CITY OF TULARE

TULARE, CALIFORNIA

TULARE WATER STORAGE TANKS IMPROVEMENT PROJECT

CLIENT PROJECT NO. 18-626

CONTRACT/TECHNICAL SPECIFICATIONS

BID SET SUBMITTAL

Volume 2 of 4

Divisions 26 through 46

July 2017

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TULARE WATER STORAGE TANKS IMPROVEMENT PROJECT

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SECTION 26_05_00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. General requirements applicable to all Electrical Work.
   2. General requirements for electrical submittals.

B. Related sections:
   1. Document 00_21_13 - Instructions to Bidders
   2. Document 00_72_00 - General Conditions.
   3. Section 01_14_00 - Work Restrictions.
   4. Section 01_29_73 - Schedule of Values.
   5. Section 01_31_19 - Project Meetings.
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   19. Section 26_05_03 - Utility Coordination.
   20. Section 26_05_33 - Conduits.
   21. Section 26_05_53 - Identification for Electrical Systems.
   22. Section 26_05_74 - Electrical System Studies.
   23. Section 26_08_50 - Field Electrical Acceptance Tests.

C. Interfaces to equipment, instruments, and other components:
   1. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
   2. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the Work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:
      a. Make all changes necessary to meet the manufacturer’s wiring requirements.

3. Submit all such changes and additions to the Engineer for acceptance as specified in Document 00_72_00.
4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:
   a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
5. Loop drawings:
   a. Provide all electrical information required in the preparation of loop drawings including, but not limited to:
      1) Conduit numbers and associated signal(s) contained within each conduit.
      2) Wire numbers.
      3) Equipment terminal numbers.
      4) Junction boxes and signal(s) contained within each junction box.
      5) Equipment power sources, and associated circuit numbers.
      6) As-built drawings detailing wiring.

D. All electrical equipment and systems for the entire Project must comply with the requirements of the Electrical Specifications, whether referenced in the individual Equipment Specifications or not:
   1. The requirements of the Electrical Specifications apply to all Electrical Work specified in other sections.
   2. Inform all vendors supplying electrical equipment or systems of the requirements of the Electrical Specifications.
   3. Owner is not responsible for any additional costs due to the failure of Contractor to notify all subcontractors and suppliers of the Electrical Specifications requirements.

E. Contract Documents:
   1. General:
      a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.
   2. Specifications:
      a. The General and Supplementary Conditions of the Contract Documents govern the Work.
      b. These requirements are in addition to all General Requirements.
   3. Contract Drawings:
      a. The Electrical Drawings show desired locations, arrangements, and components of the Electrical Work in a diagrammatic manner.
      b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work to ensure the best possible installation:
         1) The equipment locations and dimensions indicated on the Drawings are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.

2) The Contractor has the freedom to select any of the named manufacturers identified in the individual specification sections; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.

c. Installation details:

1) The Contract Drawings include typical installation details the Contractor is to use to complete the Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.

2) Not all typical installation details are referenced within the Drawing set. Apply and use typical details where appropriate.

d. Schematic diagrams:

1) All controls are shown de-energized.

2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.

3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.

4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.

5) Schematic diagrams are to be used in conjunction with the descriptive operating sequences in the Contract Documents. Combine all information and furnish a coordinated and fully functional control system.

F. Alternates/Alternatives:

1. Coordinate with Document 00_72_00 for substitute item provisions.

G. Changes and change orders:

1. As specified in Document 00_72_00.

1.02 REFERENCES

A. Code compliance:

1. As specified in Section 01_41_00.

2. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.

3. The standards listed are hereby incorporated into this Section.

a. American National Standards Institute (ANSI).

b. American Society of Civil Engineers (ASCE):

1) ASCE 7 - Minimum Design Loads for Buildings and Other Structures.

c. ASTM International (ASTM).

d. Illuminating Engineering Society (IES). Institute of Electrical and Electronics Engineers (IEEE).

e. Insulated Cable Engineers Association (ICEA).
f. International Code Council (ICC).
   1) International Code Council Evaluation Service (ICC-ES).
      a) AC 156 – Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).
g. International Society of Automation (ISA).
h. National Electrical Manufacturers Association (NEMA):
   1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
i. National Fire Protection Association (NFPA):
   1) 70 - National Electrical Code (NEC).
j. National Institute of Standards and Technology (NIST).
k. Underwriters' Laboratories, Inc. (UL).

B. Compliance with laws and regulations:
   1. As specified in Document 00_72_00.

1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth by:
   1. IEEE.
   2. NETA.
   3. IES.
   4. ISA.
   5. NEC.
   6. NEMA.
   7. NFPA.
   8. NIST.

B. Specific definitions:
   1. FAT: Factory acceptance test.
   2. ICSC: Instrumentation and controls subcontractor.
   3. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
   4. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
   5. PCIS: Process control and instrumentation system.
   6. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
   7. Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
   8. Spare: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that physically contains a device with no load connections to be made.
   9. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.

10. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.04 SYSTEM DESCRIPTION

A. General requirements:
   1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from:
      a. The Electrical Drawings are schematic in nature; use the Structural, Architectural, Mechanical, and Civil Drawings for all dimensions and scaling purposes.
   2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
   3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work.
   4. Coordinate all aspects of the Work with the electrical subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the electrical subcontractor, the other subcontractors, or suppliers.
   5. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation:
      a. As specified in the Contract Documents.
   6. Defective work:
      a. As specified in Document 00_72_00.
   7. Utility coordination: Coordinate with the electric utility as required by Section 26_05_03.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01_33_00 and this Section.

B. General:
   1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
   2. Furnish the submittals required by each section in the Electrical Specifications.
   3. Adhere to the wiring numbering scheme specified in Section 26_05_03 throughout the Project:
      a. Uniquely number each wire.
      b. Wire numbers must appear on all Equipment Drawings.
   4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

C. Seismic requirements:
   1. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads based on the seismic design criteria in Section 01_81_02.
   2. For equipment installed in structures designated as seismic design category C, D, E or F, prepare and submit the following:
      a. Statement of seismic qualification, and special seismic certification:
         1) “Statement of seismic qualification:” Provide manufacturer’s statement that the equipment satisfies the seismic design requirements of the building code indicated in Section 01_41_00, including the requirements of ASCE 7, Chapter 13.
         2) “Special seismic certification:” Provide manufacturer’s certification that the equipment, when subjected to shake table testing in accordance with ICC-ES AC 156, meets the “Post-Test Functional Compliance Verification” requirements of ICC-ES AC 156 for “Components with Ip = 1.5.” Compliance shall include both operability and containment of hazardous materials as appropriate to the unit being tested.
      b. Substantiating test data: With seismic qualification and special seismic certification statements, submit results of testing in accordance with ICC-ES AC 156.
      c. Anchoring design calculations and details:
         1) Submit project-specific drawings and supporting calculations, prepared and sealed by a professional engineer licensed in the state where the Project is being constructed, and showing details for anchoring electrical equipment to its supports and for anchoring supports provided with the equipment to the structure. Prepare calculations in accordance with the requirements of Section 01_81_02.
   3. Exemptions: A “statement of seismic qualification” and a “special seismic certification” are not required for the following equipment:
      a. Temporary or moveable equipment.
      b. Equipment anchored to the structure and having a total weight of 20 pounds or less.
      c. Distribution equipment anchored to the structure and having a total unit weight of 3 pounds per linear foot, or less.

D. Operation and maintenance manuals:
   1. As specified in Section 01_78_23.
   2. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before Functional Acceptance Testing.

E. Material and equipment schedules:
   1. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
      a. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

F. Schedule of values:
   1. In addition to completing all items referred to in the schedule of values, Section 01_29_73, submit per unit material and labor costs used in developing the final bid for the electrical system, for the express purpose of pricing and

cost justification for any proposed change orders. In addition to the items shown on the schedule of values, provide per unit material and labor costs for conduit and wire installation for specific types, sizes, and locations as indicated on the Drawings and Conduit Schedule. It is the responsibility of the electrical subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.

G. Record Documents:
   1. Furnish as specified in Section 01_77_00.

H. Test reports:
   1. As specified in Section 01_33_00.
   2. Additional requirements for field acceptance test reports are specified in Sections 01_75_17 and 26_08_50.

I. Calculations:
   1. Where required by specific Electrical Specifications:
      a. Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

1.06 QUALITY ASSURANCE

A. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01_60_00.

1.08 PROJECT OR SITE CONDITIONS

A. Site conditions:
   1. Provide an electrical, instrumentation and control system, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
   2. Seismic load resistance:
      a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01_81_02.
   3. Wind load resistance:
      a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site wind loads as specified in Section 01_81_04.
   4. Altitude, temperature and humidity:
      a. As specified in Section 01_81_01.
      b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating factors applied.
      c. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum

operating temperature, as determined by the equipment manufacturer's guidelines:
1) Provide all power conduits wiring for these devices (e.g. heaters, fans, etc.) whether indicated on the Drawings or not.
5. Site security:
a. Abide by all security and safety rules concerning the Work on the Site, as specified in Sections 01_35_22 and 01_50_00.

B. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA Standard 250 for the following types of enclosures:
1. NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
2. NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation, and freezing.
3. NEMA Type 4X: Made from corrosion resistant materials (fiberglass reinforced plastic, 316 stainless steel or equal) and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion.
4. NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt, and dripping non-corrosive liquids.

C. Plant area Electrical Work requirements:
1. Provide all Electrical Work in accordance with the following table, unless otherwise specifically indicated on the Drawings:

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Electrical Building	1, 12	Galvanized Steel	C	Galvanized Steel
Outdoors	4X Stainless Steel	PVC Coated Galvanized Steel	W	Stainless Steel

2. Modify exposed conduit runs as specified in Section 26_05_33.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. General:
1. As specified in Sections 01_31_19 and 01_75_17.
2. Testing requirements are specified in Section 01_75_17, 26_08_50 and other sections.
3. General scheduling requirements are specified in Section 01_32_17.
4. Work restrictions and other scheduling requirements are specified in Section 01_14_00.
5. Commissioning and Process Start-up requirements as specified in Section 01_75_17.

B. Pre-submittal conference:
   1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire Project, equipment, control philosophy, schedules, and submittal requirements.
   2. Contractor, electrical subcontractor, all suppliers, and individual equipment manufacturers furnishing major pieces of equipment must attend.

1.11 WARRANTY

A. Warrant the Electrical Work as specified in Document 00_72_00:
   1. Provide additional warranty as specified in the individual Electrical Specifications.

1.12 SYSTEM START-UP

A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
   1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Before Substantial Completion, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

B. Furnish all spare parts as required by other sections of the Specifications.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide similar items of same manufacturer throughout the electrical and instrumentation portion of the Project.

B. Allowable manufacturers are specified in individual Electrical Specifications.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the Specifications.

B. Provide materials complying with the applicable industrial standard as specified in Document 00_72_00.

C. Stainless steel:
  1. Where stainless steel is indicated or used for any portion of the Electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
  2. Provide exposed screws of the same alloys.
  3. Provide finished material free of any burrs or sharp edges.
  4. Use only stainless steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.
  5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
  6. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products.

PART 3 EXECUTION

3.01 EXAMINATION

A. It is the electrical subcontractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

B. Comply with pre-bid conference requirements as specified in Document 00_21_13.

C. Review the site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Equipment locations shown on Electrical Drawings may change due to variations in equipment size or minor changes made by others during construction:
   1. Verify all dimensions indicated on the Drawings:
      a. Actual field conditions govern all final installed locations, distances, and levels.
   2. Review all Contract Documents and approved equipment shop drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
   3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
   4. Provide a complete electrical system:
      a. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical system.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. Cutting and patching:
   1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:
      a. Secure the permission of the Engineer before performing any operation likely to affect the strength of a structural member such as drilling, cutting or piercing:
         1) Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:
            a) Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.
            b) Use tone-locate system or X-ray to ensure that area is clear of obstructions.
      b. Review the complete Drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
   2. Perform all patching to the same quality and appearance as the original work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
      a. 3M: CP 25WB+: Caulk.
      b. 3M: Fire Barrier: Putty.
   3. Use the installation details indicated on the Drawings as a guide for acceptable sealing methods.

D. Install all conduits and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:
   1. Install all conduits and equipment in accordance with working space requirements in accordance with the NEC.
      a. This includes any panel, disconnect switch or other equipment that can be energized while open exposing live parts regardless of whether it is likely to require examination or has serviceable parts.
   2. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.
      a. Adjust equipment locations as necessary to avoid any obstruction or interferences.
   3. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.
   4. Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.

E. Earthwork and concrete:
   1. Install all trenching, shoring, concrete, backfilling, grading and resurfacing associated with the Electrical Work:
      a. Requirements as specified in the Contract Documents.

F. Terminations:
   1. Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.

G. Miscellaneous installation requirements:
   1. In case of interference between electrical equipment indicated on the Drawings and the other equipment, notify the Engineer as specified in Document 00_72_00.
   2. Location of manholes and pullboxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pullboxes with Mechanical and Civil Work.
   3. Provide additional manholes or pullboxes to those shown where they are required to make a workable installation.

H. Labeling:
   1. Provide all nameplates and labels as specified in Sections 26_05_03 and 26_05_74.

I. Equipment tie-downs:
   1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing criteria, which apply to the Site.
   2. All control panels must be permanently mounted and tied down to structures in accordance with the Project seismic criteria.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

B. For Owner and Engineer witnessed FAT:
   1. Contractor is responsible for the Owner's and Engineer's costs associated with FAT as specified in Section 01_75_17.

C. Owner training:
   1. As specified in Section 01_75_17 and in this Section.

D. Source testing (FAT):
   1. Provide source testing and owner training on electrical equipment as defined in the table below:

Table: Source Testing and Owner Training Requirements

Section Number	Section Title	Source Testing	Owner Training Requirements	
		(Witnessed or Non-witnessed)	Maintenance (hrs per session)	Operation (hrs per session)
26_29_25	Variable Frequency Drives 60 - 500 Horsepower	Witnessed	16	16
26_32_14	Single Diesel Fueled Engine Generator Above 200 KW	Non-Witnessed	6	4

3.08 FIELD QUALITY CONTROL

A. Inspection:
   1. Allow for inspection of electrical system installation as specified in Section 01_45_00.
   2. Provide any assistance necessary to support inspection activities.
   3. Engineer inspections may include, but are not limited to, the following:
      a. Inspect equipment and materials for physical damage.
      b. Inspect installation for compliance with the Drawings and Specifications.
      c. Inspect installation for obstructions and adequate clearances around equipment.
      d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
      e. Inspect equipment nameplate data to verify compliance with design requirements.
      f. Inspect raceway installation for quality workmanship and adequate support.
      g. Inspect cable terminations.
   4. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in Section 26_08_50.

B. Field acceptance testing (Functional Testing):
   1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
   2. Perform the field acceptance tests as specified in Section 26_08_50.

3. Record results of the required tests along with the date of test:
   a. Use conduit identification numbers to indicate portion of circuit tested.

C. Workmanship:
   1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
      a. Neatly coil and label spare wiring lengths.
      b. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the Engineer.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 01_77_00.

B. Remove all foreign material and restore all damaged finishes to the satisfaction of the Engineer and Owner.

C. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust or other matter before energization of the equipment or system start-up:

D. As specified in other sections of the Contract Documents.

3.11 PROTECTION

A. Protect all Work from damage or degradation until Substantial Completion.

B. Maintain all surfaces to be painted in a clean and smooth condition.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_05_03

UTILITY COORDINATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Coordination with the utility companies to provide service.
   2. Contractor's responsibilities for connecting to utilities and providing utility service to the facilities.
   3. Descriptions of utility services required.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 26_05_00.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

B. Utility contacts:
   1. J street:
      a. Name: James Bylow.
      b. Utility: Southern California Edison.
      c. Address: 2425 S Blackstone, Tulare, CA, 93274.
      d. Phone number: 559-903-4815.
      e. Fax number: 559-685-3287.
      f. E-mail: james.bylow@sce.com.

   2. Alpine Vista:
      a. Name: Kenny Santiago.
      b. Utility: Southern California Edison.
      c. Address: 2425 S Blackstone, Tulare, CA, 93274.
      d. Phone number: 559-684-3584.
      e. Fax number: 559-685-3287.
      f. E-mail: kenny.santiago@sce.com.

1.04 SYSTEM DESCRIPTION

A. Electrical service:
   1. Provide all Work and materials and bear all costs for providing temporary construction power and the permanent electrical service, including but not limited to:
      a. All Work and materials not provided by the electric utility.

2. Provide electrical ducts, raceways, conductors and connections indicated on the Drawings, and all other Work and materials required for a complete electrical service, including but not limited to the following:
   a. Electrical service conduits and conductors from the point of electric utility connection to the service entrance equipment.
   b. Metering conduits from the instrument transformers to the meter.

B. General:
   1. Coordinate and obtain inspections and final installation approval from the serving utilities and other authorities having jurisdiction.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Certification:
   1. Submit certification that the intended installation has been coordinated with the utility companies.
   2. Include a narrative description of the utility's requirements and points of connection, names, and telephone numbers for contacts at the utilities.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. Materials and equipment used in performance of Electrical Work shall be listed or labeled by UL, or other equivalent recognized independent testing laboratory, for the class of service intended.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. General:
   1. Before start of Site Work, make arrangements for electrical service as required.

B. Electrical systems:
   1. Before bidding, the electrical contractor shall contact the utilities to determine the Work and materials that will be required from the Contractor, and all fees and permits that will be required, so that all utility systems furnished by the Contractor will be included in the bid.

2. Before commencing Work, coordinate electric service entrance requirements with local electric utility to assure that the installation will be complete as specified in these Contract Documents:
    a. Ensure power transformer size, electrical characteristics, and location are consistent with the design and service voltage provided by the electric utility coordinated with other trades.
    b. Arrange for utility revenue meter.

