments into the development of the subsequent submittal as requested by the project. The contractor shall attend a submittal review and coordination meeting following each submittal. The meetings shall be at a time and place and of a duration required by the project. The project may, at it's discretion, waive any or all of the submittal review meetings.

E. Contractor Response to Submittal Review Comments: The contractor shall provide individual written responses to each submittal review comment on a file copy of the submittal review comments and shall submit these responses and the updated and corrected files with the subsequent submittal. Responses to submittal review comments shall describe the action taken to correct or otherwise address the issue identified by each submittal review comment. Responses such as "comment noted", "will review and correct as needed", etc., are not acceptable. The review comment responses shall identify all specific areas of the program and configuration files that have been modified in response to the review comments. The review comment responses shall be accompanied by the updated programming and configuration files which contain the corrections as referenced by the review comment responses and as required by the submittal level requirements.

F. Coordination of Display Screen Development:

1. GENERAL: Coordination of all HMI and OIT devices and programming shall be within the Contractors scope of supply UNO. This includes CSI provided systems and bid and assigned Vendor provided systems. The development of display screens for these systems shall be coordinated with the Project Representative to ensure consistency of functionality and the look and feel of the systems at the plant.

2. SCREEN CONTENT: Display screens shall include the data indicated within plans and specifications. Screens shall provide navigation functions. Automatic fault messages shall appear upon alarm conditions. System operating and alarm information shall be displayed on screens in both graphical and text format. Alarm icons shall flash on the screen until the alarm has been manually or automatically cleared.
3. SCREEN CONVENTIONS: Display screens shall follow the Owners conventions for color usage, function, navigation, alarm display, graphic symbols, animation, etc. if requested. The Contractor shall coordinate display screen presentation development with the Project Representative and shall submit tag lists, alarm lists, PLC I/O lists, sample screens, color code, etc, to the Project Representative for approval.

3.2 PROGRAM INSTALLATION

A. Install the application program.

B. Edits by the Contractor to software installed in a PLC in production operation at the facility shall comply with the following:

1. Coordinate the changes, edits or reloading of the programs with the Project Representative. Make changes to the program to correct deficiencies or incorrect operation.
2. The Project Representative shall approve all changes before loading the program into the PLC.
3. All programming changes shall be downloaded locally.
4. Contractor shall provide complete record documents. All applicable documentation, drawings, copies of the program, and narratives shall be revised by the Contractor to reflect the edits to the programs and the operation of the process.

C. Programs developed by packaged system suppliers will be installed by these parties.

3.3 PROGRAM TESTING

A. Test programs in accordance with 17010.

3.4 TRAINING

A. Provide training per Section 17010.

B. Provide 16 hours of training for the owner’s personnel on all aspects of design, operation and maintenance of the programs and software provided.

C. Provide training on site at a time mutually agreed between the Contractor and the Project Representative.

D. Notify the Project Representative at least four weeks prior of the proposed training date.

END OF SECTION 17802

SECTION 17804

TESTING AND COMMISSIONING

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: The Contractor shall test, verify, document, and demonstrate each and every aspect of the functionality and characteristics of all of the devices, equipment, and systems they supply, individually and as an interconnected system in. The overriding purpose of required testing is to ensure and convince the project representative that the supplied equipment, systems, and programs are 100% functional and in full compliance with the contract and the needs of the process prior to being put into operational service. The items listed below as well as other items required by this section shall be tested in accordance with the requirements of this Section:

1. All control system hardware, components, assemblies, wiring, interconnections, cabling, etc.
2. PLC's (programmed by others)
3. OIT's
4. SCADA HMI including data acquisition servers (Programmed by others)
5. Data historian (Programmed by others)
6. Remote alarm notification system (Programmed by others)
7. Communications apparatus and channels
8. Network devices and media
9. All programming is by others
10. All configurations of PLC and SCADA/OIT are by others
11. Control panels
12. MCC's components
13. Packaged equipment control systems if applicable

B. Related Sections: The requirements of the Sections listed below are related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of the work specified in this section. It is the Contractor's responsibility to comply with all of the requirements of all of the Contract Documents.

1. Section 17010: Instrumentation and Control Systems.

C. Tests And Witnessing: A comprehensive series of Contractor conducted tests shall be performed and documented as specified. Tests shall be witnessed by the project at the projects discretion. The Contractor shall test and verify the performance of all equipment, software, and integrated systems supplied. If equipment or software does not have specific tests defined in the contract documents, then the Contractor shall develop testing procedures and submit to the project for approval.

D. Programs not provided by the csi: All programming on the project will be provided by the design consultant in conjunction with plant personnel. Programs shall be tested by those who provide the programs. The contractor and CSI shall provide integration and testing support for hardware and non

programmed system functions as required to support third party programmers in the installation, testing, commissioning, and demonstration of programming not provided by the CSI to the extent that the programming provided by others interfaces with or otherwise interacts with contractor and CSI provided systems.