C. Before commencing Site Work, coordinate underground conduit installations with other Work to eliminate conflicts and avoid interferences with other underground systems.

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Furnish materials in accordance with the applicable requirements of the utilities and as specified in these Specifications.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Furnish equipment in accordance with the applicable requirements of the utilities and as specified in these Specifications.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 26_05_00.

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_05_09

LOW VOLTAGE MOTORS UP TO 500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
  1. Low voltage motors up to 500 horsepower.

B. Related sections:
  1. Section 01_33_00 - Submittal Procedures.
  2. Section 01_75_17 - Commissioning.
  3. Section 26_05_00 - Common Work Results for Electrical.
  4. Section 26_08_50 - Field Electrical Acceptance Tests.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. American Bearing Manufacturers Association (ABMA):
  1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
  2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. American Petroleum Institute (API):
  1. 670 - Vibration, Axial Position, and Bearing Temperature Monitoring Systems.

D. ASTM International (ASTM).
  1. B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.

E. Institute of Electrical and Electronic Engineers (IEEE):
  1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
  2. 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
  3. 114 - Standard Test Procedure for Single-Phase Induction Motors.
  4. 303 - Recommended Practice for Auxiliary Devices for Rotating Electrical Machines in Class I, Division 2 and Zone 2 Locations.
  5. 841 - Standard for Petroleum and Chemical Industry-Premium-Efficiency, Severe Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500 hp).
  6. 1349 - Guide for Application of Electric Motors in Class I, Division 2 Hazardous (Classified) Locations.

F. National Electrical Manufacturers' Association (NEMA):
  1. MG-1 - Motors and Generators.
  2. MG-2 - Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators.

G. Underwriters Laboratories Inc. (UL):
   1. 674 - Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

1.04 SYSTEM DESCRIPTION

A. Furnish and install electric motors and accessories as specified in this Section and the Sections specifying driven equipment to provide a complete and operable installation.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Submit completed motor data sheets for each motor supplied:
   1. Conform to data sheet in the appendix of this Section.
   2. Manufacturer's or other data sheets are not acceptable.

C. Product data:
   1. Descriptive bulletins.
   2. Machine tag and loop number as indicated on the Drawings and in the specification section number of the driven machine.
   3. Complete electrical data.
   4. Torque, current, and power factor vs. speed curves:
      a. At 100 percent rated voltage for all full voltage started and VFD driven motors.
      b. For motors on reduced voltage start at 70, 80, 90, and 100 percent rated voltage.
   5. Accessories data:
      a. Motor winding heaters:
         1) Voltage.
         2) Watts.
      b. Winding temperature detectors:
         1) Type.
         2) Rating.
   6. Mechanical data:
      a. Bearing design and bearing life calculations.
      b. Resonant frequencies for all VFD-driven motors 50 horsepower or greater.

D. Shop drawings:
   1. Motor weight.
   2. Frame size.
   3. Conduit box(es), size(s), and location(s).
   4. Outline drawings with dimensions.
   5. Installation details for the project seismic criteria.

E. Test reports:
   1. Factory test reports with test reference standard identified.

F. Certification:
   1. When motors are driven by variable speed drive systems, submit certification that selected motor:
      a. Is capable of satisfactory performance under the intended load.
      b. Meets the requirements of the latest edition of NEMA MG-1 Part 31.

G. Calculations:
   1. Where site conditions specified in Section 26_05_00 exceed manufacturer's ratings, provide derating calculations for each motor.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

B. Motors 200 hp and larger:
   1. Rotate shaft 90 degrees once per month.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTION (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. US Motors.
   2. General Electric.
   3. Reliance.
   4. Toshiba.
   5. Baldor.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. 3-phase induction motors - general:
   1. Voltage:
      a. All motors 1/2 hp and larger shall be rated 460 V, 3 phase unless otherwise indicated on the Drawings.
      b. Dual voltage motors rated 230/460 V, 3 phase are acceptable provided all leads are brought to the conduit box.
   2. Motors driving identical machines shall be identical.
   3. All motors greater than 1 hp and up to 500 hp shall meet the "NEMA Premium Efficiency" percent listed in NEMA MG-1.
   4. Horsepower as indicated on the Drawings:
      a. Horsepower ratings indicated on the Drawings are based on vendor's estimates. Provide motors sized for the load of the actual equipment furnished without operating in the service factor.
   5. Service factor:
      a. 1.15 service factor on sine wave power.
      b. 1.0 when driven by VFD.
   6. Torque:
      a. Provide motors that develop sufficient torque for acceleration to full speed at voltage 10 percent less than motor nameplate rating.
      b. When started using reduced voltage starters:
         1) Provide motors that develop sufficient torque for acceleration to full speed.
      c. NEMA Design B except where driven load characteristics require other than normal starting torque:
         1) In no case shall starting torque or breakdown torque be less than the values specified in NEMA MG-1.
   7. Enclosures:
      a. As specified in the individual equipment Specifications or in this Section.
      b. Totally enclosed fan cooled:
         1) Cast iron conduit box.
         2) Tapped drain holes with Type 316 stainless steel plugs for frames 286 and smaller, and automatic breather and drain devices for frames 324 and larger.
      c. Lifting devices: All motors weighing 265 pounds (120 kilograms) or more shall have suitable lifting devices for installation and removal.
   8. Manufactured with cast iron frames in accordance with NEMA MG-1 or manufacturer's standard material for the specified rating.
   9. Nameplates:
      a. Provide all motors with a permanent, stainless steel nameplate indelibly stamped or engraved with:
         1) NEMA standard motor data.
            a) Indicate compliance with NEMA MG-1 Part 31 for inverter duty motors.
         2) AFBMA bearing numbers and lubrication instructions.

10. Hardware:
    a. Type 316 stainless steel.
11. Conduit boxes:
    a. Cast iron or stamped steel.
    b. Split from top to bottom.
    c. Provide gaskets at the following interfaces:
        1) Frames and conduit boxes.
        2) Conduit boxes and box covers.
    d. Rotatable through 360 degrees in 90-degree increments.
        1) Where available based on the size of the conduit box.
    e. Exceeding the dimensions defined in NEMA MG-1.
    f. Provide grounding lugs inside conduit boxes for motor frame grounding.
12. Motor bearings:
    a. Antifriction.
    b. Regreasable and initially filled with grease for horizontal motors, vertical motors per manufacturer’s standard design.
    c. Bearings and lubrication suitable for ambient temperature and temperature rise.
    d. Suitable for intended application and have ABMA L-10 rating life of 60,000 hours or more.
    e. Fit bearings with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.
    f. Where specified in the equipment Specifications, provide split-sleeve type hydrodynamic radial bearings. Provide a bearing isolator to protect bearings from contaminants.
13. Insulation systems:
    a. Motors installed in ambient temperatures 40 degrees Celsius or less:
        1) Provide Class F insulation.
        2) Design temperature rise consistent with Class B insulation.
        3) Rated to operate at an ambient temperature of 40 degrees Celsius at the altitude where the motor will be installed.
    b. Motors installed in ambient temperatures between 40 degrees Celsius and 50 degrees Celsius:
        1) Provide Class F insulation.
        2) Design temperature rise consistent with Class B insulation.
        3) Rated to operate at an ambient temperature of 50 degrees Celsius at the altitude where the motor will be installed.
    c. Motors installed in ambient temperatures between 50 degrees Celsius and 65 degrees Celsius:
        1) Provide Class H insulation.
        2) Design temperature rise consistent with Class F insulation.
        3) Rated to operate at an ambient temperature of 65 degrees Celsius at the altitude where the motors will be installed.
14. Motor leads:
    a. Insulated leads with non-wicking, non-hydroscopic material. Class F insulation.
15. Noise:
    a. Maximum operating noise level in accordance with NEMA MG-1.

B. Vertical motors:
   1. Enclosures:
      a. Totally enclosed fan cooled (TEFC) for motors less than 200 horsepower installed outdoors.
      b. Weather protected Type II (WPII) for motors 200 horsepower and larger installed outdoors.
      c. Weather protected Type I (WPI) where installed indoors.
   2. Thrust bearings:
      a. Selected for combined rotor and driven equipment loads.
      b. Coordinate with driven equipment supplier for maximum vertical thrust of driven equipment.
   3. Anti-reverse ratchet.

C. Motors driven by variable frequency drives:
   1. Compatible with the variable frequency drives specified.
   2. Inverter duty rated and labeled.
   3. Meet the requirements of NEMA MG-1 Part 31.
   4. Winding insulation meets the requirements of NEMA MG-1 Part 31.4.4.2.
   5. Capable of running continuously at 1/10th of full speed, with no harmful effects or overheating.
   6. Shaft grounding ring:
      a. Provide a shaft grounding ring for each VFD driven motor.
      b. Aluminum frame and internal components.
      c. Conductive microfiber brushes.
      d. Maintenance free design.
      e. Aegis Bearing Protection ring as manufactured by Electro Static Technology or equal.
   7. On motors over 100 HP, provide insulated bearings on bearings on both ends of the motor or on the end opposite of the shaft ground ring as recommended by the motor manufacturer.