E. TEST AND DOCUMENT ALL DATA POINTS AND FUNCTIONS END TO END: All process data points connected to the control systems shall be tested, verified, and documented by the contractor, end to end, to produce the required result from signal origin, thru logical processing and calculation functions, to signal and data destinations and process equipment responses. The test and verification of the correct reception, transmission, processing, and storage of all process data input and output points shall be individually and collectively documented in appropriate test forms, test logs, test reports, etc. All functions and logical processing of all process data input and output points shall be tested, verified, and documented individually and collectively. The generation of all data calculated from process input and output data shall be tested and verified individually and collectively.

1. Signal origins include, but are not limited to the following:

    a. Process switches
    b. Field instruments
    c. MCC control circuitry
    d. Valve actuators

2. Signal processing functions include but are not limited to the following:

    a. Control sequence functions per control strategy documents

        1) Relay logic
        2) PLC programming

    b. Alarm generation and signal trip
    c. Calculations such as counters, timers, and totalizers
    d. Data logging
    e. Automatic remote alarm annunciation functions
    f. Report generation
    g. Network communications

3. Signal and data destinations and results include but are not limited to the following:

    a. Display devices of any kind
    b. SCADA, Historian, PLC, Auto dialer data bases
    c. Data reports and Historian queries
    d. MCC control circuitry
    e. Packaged equipment control panels
    f. Valve actuators
    g. Stand alone motor controls
    h. Remote access devices

1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below. In case of conflict between the requirements of this Section and those of the listed documents, the more stringent requirements shall govern.

1.3 SUBMITTALS

A. GENERAL: Per Division 1

B. TEST PLANS AND DOCUMENTATION: Provide complete documentation of all test schedules, plans, procedures, and results. Test results documentation shall utilize a tracking process for each component of the system and the system as a whole. The tracking process shall document all tests, the outcome of each test, shall record failures, the reasons for failures, and the remedies used to correct the failures. Test schedules, plans, procedures, forms, formats, etc., shall be submitted the project for review and approval before the start of factory tests and site tests. Provide the documents listed below as well as any other documents required by this section:

1. Factory test schedule, plan, procedures, forms, logs, reports, etc., as specified in Part 2.
2. Site test schedule, plan, procedures, forms, logs, reports, etc., as specified in Part 2.

C. SUBMITTAL FORMAT: All documentation shall be submitted in hard copy and electronic file format.

PART 2 - PRODUCTS

2.1 TEST PLANS

A. GENERAL: Prepare separate test plans for the Factory Tests and Site Tests (start up and commissioning).

B. FACTORY TEST PLAN: Test plan shall include the items listed below.

1. Test Schedule
2. Test procedures
3. Test report format
4. Test log format
5. Door mounted discrete interface and display device test form
6. PLC and MCC discrete and analog I/O test forms
7. Instrument calibration form
8. Loop test form
9. Non programmed function test form
10. Programmed function test form
11. Test instrument list including calibration data
12. Test fixture information, for simulating field wiring connections
13. INTEGRATION TEST DIAGRAM: For factory test provide a test setup diagram showing all hardware and interconnections planned to accomplish factory integration testing of the supplied system. The diagram should include the following components:

a. Control panels
b. MCC's
c. OIT's
d. SCADA components
e. Cabling and wiring
f. Network devices and media
g. Communication devices and media
h. Test fixture

C. SITE TEST PLAN: All system components must be re check after installation on site. Test plan shall include the items listed below.

1. Test Schedule
2. Test procedures
3. Test report format
4. Test log format
5. Door mounted discrete interface and display device test form
6. PLC and MCC discrete and analog I/O test forms
7. Instrument calibration form
8. Loop test form
9. Non programmed function test form
10. Programmed function test form
11. Test instrument list including calibration data

2.2 TEST SCHEDULE:

A. Provide test schedule to Project Representative 30 days prior to planned testing activities. Indicate itinerary for each planned day of testing. Indicate planned witnessed test dates. Indicate expected test report transmittal dates.