D. Single phase motors:
   1. Capacitor start type rated for operation at 115 volts, 60 hertz, unless otherwise specified or as indicated on the Drawings.
   2. Totally enclosed fan cooled (TEFC) motors manufactured in accordance with NEMA MG 1.
   3. Ball bearings: Sealed.
   4. 1/2 horsepower or less fan motors:
      a. Split-phase or shaded pole type when standard for the equipment.
      b. Open type when suitably protected from moisture, dripping water, and lint accumulation.
   5. Wound rotor or commutator type single-phase motors only when their specific characteristics are necessary for application and their use is acceptable to the Engineer.
   6. Integral overload protection.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Motor winding heaters:
   1. Provide all 3 phase motors with belted or cartridge space heaters mounted within the motor enclosure.
   2. Space heater rating shall be 120 volts, single-phase, unless otherwise indicated on the Drawings.
   3. Power leads for heaters wired into conduit box.
   4. Installed within motor enclosure adjacent to core iron.

B. Winding temperature detectors:
   1. Provide factory installed winding temperature detector with leads terminating in the conduit box:
      a. Where required by the driven equipment Specification or as indicated on the Drawings.
   2. Temperature switches with normally closed contacts as indicated on the Drawings.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Install motors in accordance with manufacturer's instructions.

C. Install shaft grounding ring on VFD driven motors in accordance with the manufacturer’s instructions.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING AND PROCESS START-UP

A. As specified in Section 01_75_17.

B. Factory testing:
   1. Motors less than 250 horsepower:
      a. Perform manufacturer’s standard production tests including but not limited to:
         1) No load current.
         2) High potential test.
         3) Winding resistance.
      b. Furnish copies of standard test reports on prototype or identical units.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

B. Before start-up, perform insulation resistance test on each motor furnished or installed on this project:
   1. Windings energized to 1,000 volts DC for 1 minute.
   2. Resistance measured at the end of the test, recorded, and submitted to the Engineer for review.
   3. Inform the Engineer of any unusual or unacceptable test results.
   4. This test is in addition to the acceptance tests in Section 26_08_50.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 26_05_00.

END OF SECTION

MOTOR DATA SHEET

MOTOR/ EQUIPMENT TAG ____________ MOTOR NUMBER ____________

SPECIFICATION NUMBER OF DRIVEN MACHINE ____________

MOTOR NAMEPLATE DATA

MANUFACTURER ________ MODEL/SERIES ________ MODEL NO. ________

FRAME ________ ENCLOSURE ________ NEMA DESIGN ________

HP ________ SERVICE FACTOR ________ RPM ________

INSULATION CLASS ________ VOLTS ________ FULL LOAD AMPS ________

AMBIENT TEMP ________ PHASE ________ NO LOAD AMPS ________

DESIGN TEMP ________ HERTZ ________ LOCK ROTOR AMPS ________

INRUSH CODE LETTER ________

	100% LOAD	75% LOAD	50% LOAD
GUARANTEED MINIMUM EFFICIENCIES:	________	________	________
GUARANTEED MINIMUM POWER FACTOR:	________	________	________

MAXIMUM SIZE OF POWER FACTOR CORRECTION CAPACITOR: ________ KVAR

ACCESSORIES

MOTOR WINDING HEATER ________ VOLTS ________ WATTS

WINDING THERMAL PROTECTION

WINDING TEMP SWITCHES (YES/NO) ________

RTD:

TYPE ________ QUANTITY PER PHASE ________ # OF WIRES ________

NOMINAL RESISTANCE ________ NOMINAL TEMP ________ COEFFICIENT ________

RECOMMENDED ALARM ________ DEGREES CELSIUS RECOMMENDED TRIP ________ DEGREES CELSIUS

SPECIAL APPLICATIONS

INVERTER DUTY* (YES/NO) ____ PART WINDING (YES/NO) ____ WYE - DELTA (YES/NO) ____

2 SPEED, 1 WINDING (YES/NO) ________ 2 SPEED, 2 WINDING (YES/NO) ________

AREA CLASSIFICATION:

CLASS ________ DIVISION ________ GROUP ________ TEMP CODE ________

* Conforms to NEMA MG-1 Part 31.

SECTION 26_05_18

600-VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. 600 volt class or less wire and cable.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 - Common Work Results for Electrical.
   4. Section 26_05_26 - Grounding and Bonding.
   5. Section 26_05_53 - Identification for Electrical Systems.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. ASTM International (ASTM):
   1. B3 - Standard Specification for Soft or Annealed Copper Wire.
   2. B8 - Standard Specification for Concentric-Lay–Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

C. CSA International (CSA).

D. Insulated Cable Engineers Association (ICEA):
   1. NEMA WC 70/ICEA S-95-658-1999 - Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
   2. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.

E. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).
   2. 72 - National Fire Alarm and Signaling Code.
   3. 101 - Life Safety Code.

F. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
   1. 568-C.2 - Balanced Twisted-Pair Telecommunication Cabling and Components Standard.

G. Underwriter's Laboratories Inc., (UL):
   1. 44 - Thermoset-Insulated Wires and Cables.
   2. 1277 - Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
   3. 1424 - Standard for Cables for Power-Limited Fire-Alarm Circuits.
   4. 1569 - Standard for Metal-Clad Cables.

5. 2196 - Standard for Tests for Fire Resistive Cables.
6. 2225 - Standard for Cables and Cable-Fittings For Use in Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

B. Definitions of terms and other electrical considerations as set forth in the:
1. ASTM.
2. ICEA.

1.04 SYSTEM DESCRIPTION

A. Furnish and install the complete wire and cable system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
1. Manufacturer of wire and cable.
2. Insulation:
    a. Type.
    b. Voltage class.
3. American wire gauge (AWG) size.
4. Conductor material.
5. Pulling compounds.

C. Shop drawings:
1. Show splice locations.
    a. For each proposed splice location provide written justification describing why the splice is necessary.

D. Test reports:
1. Submit test reports for meg-ohm tests.

E. Calculations:
1. Submit cable pulling calculations to the Engineer for review and comment for all cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:
    a. Provide a table showing the manufacturer’s recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
    b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. All wires and cables shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER`S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
  1. 600 volt class wire and cable:
     a. General Cable.
     b. Okonite Company.
     c. Southwire Company.
  2. Instrumentation class wire and cable:
     a. Alpha Wire Company.
     b. Belden CDT.
     c. General Cable BICC Brand.
     d. Okonite Company.
     e. Rockbestos Surprenant Cable Corporation.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Conductors:
  1. Copper in accordance with ASTM B3.

2.04 MANUFACTURED UNITS

A. General:
  1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
  2. Permanently mark each wire and cable with the following at 24-inch intervals:
     a. AWG size.

b. Voltage rating.
c. Insulation type.
d. UL symbol.
e. Month and year of manufacture.
f. Manufacturer's name.
3. Identify and mark wire and cable as specified in Section 26_05_53:
a. Use integral color insulation for Number 2 AWG and smaller wire.
b. Wrap colored tape around cable larger than Number 2 AWG.

B. 600 volt class wire and cable:
1. Provide AWG or kcmil sizes as indicated on the Drawings or in the Conduit Schedules:
a. When not indicated on the Drawings, size wire as follows:
1) In accordance with the NEC:
a) Use 75 degree Celsius ampacity ratings.
b) Ampacity rating after all derating factors, equal to or greater than rating of the overcurrent device.
2) Provide Number 12 AWG minimum for power conductors.
3) Provide Number 14 AWG minimum for control conductors.
2. Provide Class B stranding in accordance with ASTM B8:
a. Provide Class C stranding where extra flexibility is required.
3. Insulation:
a. XHHW-2.
b. 90 degrees Celsius rating.

C. Instrumentation class cable:
1. Type TC.
2. Suitable for use in wet locations.
3. Voltage rating: 600 volts.
4. Temperature rating:
a. 90 degrees Celsius rating in dry locations.
b. 75 degrees Celsius rating in wet locations.
5. Conductors:
a. Insulation:
1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
b. Number 16 AWG stranded and tinned.
c. Color code:
1) Pair: Black and white.
2) Triad: Black, white and red.
3) Multiple pairs or triads:
a) Color-coded and numbered.
6. Drain wire:
a. 18 AWG.
b. Stranded, tinned.
7. Jacket:
a. Flame retardant, moisture and sunlight resistant PVC.
b. Ripcord laid longitudinally under jacket to facilitate removal.
8. Shielding:
a. Individual pair/triad:
1) Minimum 1.35-mil double-faced aluminum foil/polyester tape overlapped to provide 100 percent coverage.

b. Multiple pair or triad shielding:
   1) Group shield: Minimum 1.35-mil double-faced aluminum foil/polyester tape overlapped to provide 100 percent coverage.
   2) Completely isolate group shields from each other.
   3) Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
c. All shielding to be in contact with the drain wire.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Wire ties:
   1. One of the following or equal:
      a. T&B "Ty-Rap" cable ties.
      b. Panduit cable ties.