2.3 TEST PROCEDURES

A. GENERAL: Structure test procedures in a step-by-step manner. Provide separate procedures for separate function and test types. The procedures shall facilitate the generation and reporting of test results and the re-creation of error conditions. Procedures shall provide methods to test and document all required system functions, sequences, and responses to field conditions. Provide test procedures for the following types of tests as well as any others required by this section:

1. Discrete input and output loop tests, PLC and MCC
2. Analog input and output loop tests, PLC and MCC
3. Panel front and MCC unit door device tests
4. Non programmed function tests
5. Programmed function tests
6. Programmed display device tests
7. Data bases, Historian, and reporting function tests
8. Software alarm dialer tests

2.4 TEST REPORTS

A. GENERAL: Compile and prepare reports for documenting un witnessed portions of Factory and Site Tests (start up and commissioning). Develop test report formats to record test results and conditions. Reports shall be completed and submitted for review and approval prior to witnessed portions of factory and site tests. Test reports shall include the items listed below. Complete and submit the following for review and approval:

1. Test summary

    a. Summary description of tests being conducted
    b. Test dates
    c. Tester names
    d. Witness names
    e. Prerequisite tests and status
    f. Test objectives and methods summary
    g. Test and monitoring equipment lists
    h. Test results summary

2. Test log
3. Test procedures
4. Test forms listed below, completed
5. Test check off documents listed below, completed
6. Listing of all configurable device parameters and settings for all configurable equipment

2.5 TEST LOG:

A. The CSI shall keep a test log that shall be developed during un witnessed portions of factory and site testing which documents the performance of each device, loop, circuit, function, feature, etc., of the system. Failures shall be noted in the test log and corrected prior to witnessed portions of factory and site testing. Log format may be somewhat informal. Logs shall be kept for each day of testing. Logs shall be signed and dated by all testers.

2.6 TEST CHECK OFF DOCUMENTS:

A. Approved, as-built process and instrumentation drawings, contract or shop schematic drawings (factory test only), and control strategy documents shall be used as check lists during testing to ensure all items and functions are tested. All items on applicable documents shall be tested, verified to provide the required result, and checked off to indicate completion of testing for each element, feature, and function. All sheets of these documents shall be signed and dated by the tester and included in test report submittals.

B. Conformance of contract documents prior to testing: Applicable contract and shop documents and control strategies shall be revised by the contractor as needed to conform to the actual systems, equipment, and control strategies submitted and installed by the contractor or supplier prior to use in testing.

C. Screen shots of all OIT and SCADA HMI screens with all elements check marked to indicate successful testing of required functionality and characteristics. Correct and retest until all elements test successfully for inclusion, color usage, animation, and read-write functionality. Testers shall sign and date sheets and include with test report submittal.

2.7 TEST FORMS

A. FORM TYPES: Form types may be combined where appropriate. Provide appropriate forms for the following types of tests:

1. Door mounted discrete interface and display device test form for control panels and MCCs
2. PLC and VFD discrete and analog I/O test and calibration forms
3. Instrument calibration form
4. Field Loop test form
5. Programmed and non programmed function test forms
6. PID loop tuning form
7. Programmable and non programmable display device test forms
8. Data base, Historian, and reporting function test forms
9. Software alarm dialer test form
10. Communications channel test form
11. Network connectivity test form

B. GENERAL INFORMATION ON FORMS: Forms shall include appropriate general information such as the following:

1. Point or loop identification for all analog, discrete, or communications signals.
2. Applicable drawing and control strategy document numbers
3. Logical function of signal or complex function
4. Test Procedure text or reference to typical procedure
5. Test equipment used
6. Signal stimulus method if signal is forced. Provide all thresholds and ranges in process engineering units.
7. Process manipulation method if process variation is used to test the signal. Provide all thresholds and ranges in process engineering units.
8. Expected result, allowable limits, success criteria
9. Actual result
10. Accuracy calculation
11. Conclusion (successful or description of corrective action)
12. Tester name, test date

C. LOOP AND FUNCTION TEST FORMS: The contractor or packaged system supplier, as applicable, shall test, verify, and document that all signal interfaces between provided control system components and plant equipment, MCC's, devices, and other control systems correctly transmit and receive and produce the required results. The contractor and system supplier shall provide a separate test and verification form for each discrete, analog, and digital data connection to the provided systems as well as for all required system functions. The forms shall include the information listed above as well as any additional information needed to clearly demonstrate that each interface data communications signal functions as required and produces the desired result:

1. Provide for all discrete and analog input and output data points
2. Provide for all hardwired and programmed functions.
3. Provide for control panel signal loops and motor control equipment signal loops.
4. Provide for digital data exchange between software components

D. CALIBRATION AND TEST FORMS PROVIDED WITH SPECIFICATIONS

1. Sample calibration and test forms are included with these specifications. Appropriate forms shall be used as needed and where ever calibration and test forms are referenced by Division 17 specifications. The CSI shall submit additional forms as needed where a suitable form is not included in the provided set of forms. Test forms shall be completed for all devices and subsystems as required by Division 17 specifications for all required test phases. Completed forms shall be submitted with test reports following un witnessed potions of factory and site tests. Provide a final set of calibration and test forms with the O&M manual submittal.
2. Any testing, calibrations, and report forms provided in these documents are provided to the contractor as is and for use and modification, if needed, by the contractor. The provided forms do not necessarily provide all needed forms or data fields and do not necessarily support all required testing, documentation, and report formats. The contractor shall provide any additional forms or shall modify the provided forms as needed to meet the testing and reporting documentation requirements. Simply filling out the provided forms will not necessarily satisfy the requirements of this section. The specified testing and documentation requirements do not necessarily require all of the provided forms.