B. Wire markers:
   1. As specified in Section 26_05_53.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Assembly and testing of cable shall comply with the applicable requirements of ICEA S-95-658-1999.

B. Test Type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Color-coding:
   1. Color-coding shall be consistent throughout the facility.
   2. The following color code shall be followed for all 240/120 volt and 208/120 volt systems:
      a. Phase A - Black.
      b. Phase B - Red.
      c. Phase C - Blue.

d. Single phase system - Black for one hot leg, red for the other.
e. Neutral - White.
f. High phase or wild leg - Orange.
g. Equipment ground - Green.

3. The following color code shall be followed for all 480/277 volt systems:
   a. Phase A - Brown.
   b. Phase B - Orange.
   c. Phase C - Yellow.
   d. Neutral - Gray.
   e. Equipment ground - Green.
4. The following color code shall be followed for all 120 VAC control wiring:
   a. Power - Red.
   b. Neutral - White.
5. The following color code shall be followed for all general purpose DC control circuits:
   a. Grounded conductors - White with blue stripe.
   b. Ungrounded conductors - Blue.
6. Switch legs shall be violet. Three-way switch runners shall be pink.
7. Wires in intrinsically safe circuits shall be light blue.
8. Wire colors shall be implemented in the following methods:
   a. Wires manufactured of the desired color.
   b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
      1) Colored tape shall be wrapped to overlap 1/2 of the width of the tape.

C. Install conductors only after the conduit installation is complete, and all enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
   1. Install wires only in approved raceways.
   2. Do not install wire:
      a. In incomplete conduit runs.
      b. Until after the concrete work and plastering is completed.

D. Properly coat wires and cables with pulling compound before pulling into conduits:
   1. For all Number 4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
      a. Ideal Products.
      b. Polywater Products.
      c. 3M Products.
      d. Greenlee Products.
      e. Or equal as recommended by cable manufacturer.
      f. Do not use oil, grease, or similar substances.

E. Cable pulling:
   1. Prevent mechanical damage to conductors during installation.
   2. For cables Number 1 AWG and smaller, install cables by hand.
   3. For cables larger than Number 1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
   4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.

5. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.
6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer's recommendation for the specified cable size:
   a. Make splices in manholes or pull boxes only.
   b. Leave sufficient slack to make proper connections.

F. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer's recommendations.

G. Install and terminate all wire in accordance with manufacturer's recommendations.

H. Neatly arrange and lace conductors in all switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
   1. Do not lace wires in gutter or panel channel.
   2. Install all wire ties with a flush cutting wire tie installation tool:
      a. Use a tool with an adjustable tension setting.
   3. Do not leave sharp edges on wire ties.

I. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug:
   1. Use ring type lugs if box lugs are not available on the equipment.

J. Lighting circuits:
   1. Each circuit shall have a dedicated neutral.

K. Apply wire markers to all wires at each end after being installed in the conduit and before meg-ohm testing and termination.

L. Instrumentation class cable:
   1. Install instrumentation class cables in separate raceway systems from power cables:
      a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
      b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
   2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
   3. Shield grounding requirements as specified in Section 26_05_26.

M. Signal cable:
   1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.

N. Wiring allowances:
   1. Equipment locations may vary slightly from the drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
   2. Locations for pull boxes, manholes, and duct banks may vary slightly from the drawings. Include an allowance for necessary conductors and related

materials to provide conductors to all pull boxes, manholes and duct banks within 20 linear feet of locations indicated on the Drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

B. Grounding:
   1. As specified in Section 26_05_26.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_05_21

LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Wire connecting devices.
   2. Terminations.
   3. Splices.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 - Common Work Results for Electrical.
   4. Section 26_05_18 - 600-Volt or Less Wires and Cables.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. ASTM International (ASTM):
   1. D3005 – Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.

C. CSA International (CSA):
   1. C22.2 - No.197-M1983 (R2208) - PVC Insulating Tape.

D. Underwriters Laboratories, Inc. (UL):
   1. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

1.04 SYSTEM DESCRIPTION

A. Provide a complete system of wiring connectors, terminators, fittings, etc. for a complete wiring system suitable for the cables and conductors used.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
   1. Catalog cut sheets.
   2. Installation instructions.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. All materials shall be UL listed.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Control connections:
   1. Use insulated ring type wire terminators for connections to all screw terminals:
      a. With chamfered/funneled terminal barrel entry.
      b. Deep internal serrations.
      c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.

d. Electroplated-tin copper conductor.
e. Manufacturer: The following or equal:
1) Thomas and Betts, Stakon.
2. For process equipment connections work from manufacturer's drawings.

B. Joints, taps, and connections:
1. 600-volt conductors:
a. Use solderless connectors.
b. Use only plated copper alloy connectors or lugs:
1) Aluminum connectors or lugs are not acceptable for copper conductors.
c. For wire Number 10 AWG and smaller use compression splice caps, with insulating caps:
1) Manufacturer: The following or equal:
a) Buchanan 2006S or 2011S, with 2007 or 2014 insulating caps.
d. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
1) Manufacturer: One of the following or equal:
a) Burndy.
b) Thomas and Betts.
e. Heat shrink tubing:
1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
2) Minimum shrink ratio: 4 to 1.
3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
4) Internally applied adhesive sealant.
5) Cross-linked polyolefin:
a) Manufacturers, one of the following or equal:
(1) 3M ITCSN.
(2) Thomas & Betts Shrink-Kon.

C. Insulating tape:
1. General purpose insulating tape:
a. Minimum 7 mil vinyl tape.
b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
d. Flame retardant, hot- and cold- weather resistant, UV resistant.
e. For use as a primary insulation for wire cable splices up to 600 VAC.
f. Meeting and complying with:
1) ASTM D3005 Type I.
2) UL 510.
3) CSA C22.2.
g. Manufacturer: The following or equal:
1) 3M - Scotch Number Super 33+.
2. General-purpose color-coding tape:
a. Minimum 7 mil vinyl tape.
b. Suitable for application on PVC and polyethylene jacketed cables.
c. For use indoors and outdoors in weather protected enclosures.
d. Available with the following colors:
1) Red.

2) Yellow.
3) Blue.
4) Brown.
5) Gray.
6) White.
7) Green.
8) Orange.
9) Violet.

e. For use as phase identification, marking, insulating, and harnessing.
f. Meeting and complying with:
   1) UL 510.
   2) CSA C22.2.
g. Manufacturer the following or equal:
   1) 3M - Scotch Number 35.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Load connections:
   1. Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 26_05_18.

C. Zero to 600-volt systems:
   1. Make all connections with the proper tool and die as specified by the device manufacturer.
   2. Use only tooling and dies manufactured by the device manufacturer.
   3. Insulate all connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
   4. Number all power and control wires before termination.

D. Motor connections (600 volts and below):
   1. Terminate wires with compression type ring lugs at motors.

2. Connection at both the motor leads and the machine wires shall have ring type compression lugs.
3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
   a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
   b. Shrink cap with low heat as recommended by manufacturer.
4. Wire markers shall be readable after boot installation.
5. Manufacturer: The following or equal:
   a. Raychem MCK.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_05_26

GROUNDING AND BONDING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Grounding materials and requirements.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 - Common Work Results for Electrical.
   4. Section 26_08_50 - Field Electrical Acceptance Tests.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. ASTM International (ASTM):
   1. B3 - Standard Specification for Soft or Annealed Copper Wire.
   2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.

D. Underwriters Laboratories, Inc. (UL):
   1. 467 - Ground and Bonding Equipment.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

1.04 SYSTEM DESCRIPTION

A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.

B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:
   1. Grounding electrodes.
   2. Bonding jumpers.
   3. Ground connections.

C. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.

D. The ground system resistance (electrode to ground) of the completed installation, as determined by tests specified in Section 26_08_50, shall be:
   1. 5 ohms or less for industrial systems.
   2. 1 ohm or less for electrical buildings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
   1. Catalog cut sheets.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. All grounding components and materials shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

1.08 PROJECT/SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Compression connectors: One of the following or equal:
   1. FCI Burndy.
   2. Thomas & Betts.

B. Ground rods: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Conex.

C. Ground cable: One of the following or equal:
   1. Nehring.
   2. Harger.
   3. Southwire.

D. Precast ground well boxes: One of the following or equal:
   1. Brooks Products, 3-RT Valve Box.
   2. Christy Concrete Products, G12 Valve Box.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Ground rod:
   1. Minimum: 3/4-inch diameter, 10 feet long.
   2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core:
      a. The copper-to-steel bond shall be corrosion resistant.
   3. In accordance with UL 467.
   4. Sectional type joined by threaded copper alloy couplings.
   5. Fit the top of the rod with a threaded coupling and steel-driving stud.

B. Ground cable:
   1. Requirements:
      a. Soft drawn (annealed).
      b. Concentric lay, coarse stranded in accordance with ASTM B8.
      c. Bare copper in accordance with ASTM B3.
   2. Size is as indicated on the Drawings, but not less than required by the NEC.

C. Compression connectors:
   1. Manufactured of high copper alloy specifically for the particular grounding application.
   2. Suitable for direct burial in earth and concrete.
   3. Identifying compression die number inscription to be impressed on compression fitting.

D. Equipment grounding conductors:
   1. Conductors shall be the same type and insulation as the load circuit conductors:
      a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
   2. Minimum size in accordance with the NEC.

E. Grounding electrode conductors:
   1. Minimum size in accordance with the NEC.

F. Main bonding jumpers and bonding jumpers:
   1. Minimum size in accordance with the NEC.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Precast ground well boxes:
   1. Minimum 10 inch interior diameter.
   2. Traffic-rated cast iron cover.
   3. Permanent “GROUND” marking on cover.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material.
   1. Provide a separate grounding conductor in each individual raceway for parallel feeders.

C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
   1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.

D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
   1. Individually bond these raceways to the ground bus in the equipment.

E. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.

F. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

G. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.

H. Duct bank ground system:
   1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.
   2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.

I. Grounding at service (600 V or Less):
   1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.

J. Ground connections:
   1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using compression type grounding connectors as indicated on the Drawings, UL listed, and labeled for the application.
   2. Make ground connections in accordance with the manufacturer's instructions.
   3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.

K. Grounding electrode system:
   1. Ground ring:
      a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
      b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size as indicated on the Drawings.
      c. Minimum burial depth 36 inches or as indicated on the Drawings.
      d. Re-compact disturbed soils to original density in 6-inch lifts.
   2. Ground rods:
      a. Locations as indicated on the Drawings.
      b. Length of rods forming an individual ground array shall be equal in length.
      c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
      d. Pre-crimp all ground rods, as recommended by the manufacturer, before crimping connector to ground rod.
   3. Metal underground water pipe:
      a. Bond metal underground domestic water pipe to grounding electrode system.
   4. Metal frame of building or structure:
      a. Bond metal frame of building or structure to grounding electrode system.
   5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
   6. Where grounding conductors are not concrete-encased or direct buried, install in Schedule 40 PVC conduit for protection.

7. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.

L. Shield grounding:
   1. Shielded instrumentation cable shall have its shield grounded at one end only unless shop drawings indicate otherwise:
      a. The grounding point shall be at the control panel or at the power source end of the signal carried by the cable.
   2. Terminate the shield drain wire on a dedicated terminal block.
   3. Use manufacturer’s terminal block jumpers to interconnect ground terminals.
   4. Connection to the panel main ground bus shall be via a green No. 12 conductor to the main ground bus for the panel.

M. Antenna ground:
   1. Install individual ground rod or ground system for communication system antenna:
      a. Install a dedicated grounding electrode conductor from the antenna ground to the grounding electrode system.
      b. Do not connect any other grounds to the antenna grounding electrode conductor.
   2. Install ground rod or ground system in accordance with the radio manufacturer's requirements.

N. Where indicated on the Drawings, install ground rods in precast ground wells.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.09 ADJUSTING

A. Under the direction of the Engineer, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:
   1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_05_29

HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Mounting and supporting electrical equipment and components.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_41_00 - Regulatory Requirements.
   3. Section 01_75_17 - Commissioning.
   4. Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   5. Section 09_91_00 - Painting.
   6. Section 26_05_00 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. ASTM International (ASTM):
   1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   3. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Conform to the requirements of the Building Code as specified in Section 01_41_00.
   2. Demonstrate the following using generally accepted engineering methods:
      a. That the anchors to the structure are adequate to resist the loads generated in accordance with the Building Code and equipment requirements.
      b. That the required load capacity of the anchors can be fully developed in the structural materials to which they are attached.
   3. Design loading and anchoring requirements:
      a. As indicated in the Building Code unless otherwise specified.

b. Seismic loading requirements:
   1) Freestanding, suspended, or wall-hung equipment shall be anchored in place by methods that will satisfy the requirements for the seismic design specified in Section 26_05_00.
c. Wind loading requirements:
   1) All exterior equipment shall be anchored in place by methods that will satisfy the requirements for wind design specified in Section 26_05_00.
d. Minimum safety factor against overturning: 1.5.
e. The foundation and structures to which hangers and supports are attached shall be capable of withstanding all anchor loads.

B. Performance requirements:
   1. Hangers and supports individually and as a system shall resist all weights and code-required forces without deflections and deformations that would damage the supporting elements, the equipment supported, or the surrounding construction.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
   1. Supports:
      a. Materials.
      b. Geometry.
      c. Manufacturer.
   2. Hardware:
      a. Materials.
      b. Manufacturer.

C. Shop drawings:
   1. Complete dimensioned and scalable shop drawings of all supporting structures, trapezes, wall supports, etc.
   2. Complete anchoring details for equipment, lighting and raceway, supporting structures, trapezes, wall supports for all equipment in excess of 200 pounds, and all freestanding supports:
      a. Stamped by a professional engineer licensed in the state where the Project is being constructed.
      b. Said submittals, by virtue of the fact that they bear the stamp of a registered engineer, will be reviewed for general consistency with the requirements specified in the Contract Documents, but not for context, accuracy, or method of calculation.
   3. Include data on attachment hardware and construction methods that will satisfy the design loading and anchoring criteria.

D. Installation instructions:
   1. Furnish anchorage instructions and requirements based on the seismic and wind conditions of the Site:
      a. Stamped by a professional engineer licensed in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM STARTUP

A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Thomas & Betts.
   2. Power-Strut.
   3. Unistrut.
   4. Cooper B-Line.
   5. Robroy.
   6. Aickinstrut.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Use materials appropriate for the area as specified in Section 26_05_00.

B. Hot dip galvanized steel:
   1. Supports:
      a. In accordance with ASTM A123 or A153.
      b. Minimum zinc coating thickness of 2.5 mils.
   2. Hardware:
      a. Electro-galvanized.

b. In accordance with ASTM A153.

C. Stainless steel:
1. Supports:
a. In accordance with ASTM A240.
b. ANSI Type 316 material.
2. Hardware:
a. ANSI Type 316 material.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Anchor bolts:
1. As specified in Section 05_05_24.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Paint and finish all supporting structures as specified in Section 09_91_00.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Mount all raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated racks unless otherwise indicated on the Drawings.
1. Provide the necessary sway bracing to keep trapeze type structures from swaying under seismic events or wind loading.

C. Brace and anchor freestanding equipment supports using methods that provide structural support based on the seismic loads and wind loads:
1. Lateral deflection at top of supports not to exceed support height divided by 240 unless otherwise approved by the Engineer.

D. Provide fabricated steel support pedestals for wall mounted panels that weigh more than 200 pounds:
   1. Fabricate pedestals out of welded angle, tube sections, or preformed channel.
   2. If the supported equipment is a panel or cabinet, match the supported equipment in physical appearance and dimensions.
   3. Provide auxiliary floor supports for transformers hung from stud walls and weighing more than 200 pounds.
   4. Mount all equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel.
      a. Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.

E. Corrosion protection:
   1. Isolate dissimilar metals, except where required for electrical continuity.
      a. Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.

F. Raceway:
   1. Furnish all racks and trapeze structures needed to support the raceway from the structure.
      a. Group raceway and position on racks to minimize crossovers.
      b. Provide the necessary bracing to keep trapeze type structures from swaying under loads from cable installation, seismic forces, or wind forces.

G. Anchoring methods:
   1. Solid concrete: Anchor bolts, anchor rods, or post-installed anchors as specified in Section 05_05_24.
   2. Metal surfaces: Machine screws or bolts.
   3. Hollow masonry units: Post-installed anchors as specified in Section 05_05_24.

H. Recoat or seal all drilled holes, cut or scratched surfaces or with products recommended by the manufacturer.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_05_33

CONDUITS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
1. Metallic conduits.
2. Nonmetallic conduits.
3. Conduit bodies.
4. Conduit fittings and accessories.
5. Conduit installation.

B. Related sections:
1. Section 01_33_00 - Submittal Procedures.
2. Section 01_75_17 - Commissioning.
3. Section 26_05_00 - Common Work Results for Electrical.
4. Section 26_05_29 - Hangers and Supports.
5. Section 26_05_53 - Identification for Electrical Systems.
6. Section 26_05_44 - Duct Banks.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. American National Standards Institute (ANSI):
1. C80.1 - Electrical Rigid Steel Conduit.
2. C80.3 - Steel Electrical Metallic Tubing.
3. C80.5 - Electrical Rigid Aluminum Conduit.
4. C80.6 - Electrical Intermediate Metal Conduit.

C. National Electrical Manufacturer’s Association (NEMA):
1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
2. TC2 - Electrical Polyvinyl Chloride (PVC) Conduit.
3. TC3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
4. TC7 - Smooth-Wall Coilable Electrical Polyethylene Conduit.
5. TC13 - Electrical Nonmetallic Tubing.
6. TC14 - Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

D. Underwriters Laboratories (UL):
1. 1 - Standard for Flexible Metal Conduit.
2. 6 - Standard for Electrical Rigid Metal Conduit - Steel.
3. 6A - Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel.
4. 360 - Standard for Liquidtight Flexible Steel Conduit.
5. 651 - Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
6. 651B - Standard for Continuous Length HDPE Conduit.