PART 3 - EXECUTION

3.1 TESTS AND INSPECTIONS GENERAL REQUIREMENTS:

A. INSPECTION: Materials, equipment, and construction included under this Specification shall be inspected in accordance with the contract plans, specifications, and the approved shop drawings. Any and all substitutions will require re submittal and rigorous quality control.

B. NOTIFICATION AND SCHEDULE: No required test shall be performed without prior verifiable notice to the Project Representative. The Contractor shall provide test plans, schedules, and procedures per sections 2.01, 2.02, and 2.03, 30 days prior to the planned beginning of each test phase.

C. SCOPE: The CSI shall provide all programming and associated testing, documentation, and commissioning services specified UNO. The Contractor and the CSI shall provide all personnel, facilities, utilities, labor, tools, material, equipment, etc., required to accomplish the testing and documentation requirements.

D. COMMISSIONING SUPPORT: The CSI and packaged system suppliers shall continuously support the Contractor during witnessed site testing (commissioning) of the completed project. The CSI and packaged equipment suppliers shall be required to provide this support to the extent and on the schedule requested by the project representative. Typically the CSI, packaged equipment suppliers, and the Contractor will be asked to have one qualified tradesman each onsite and available for the duration of testing tasks.

E. PACKAGED EQUIPMENT: Packaged system vendors shall perform factory testing of packaged control systems in vendor facilities and site testing on site. Packaged equipment vendors shall comply with all of the submittal, testing, and documentation requirements of this section applied to their scopes of supply. Packaged equipment test schedules shall parallel and integrate with contractor test schedules. The project representative may elect to or decline to witness packaged equipment factory tests at their discretion. The Contractor shall inform the project representative of the vendor's factory test schedule 30 days in advance of the planned start date.

F. WITNESSED TESTING PREREQUISITES: All systems shall be tested and tests documented by suppliers of all control systems prior to any scheduled witnessed testing. The un witnessed factory and site test reports shall be provided to the project at least one week prior to planned witnessed testing. The project may request complete testing to be witnessed, may request to witness some but not all of the tests, or may waive the witnessed testing.

G. DURATION: Test duration shall be per the contract documents and project schedule. The contractor, sub contractor, and equipment suppliers shall be sufficiently organized and have accomplished sufficient progress such that no witnessed test phase shall take more than 5 working days.

3.2 FACTORY TESTING:

A. GENERAL: Factory acceptance test and verification for all deliverable equipment, programs, and associated documentation shall be performed prior to shipment of the system to the site. The tests shall verify that all equipment including control panels, PLC, OIT, SCADA equipment, MCC's, etc., are manufactured, configured, and assembled correctly, and are operating as required. The tests shall verify that the software and hardware meet the quality, functional, and performance requirements of the project.

B. UN WITNESSED tests shall be documenteD: All test documents shall be completed and submitted to the project representative prior to witnessed testing.

C. DEVICE AND ASSEMBLY VERIFICATION (UN WITNESSED): The completed control systems assemblies shall be thoroughly verified in the shop of and by the supplier prior to witnessed factory testing. Testing shall verify the functionality of all supplied devices, the correctness of all panel wiring, and shall verify all required system functions and features including non programmable control logic, annunciation, alarming, networking, communications, etc. The CSI shall verify the proper operation of all system devices and circuits, including but not limited to all inputs, outputs, loops, circuits, control devices, etc. The CSI shall configure and verify the functionality of all supplied communications and network devices. Testing of the supplied control system shall include energizing each discrete input and output and simulating each analog input and output using a loop simulator and calibrator or other appropriate device. All circuits shall be energized simultaneously or as expected in maximum power supply loading operation during testing. Un witnessed testing of the supplied control system shall be conducted continuously, 24 hours per day, for at least seven (7) days without a failure or interruption. Provide the documents listed below as well as others required by this specification section:

1. PLC IO WIRING: Test and verify the correctness of all wiring of PLC discrete and analog input and output modules to the correct field terminals. Provide completed PLC IO verification forms to document this test. Include description of test methods.

2. PLC ANALOG IO CALIBRATION: Test the accuracy of all PLC analog input and analog output points to the field terminals. Provide PLC analog IO calibration forms to document this test. Include description of test methods.
3. VFD ANALOG IO: Configure supplied VFD's per the requirements and specifications. Test and verify the accuracy and response of VFD analog IO. Provide MCC analog IO calibration forms to document this test. Include description of test methods.
4. DISCRETE INTERFACE AND DISPLAY: Test and verify all discrete field located and control panel or MCC door mounted display and operator interface devices. Document these function tests individually or in logical groups on appropriate forms. Include description of test methods.
5. NON PROGRAMMED FUNCTIONS: Test and verify the responses of all non programmed hardware driven logical functions at control panels and MCC's. Functions include signal trip, alarm generation, relay logic, interlocks, etc. Document these tests individually or in logical groups on appropriate forms. Include description of test methods.

D. FACTORY INTEGRATION TESTING (un witnessed): All packaged equipment supplier or CSI provided programs including PLC, OIT, SCADA components, historian, alarm dialer, etc., programs shall be 100% complete, installed, and functioning prior to factory integration testing. All programs shall be thoroughly tested and verified prior to factory test witnessing. This requirement applies to all programs within the scope of services of the contractor or packaged system supplier. The CSI or system supplier shall verify all required functions and features of the system. Testing shall verify all instrumentation, display, communications, network, automatic control, manual control, annunciation, alarming, OIT (UNO), SCADA HMI (UNO), etc., functions of the control system. For CSI or packaged equipment supplier provided programming, provide the following documentation as well as other documentation required by this section:

1. PROGRAMMED FUNCTIONS: Test and verify all programmed control strategy functions. Specified input conditions shall produce all specified output and operational results. Document these tests individually or in logical groups on appropriate forms. Include description of test methods.
2. PROGRAMMABLE DISPLAYS: Test and verify the correct display, read-write functionality, and animation of all specified data points on programmable display devices. Document these tests by providing complete sets of contract P&ID drawings and display screen print outs with each item check marked to indicate compliance or other equivalent and appropriate means. Include description of test methods.
3. DATA HISTORIAN: Test and verify the correct logging of process data to the data historian and the correct rendering of required data reports from the process data historian. Document this test by providing tag lists and report formats with each item check marked to indicate compliance or other appropriate and equivalent means. Include description of test methods.
4. REMOTE ALARM NOTIFICATION: Test and verify the correct configuration and callout functionality of all specified remote alarm notification system points. Document this test by providing the call out tag list with each tag check marked to indicate compliance. Include description of test methods. Coordinate and provide staff call list during the un witnessed site test phase.

E. FIELD WIRING AND TEST FIXTURE: The electrical interfaces of all system equipment not present for factory testing shall be simulated with a test fixture provided by the CSI. The test fixture shall provide switches, indicator lights, digital signal displays, labeling, etc., as required to simulate field devices. All supplied control system I/O not connected to actual system equipment shall be connected to interface or indication devices on the test fixture. The test fixture devices connected to control system I/O shall be labeled to indicate the control system function being performed or indicated. Sufficient loop

simulators (or other appropriate device) needed to satisfy all analog programming conditions simultaneously shall be provided by the CSI. Digital panel meters shall be provided for analog outputs not connected to actual system devices. It is essential that all I/O be simultaneously connected to actual project equipment or the simulation devices on the test fixture.

F. A PLC and OIT based test fixture of equivalent functionality and convenience may be used in lieu of the test box described above.

G. TEST LOG: A factory test log shall be kept per Part 2 of this document.

H. FACTORY TEST REPORT: A test report shall be prepared to demonstrate thoroughness of testing and to document and communicate factory testing results. The report shall contain data and documentation as indicated in Part 2 of this document. The test report documentation shall be provided to the Project Representative prior to witnessed factory testing. The acceptability of the test results and report shall be determined by the Project Representative. Witnessed factory testing shall not be scheduled prior to verifiable receipt of acceptance of the test results and report by the Project Representative. Prior to witnessed testing all aspects of the control system should be fully checked out and verified. All that should remain to be done is for the supplier to demonstrate this to the witness.

I. Witnessed Factory Testing: Following acceptance of un-witnessed factory test report documents the CSI shall demonstrate system compliance to the project representative. The project shall not be expected to orchestrate or lead the testing. The CSI shall demonstrate all required functions and features of the system, or requested subset thereof, including but not specifically limited to control, indication, alarming, monitoring, data logging (UNO), network, communications, PLC (UNO), OIT (UNO), SCADA HMI (UNO), etc functions to the Project Representative. The CSI shall revise, correct, modify, calibrate, and adjust the system as required by the Project Representative during witnessed testing to achieve and successfully demonstrate all required functions and features. All deficiencies discovered shall be corrected by the CSI. Testing shall continue until the system is approved by the Project Representative. Upon approval, the Project Representative shall provide verifiable notice of factory test approval to indicate the completion of factory testing. The panels shall not be shipped prior to receipt of the Project Representative’s notice of acceptance of factory testing.