7. 797 - Standard for Electrical Metallic Tubing - Steel.
8. 1242 - Standard for Electrical Intermediate Metal Conduit - Steel.
9. 1653 - Standard for Electrical Nonmetallic Tubing.
10. 1660 - Standard for Liquidtight Flexible Nonmetallic Conduit.
11. 1684 - Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

B. Specific definitions and abbreviations:
1. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to, Shapes C, E, LB, T, X, etc.
2. Conduit fitting: An accessory that primarily serves a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.
3. GRC: Galvanized rigid steel conduit.
4. PCS: Polyvinyl chloride (PVC) coated rigid steel conduit.
5. PVC: Polyvinyl chloride rigid nonmetallic conduit.
6. SLT: Sealtight-liquidtight flexible conduit.
7. NPT: National pipe thread.

1.04 SYSTEM DESCRIPTION

A. Provide conduits, conduit bodies, fittings, junction boxes, and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
1. Furnish complete manufacturer’s catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
2. Furnish complete manufacturer’s recommended special tools to be used for installation if required.
3. Certified test results for PVC-coated metallic conduit showing the adhesive bond is stronger than the tensile strength of the PVC.

C. Certifications:
1. Furnish PVC-coated conduit manufacturer’s certification for each installer.

D. Record Documents:
1. Incorporate all changes in conduit routing on electrical plan drawings.
2. Dimension underground and concealed conduits from building lines.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. All conduits, conduit bodies, and fittings shall be UL listed and labeled.

C. Every installer of PVC-coated metallic conduit shall be certified by the manufacturer for installation of the conduit.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

B. Do not expose nonmetallic to direct sunlight.

C. Do not store conduit in direct contact with the ground.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING

A. Before installing any conduit or locating any device box:
   1. Examine the complete set of Drawings and Specifications, and all applicable shop drawings.
   2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Galvanized rigid steel conduit:
   1. One of the following or equal:
      a. Western Tube and Conduit.
      b. Allied Tube and Conduit.
      c. Wheatland Tube Co.

B. PVC-coated rigid steel conduit:
   1. One of the following or equal:
      a. Robroy Industries.
      b. Ocal, Inc.

c. Calbond.

C. Sealtight-liquidtight flexible conduit:
1. One of the following or equal:
a. Southwire.
b. AFC Cable Systems.
c. Electri-Flex Company.
d. Anaconda.

D. Conduit bodies:
1. One of the following or equal:
a. Crouse-Hinds.
b. Appleton.
c. O-Z/Gedney.
d. Ocal, Inc.
e. Robroy Industries.
f. Calbond.
g. Carlon.

E. Joint compound:
1. Thomas and Betts.

F. Galvanized rigid steel conduit expansion fittings:
1. One of the following or equal:
a. Crouse-Hinds.
b. Appleton.
c. O-Z/Gedney.

G. Conduit hangers and supports:
1. As specified in Section 26_05_29.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. GRC:
1. All threads: NPT standard conduit threads with a 3/4-inch taper per foot:
a. Running conduit threads are not acceptable.
2. Hot-dip galvanized inside and out:
a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
b. Electro-galvanizing is not acceptable.
3. Manufactured in accordance with:
a. UL-6.
b. ANSI C80.1.

B. PCS:
   1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for Type GRC.
   2. Coated conduit NEMA Standard RN-1:
      a. The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
   3. Factory-bonded PVC jacket:
      a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
      b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictates otherwise.
      c. PVC coating on conduits and associated fittings shall have no sags, blisters, lumps, or other surface defects and shall be free of holes and holidays.
      d. The PVC adhesive bond on conduits and fittings shall be greater than the tensile strength of the PVC plastic coating:
         1) Confirm bond with certified test results.
   4. A urethane coating shall be uniformly and consistently applied to the interior of all conduits and fittings:
      a. Nominal thickness of 0.002 inch.
      b. Conduits having areas with thin or no coating are not acceptable.
      c. All threads shall be coated with urethane.
   5. The PVC exterior and urethane interior coatings applied to the conduits shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
   6. PCS conduit bodies and fittings:
      a. Malleable iron.
      b. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.
      c. The PVC coating on the outside of conduit bodies shall be 0.040-inch thick and have a series of longitudinal ribs to protect the coating from tool damage during installation.
      d. 0.002-inch interior urethane coating.
      e. Utilize the PVC coating as an integral part of the gasket design.
      f. Stainless steel cover screw heads shall be encapsulated with plastic to ensure corrosion protection.
      g. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
         1) The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
         2) The sleeve shall provide a vapor- and moisture-tight seal at every connection.

C. SLT:
   1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
      a. General purpose:
         1) Temperature range: -20 degrees Celsius to +80 degrees Celsius.
      b. Oil-resistant:
         1) Temperature range: -20 degrees Celsius to +60 degrees Celsius.
   2. Sunlight-resistant, weatherproof, and watertight.

3. Manufactured from single strip steel, hot-dip galvanized on all 4 sides before conduit fabrication.
4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
5. Overall PVC jacket.
6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 1-1/4 inch.

D. PVC:
1. Extruded from virgin PVC compound:
   a. Schedule 40 unless otherwise specified.
   b. Schedule 80 extra-heavy wall where specified.
2. Rated for 90 degrees Celsius conductors or cable.
3. Rated for use in direct sunlight.

E. Conduit bodies:
1. Material consistent with conduit type:
   a. Malleable iron bodies and covers when used with Type GRC.
   b. PVC-coated malleable iron bodies and covers when used with Type PCS.
2. Conduit bodies to conform to Form 8, Mark 9, or Mogul design:
   a. Mogul design conforming to NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire-bending space.
3. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

2.07 ACCESSORIES

A. Connectors and fittings:
1. Manufactured with compatible materials to the corresponding conduit.

B. Insulated throat metallic bushings:
1. Construction:
   a. Malleable iron or zinc-plated steel when used with steel conduit.
   b. Positive metallic conduit end stop.
   c. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
   d. Use fully insulated bushings on nonmetallic conduit system made of high-impact 150 degrees Celsius rated non-combustible thermosetting phenolic.

C. Insulated grounding bushings:
1. Construction:
   a. Malleable iron or steel, zinc-plated, with a positive metallic end stop.
   b. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
   c. Tin-plated copper grounding saddle for use with copper or aluminum conductors.

D. Electrical unions (Erickson Couplings):
1. Construction:
   a. Malleable iron for use with steel conduit.
   b. Concrete tight, 3-piece construction.

c. Rated for Class I Division 1 Group D in hazardous areas.

E. SLT fittings:
1. Construction:
a. Malleable iron.
b. Furnished with locknut and sealing ring.
c. Liquidtight, rain-tight, oil-tight.
d. Insulated throat.
e. Furnish as straight, 45-degree elbows, and 90-degree elbows.
f. Designed to prevent sleeving:
1) Verify complete bonding of the raceway jacket to the plastic gasket seal.
g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device, if inserted into raceway and directly in contact with conductors, shall have rolled-over edges for sizes under 5 inches.
h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture-resistant/oil-resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.
2. Corrosion-resistant and outdoor SLT fittings:
a. Construction:
1) PVC-coated liquidtight fittings with a bonded 0.040-inch thick PVC coating on the metal connector to form a seal around the SLT conduit.
2) Insulated throat and an integral sealing ring.

F. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
1. Construction:
a. Insulated throat.
b. PVC-coated when used in corrosive areas.
c. Bonding locknut.
d. Recessed neoprene O-ring to ensure watertight and dust-tight connector.
e. One half (1/2)-inch through 1-1/4-inch steel zinc electroplated.
f. One and one half (1-1/2)-inch through 6-inch malleable iron zinc plated.
2. Usage:
a. All conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.

G. PVC fittings:
1. Materials:
a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.
b. All metal hardware shall be stainless steel.

H. Expansion/deflection couplings:
1. Use to compensate for movement in any directions between 2 conduit ends where they connect.
2. Shall allow movement of 3/4 inch from the normal in all directions.
3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.

4. Constructed to maintain electrical continuity of the conduit system.
5. Materials:
    a. End couplings: Bronze or galvanized ductile iron.
    b. Sleeve: Neoprene.
    c. Bands: Stainless steel.
    d. Bonding jumper: Tinned copper braid.

I. Expansion couplings:
1. Shall allow for expansion and contraction of conduit:
    a. Permitting 8-inch movement, 4 inches in either direction.
2. Constructed to maintain electrical continuity of the conduit system.
3. Materials:
    a. Head: Malleable or ductile iron.
    b. Sleeve: Steel.
    c. Insulating bushing: Phenolic.
    d. Finish: Hot-dip galvanized.

J. Conduit markers:
1. As specified in Section 26_05_53.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 26_05_00.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. General:
1. Conduit routing:
    a. The electrical drawings are diagrammatic in nature:
        1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
        2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
            a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
            b) Make changes in conduit routing due to the relocation of equipment.