J. UPDATE SHOP DRAWINGS: All shop drawings shall be corrected and updated following factory testing. All corrections and revisions made to the system or the drawings shall be incorporated by CAD into the shop drawings and provided to the Project Representative and the contractor prior to installation of the equipment by the contractor.

K. THIRD PARTY PROGRAMMERS: Third party programmers will provide, install, test, and demonstrate programming they provide. The CSI shall provide integration testing support as needed and as requested by the project representative. The CSI shall support the third party programmer throughout the programmers testing activities as required to verify that contractor provided equipment responds and reports to third party provided programs as specified by the contract documents. The CSI shall support testing activities of the third party programmer on all issues concerning interface of contractor provided equipment and functions with third party provided programming.

L. PACKAGED EQUIPMENT: Suppliers of packaged control systems shall provide and accomplish factory testing and documentation equivalent to that described above for their systems.

3.3 CONTROL SYSTEM INSTALLATION AND CALIBRATION:

A. GENERAL: Supplied control systems shall be installed and all field wiring and interconnections verified. When the installation of the supplied control system is substantially complete, the CSI shall calibrate all components of the supplied control system including but not limited to all instruments, indicators, recorders, loops, etc. The CSI shall configure all communications and network devices and shall verify proper communications of devices across all network and communications channels and media. Each component shall be adjusted to be within the Manufacturer's required performance range for the specific application. Components supplied by the CSI that do not function properly, that cannot be properly calibrated, or that are found to not meet the Manufacturer's performance specifications shall be removed and replaced at no additional cost to the owner.

B. DOCUMENTATION: The CSI shall complete device calibration forms and network and communications channel test forms. Calibration forms identifying each process switch, instrument, final elements such as actuators and VFD's, and test forms for each network and communications device and channel tested shall be completed and included in the un witnessed site test report. Provide the following calibration documentation as well as other documentation required by this section:

1. Test and calibrate all devices which provide an analog input to control system equipment. Test and calibrate all analog instruments, VFD analog outputs, valve actuator analog outputs, packaged control system analog outputs, etc. Document these tests on appropriate calibration forms, one each per device. Describe test procedure. All field wiring shall be included in the test procedure. Provide correlation of process parameter value to analog signal and PLC register value at 0, 25, 50, 75, and 100 percent of range. Compare to expected values and calculate accuracy. Include all display device calibration.
2. Test and calibrate all analog outputs from control systems to other equipment. Test and calibrate all VFD analog inputs, valve actuator analog inputs, packaged control system analog inputs, etc. Document these tests on appropriate calibration forms, one each per device. Describe test procedure. All field wiring shall be included in the test procedure. Provide correlation of PLC register and analog signal value at 0, 25, 50, 75, and 100 percent of range to process and equipment parameter or response. Compare to expected values and calculate accuracy. Include display device calibration.
3. Test and calibrate all devices which provide discrete input to the control system. Document these tests on appropriate test forms. Describe test procedures. All field wiring shall be included in the tests. Record increasing and decreasing trip points and correlate to process parameter values. Compare with expected values and calculate accuracy.
4. Test and calibrate all devices which receive discrete outputs from the control system. Verify the correct response occurs. Document these tests on appropriate test forms. Describe test procedures. All field wiring shall be included in the tests.
5. Configure and verify the functionality of all communications, networks, and connected devices. Document these tests on appropriate test forms. Describe test procedures. Provide all device configuration settings.
6. ANALYTICAL INSTRUMENTS: Provide test gasses, buffer solutions, and reference fluids for tests and calibration of all analytical instruments. Test per manufacturer's instructions.

C. THIRD PARTY PROGRAMMERS: The Contractor shall complete all calibration documents and provide to third party programmers prior program installation and system site testing.

D. PACKAGED SYSTEMS: Packaged system suppliers shall perform and document the calibration tasks described above for their scopes of supply.

E. FIELD WIRING: All field wiring shall be included and verified in calibration and site testing tasks.

3.4 UN WITNESSED SITE TESTING (START-UP):

A. GENERAL: Control systems shall be fully tested prior to any witnessed site testing. Control systems shall be put into operation by the CSI or the packaged system supplier. The functionality of all aspects of the system shall be verified by the CSI or packaged system supplier. All aspects of the control systems, including but not limited to all inputs, outputs, circuits, loops, instruments, annunciation, display, alarming, automatic control, manual control, PLC (UNO), OIT (UNO), SCADA (UNO), data logging, reporting, remote alarm notification, PID loops, etc shall be verified to be working correctly. A test log shall be kept per Part 2 of this document. A Test Report shall be prepared by the CSI for this phase per Part 2 of this document. All deficiencies shall be corrected and the test report provided to the Project Representative prior to scheduling of witnessed site testing (commissioning) with the Project Representative present. The acceptability of the calibration and un witnessed site test results and report shall be determined by the Project Representative. All plant systems shall be complete, integrated, fully tested, fully verified, and all tests fully documented by the contractor prior to witnessed site testing (commissioning). All that should remain to be done is to demonstrate system compliance to the project representative. The system shall be complete, fully integrated, fully tested; all tests and operational data documented, and ready to be put into continuous production operation at this point in the process. The system capabilities listed below and all other capabilities specified shall be tested, verified, and documented in the un-witnessed site test report:

1. All automatic and manual control functions specified
2. All programmed and non programmed functions specified
3. All programmed and non programmed display and annunciation functions specified
4. All operator interface and monitoring functions specified
5. All communications functions specified
6. All network functions specified
7. All SCADA functions specified
8. All data historian functions specified
9. All motor control and MCC functions specified
10. All control panel functions specified
11. All packaged equipment control system functions specified
12. All Remote alarm notification and auto dialer functions specified
13. Provide all PID loop tuning parameters

B. PACKAGED CONTROL SYSTEMS: Package equipment vendors shall install, calibrate, startup, test, and verify their supplied systems as described above for CSI supplied systems per the project site test schedule. Packaged equipment suppliers shall document testing of their systems as described above. Communications and interface functionality required between vendor systems and plant systems and equipment, including MCC’s and plant SCADA system application software and equipment shall be tested, verified, and documented during this test phase.

C. Third Party Programmers: Where specifically noted, the programmer shall install, test, and verify programs provided for the Contractor supplied PLC’s, OIT’s, and SCADA components. The contractor shall provide support as needed and as requested by the Project Representative to support testing of these programs and to verify the proper responses of related equipment.

D. PROCESS CONDITIONS: The contractor shall provide conditions at the facility which fully exercise process equipment to enable realistic testing and verification of the control system and associated equipment. This includes but is not limited to adequate flow quantities and flow rates of water required to simulate operational process conditions.

3.5 WITNESSED SITE TESTING (COMMISSIONING):

A. GENERAL: After un witnessed site testing (start-up) is completed by the CSI, packaged system suppliers, third party programmers, and the contractor, and the required test report approved by the Project Representative, commissioning demonstrations shall be presented to and witnessed by the Project Representative and the Owner. The contractor shall lead and orchestrate commissioning demonstrations of the complete and integrated systems. Commissioning shall include demonstration of all instruments, components, features, and functions of the entire control and communication system and all sub systems. Commissioning shall be considered complete when the Project Representative has determined that all of the system requirements have been met.

B. SCOPE: The project representative may request the rerun of all un-witnessed site tests or a subset thereof. The required un-witnessed site test report and associated documentation may be verified in whole or in part during commissioning at the project representatives discretion.

C. SUPPORT: During the commissioning phase, the CSI, the Electrical Contractor, and packaged equipment suppliers shall revise, correct, modify, and make adjustments as required by the Project Representative to achieve the operation required. The CSI, packaged equipment suppliers, and the Contractor shall be continuously present during commissioning to exercise all aspects of the control system and associated process equipment and to correct deficiencies as they are found.

D. Third Party Programmers: When a third party programmer is used to program contractor supplied PLC's, OIT's, and SCADA components, the programmer shall conduct the commissioning for the programs provided and the contractor shall provide support as requested by the project representative.

3.6 LOOP TEST STAGES:

A. General: Test and document each instrument loop in the following sequence:

Testing sequence		Form
1.	Wiring	17000-A
2.	Piping	17000-B
3.	Individual components	17000-C through I
4.	Individual loops	17000-J
5.	Loop commissioning	17000-K

B. Testing of piping, wiring, and individual components: Shall be completed with certified test reports completed which shall be provided to the Project Representative prior to commencement of individual loop testing.

C. Individual component calibration and test:

1. Each instrument and final element shall be field calibrated in accordance with the manufacturer's recommended procedure. Instruments shall then be tested in compliance with ISA S51.1 and the data entered on the applicable test form.
2. The Project Representative may elect to witness these tests.
3. Alarm trips, control trips, and switches shall be set to initial values specified in the Instrument Schedule.
4. Final elements shall be checked for range, dead-band, and speed of response.
5. Any component that fails to meet the required tolerances shall be repaired by the manufacturer or replaced.
6. Repeat above tests until the component is within tolerance.
7. Record all threshold, range, and dead band data in engineering units appropriate to the process on test forms.

D. Loop Test:

1. Test each instrument loop as an integrated system. This test shall check operation from transmitter to signal receiving components, and from the supplied control panels to final control elements.
2. The Project Representative may elect to witness these tests.
3. Manipulate the process or inject signals at the field terminations to simulate primary measuring elements. Record method of signal stimulus on test forms.
4. Output of each auto/manual control function shall be manually varied from 0 to 100 percent, and correct operation of final control element verified.
5. Each process switch and alarm circuit shall be manually actuated at the field sensor.
6. Verify correct operation of all annunciator windows, indicator lights, or OIT/HMI screen elements as applicable.
7. Record all threshold, range, and dead band data in engineering units appropriate to the process on test forms.

E. Closed-loop test:

1. Project Representative may elect to witness these tests.
2. Test shall demonstrate stable operation of each loop under actual process operating conditions. This test includes adjustment of loop tuning parameters. Loops shall be tuned and documented prior to witnessing by the project. Record all loop parameters on test forms for each loop test.
3. Unless otherwise specified, adjust tuning parameters (proportional gain, integral time constant, and derivative time constant) for each control loop to provide ¼-amplitude damping.
4. Prepare a chart recording showing loop response to a step disturbance for each loop.
5. Make two charts for cascade loops if applicable, one showing the secondary loop response with its set point on manual, and the second showing overall loop response.
6. Chart recordings shall be made at sufficient speed and amplitude to clearly show specified amplitude damping and shall be annotated to show loop number and title, and settings of parameters and set points.

F. Programmers other than the CSI: Third party programmers and packaged system suppliers shall tune and commission all loops controlled by supplied programs. The contractor and sub contractors shall provide integration support as requested by the project representative.

3.7 OIT, HMI, SCADA TEST:

A. Test and verify all required read and write functionality. Verify correct addressing to the correct PLC registers.

B. Test and verify correct presentation and function of all display elements on all display screens.

C. Provide the services of a qualified technician for the needed duration to assist in this test.

D. Test and verify all process data communications between PLC's, OIT's, packaged equipment HMI, plant SCADA system, data historian, and remote alarm annunciation software.

E. Test and verify all displayed historical and real time trends are functioning correctly.

F. Test and verify the process data historian is configured and logging required data correctly.

G. Test and verify that all parts of the process network are functioning correctly.

H. Provide screen shots of all OIT and SCADA HMI screens. Notate screen shots to indicate the test status of each screen element. A check mark shall indicate that the element was fully and successfully tested. Make corrections until all elements test successfully. Tester shall sign and date each screen shot and shall provide the documents with other test reports and forms to the project.

I. Test and verify all required historical data reports are configured and functioning correctly.

J. PROGRAMMERS OTHER THAN THE csi: Third party programmers and packaged system suppliers shall test and commission all programs they supply. The contractor and sub contractors shall provide integration support as requested by the project representative.

3.8 CALIBRATION EQUIPMENT AND TESTING APPARATUS:

A. The contractor shall have available test and calibration equipment for factory panel tests, installation, start-up, service contract, and maintenance or troubleshooting purposes. The equipment required for these tests is as follows:

B. Digital Multimeter with an accuracy of plus or minus 0.1 percent - sufficient number to satisfy simultaneous field signal requirements.

C. Signal calibrator for analog signals - sufficient number to satisfy simultaneous field signal requirements.

D. One - 60-inch Water Manometer with 0.1-inch graduations. Include accessories of floor stand, pipe clamp, tubing, air bulb with shutoff and fittings for 0.25 inch and 0.375 inch threaded taps for "Tee" fittings to connect manometer.

E. One - 20-inch Mercury Manometer graduated in inches of water. Include accessories of floor stand, pipe clamp, tubing, air bulb with shutoff and fittings for 0.25 inch and 0.375 inch threaded taps and "Tee" fittings to connect manometer.

F. One - 0 to 100 psi, 6-inch-diameter pressure gauge with 1 psi graduations and plus or minus 1 percent accuracy. Include "Tee" fittings and fittings for 0.25 inch through 1 inch threaded taps to connect gauge.

G. One - Air tank pressurized to 150 psi with 2 regulators. One regulator for the 0 to 30 psi range, and one regulator for the 30 to 100 psi range. Include accessories of fittings for 0.25 inch through 1 inch threaded taps to connect air tank.

H. One - 30-foot supply of 0.375-inch PVC clear plastic tubing with fittings for 0.25 inch and 0.375 inch threaded taps to make manometers for Venturi tubes, orifice plates, etc., for calibration checks.

I. One - Decibel meter for telemetry work capable of reading minus 40 db to plus 10 db over frequency range of 300 to 2,500 hertz with a selective narrow band filter.

J. One - High-impedance earplug speaker with alligator clips for telemetry monitoring of transmitter keying.

K. One - Signal generator for telemetry adjustable over 300 to 2,500 hertz with 1 milliwatt output into 600 ohm line.

L. One - Set of portable radios capable of operating within buildings at one location and 5 miles outside of buildings in hilly terrain.

M. One - Programming terminal with software to configure programmable equipment.

N. Modify and add to the list as required to fully and efficiently start up, calibrate, test, and commission all supplied equipment.

END OF SECTION 17804