3) The electrical drawings do not indicate all required junction boxes and pull boxes:
   a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
      (1) To meet cable manufacturer's pulling tension requirements.
      (2) To limit total conduit bends between pull locations.
   b) Install junction boxes and pull boxes at locations acceptable to the Engineer.

b. The Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
   1) The Engineer is the sole source in determining whether the change is constituted as a deviation:
   2) Perform any changes resulting in additional conduits, or extra work from such deviations.
   3) Incorporate any deviations on the Record Documents.

2. Use only tools recommended by the conduit manufacturer for assembling the conduit system.
3. Provide adequate clearances from high-temperature surfaces for all conduit runs.
4. Do not install 1-inch or larger conduits in or through structural members unless approved by the Engineer.
5. Run conduits exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
   a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
   b. Make changes in direction with long radius bends or with conduit bodies.
6. Install conduits with total conduit bends between pull locations less than or equal to 270 degrees.
7. Route all exposed conduits to preserve headroom, access space and work space, and to prevent tripping hazards and clearance problems:
   a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment-removal hatches.
   b. Route conduits to avoid drains or other gravity lines. Where conflicts occur, relocate the conduit as required.
8. When installing conduits through existing slabs or walls, make provisions for locating any possible conflicting items where the conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into the existing conduits, piping, cables, post-tensioning cables, etc.
9. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
10. For 2-inch and larger conduit runs, snake conduits with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit:
    a. Remove and replace conduits through which mandrel will not pass.
11. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
12. Install complete conduit systems before conductors are installed.

13. Provide metallic conduits terminating in transformer, switchgear, motor control center, or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
14. Underground conduits:
    a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
        1) As specified in Section 26_05_44.
    b. Make underground conduit size transitions at handholes and manholes.
    c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.
    d. Seal around conduit penetrations of below grade walls with a mechanical seal.

C. Lighting and receptacle conduits:
1. Provide conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings:
2. Install conduits in accordance with the requirements of this Section unless otherwise indicated.
3. Minimum conduit size:
    a. 3/4-inch for exposed conduits.
    b. 1-inch for underground or in-slab conduits.
4. Provide conduit materials for the installed location as specified in Section 26_05_00.

D. Conduit usage:
1. Exposed conduits:
    a. Rigid conduit:
        1) Install the rigid conduit type for each location as specified in Section 26_05_00.
        2) Minimum size: 3/4-inch.
    b. Flexible conduit:
        1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment, or where required for equipment servicing:
            a) Use Type SLT with rigid metallic conduit.
        2) Minimum size: 3/4-inch:
            a) 1/2 when required for connection to instruments.
        3) Maximum length:
            a) Fixed equipment:

Conduit Trade Size	**Flexible Conduit Length (inch)**
3/4	18
1	18
1-1/4	18
1-1/2	18
2	36
2-1/2	36

Conduit Trade Size	Flexible Conduit Length (inch)
3	36
3-1/2	38
4	40

b) Removable instruments or hinged equipment:
(1) As required to allow complete removal or full movement without disconnecting or stressing the conduit.

2. Concrete-encased and embedded conduits:
a. Type PVC Schedule 40 and PVC-coated rigid metallic conduit as specified below:
1) Use Type PCS in underground and embedded installation as follows:
a) Stub-up and risers to grade floor or equipment from nonmetallic conduits.
b) Entering and exiting underground or embedded conduit runs a minimum 12 inches above and below grade of finished floor.
c) For any and all bends where the total deflection is greater than 45 degrees.
b. Minimum size:
1) 2-inch in duct banks unless otherwise indicated on the Drawings.
2) 1-inch for in-slab conduits unless otherwise indicated on the Drawings.
3. Direct-buried and sand-bedded duct bank conduits:
a. Type PCS.
b. Minimum size: 1-inch.
4. PVC-coated rigid metallic conduit:
a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.
5. GRC:
a. Conduit shall be cut square and reamed before threading.
6. PVC:
a. Conduit terminations shall be via threaded adapters into threaded hubs on the junction boxes or conduit bodies.
b. Conduit terminations into boxes without threaded hubs shall utilize a threaded adapter and a flat neoprene washer on the outside of the box.
1) Use a locknut on the inside of the box to tighten the adapter to the box.
c. Route conduit to afford it the maximum physical protection.
1) If necessary, cover conduit to afford additional protection when it cannot be shielded by the structure or machinery frames.
a) Use Schedule 80 where exposed runs may be subject to physical damage.

E. Conduit joints and bends:
1. General:
a. Where conduit is underground, under slabs on grade, exposed to the weather, or in NEMA Type 4 or NEMA Type 4X locations, make joints liquidtight.
b. Keep bends and offsets in conduit runs to an absolute minimum.
c. All bends shall be symmetrical.

d. The following conduit systems shall use large-radius sweep elbows:
   1) Underground conduits.
   2) Conduits containing shielded cables.
e. Provide large-radius factory-made bends for 1-1/4-inch trade size or larger.
f. Make field bends with a radius of not less than the requirements found in the NEC:
   1) The minimum bending radius of the cable must be less than the radius of the conduit bend.
   2) Make all field bends with power bending equipment or manual benders specifically intended for the purpose:
      a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
      b) For the serving utilities, make bends to meet their requirements.
g. Replace all deformed, flattened, or kinked conduit.

2. Threaded conduit:
   a. Cut threads on rigid metallic conduit with a standard conduit-cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench-tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
   b. Thoroughly ream conduit after threads have been cut to remove burrs.
   c. Use bushings or conduit fittings at conduit terminations.
   d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing “Galvabar,” or CRC “Zinc It.”
   e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
      1) Apply to the male threads and tighten joints securely.
      2) Clean excess sealant from exposed threads after assembly.
   f. Securely tighten all threaded connections.
   g. Any exposed threaded surfaces must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.

3. PVC:
   a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray-type cement is not allowed.
   b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to ensure full inside diameter at all bends:
      1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

F. Conduit sealing and drainage:
   1. Conduit drainage and sealing:
      a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above-grade conduit runs at the points at which the conduit enters buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
      b. Provide seal fittings with drains in vertical drops directly above grade for exterior and above-grade conduit runs that are extended below grade.

c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
   1) Where portions of an interior raceway pass through walls, ceilings, or floors that separate adjacent areas having widely different temperatures.

G. Conduit supports:
1. General:
   a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
      1) As specified in Section 26_05_29.
      2) Provide support materials consistent with the type of conduit being installed as specified in Section 26_05_00.
   b. Support conduit at the intervals required by the NEC.
   c. Perforated strap and plumbers tape are not acceptable for conduit supports.
2. Conduit on concrete or masonry:
   a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
   b. Use preset inserts in concrete when possible.
   c. Use pipe spacers (clamp backs) in wet locations.
   d. On plaster or stucco, use 1-hole malleable iron straps with toggle bolts.
3. Conduit on metal decking:
   a. Use 1-hole malleable iron straps with 1-inch long cadmium-plated Type A panhead sheet-metal screws. Fully or partially hammer-driven screws are not acceptable.
4. Suspended conduit:
   a. Use malleable-iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.
   b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2-feet long, provide rigid sway bracing.
5. Supports at structural steel members:
   a. Use beam clamps.
   b. Drilling or welding may be used only as specified or with approval of the Engineer.
6. PVC-coated rigid metal systems:
   a. Provide right-angle beam clamps and “U” bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide "U" bolts with PVC-encapsulated nuts that cover the exposed portions of the threads.
   b. Securely fasten exposed conduits with Type 316 stainless steel clamps or straps.

H. Expansion or expansion/deflection fittings:
1. General:
   a. Align expansion coupling with the conduit run to prevent binding.
   b. Follow manufacturer’s instructions to set the piston opening.

c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
d. Furnish fittings of the same material as the conduit system.

I. Empty conduits:
1. Provide a polyethylene rope rated at 250 pounds tensile strength in each empty conduit more than 10 feet in length.
2. Seal ends of all conduits with approved, manufactured conduit seals, caps, or plugs immediately after installation:
a. Keep ends sealed until immediately before pulling conductors.

J. Miscellaneous:
1. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
a. Running threads and threadless couplings are not allowed.
2. Replace any conduits installed that the Engineer determines do not meet the requirements of this Specification.

3.04 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_05_34

BOXES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Device boxes.
   2. Raceway system boxes.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. ASTM International (ASTM):
   1. A47 - Standard Specification for Ferritic Malleable Iron Castings.
   2. D149 - Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
   3. D495 - Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
   4. D570 - Standard Test Method for Water Absorption of Plastics.
   5. D648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
   6. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
   7. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

C. Joint Industry Conference (JIC).

D. Underwriters Laboratories, Inc. (UL):
   1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

B. Specific definitions:
   1. Raceway system boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.

1.04 SYSTEM DESCRIPTION

A. Provide outlet boxes for devices such as switches, receptacles, telephone and computer jacks, security systems, junction, and pullboxes for use in the raceway systems, etc.

B. Provide boxes as indicated on the Drawings or as needed to complete the raceway installation.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
   1. Manufacturer.
   2. Materials.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
      d. Weight.
      e. NEMA rating.
   4. Conduit entry locations.
   5. Catalog cut sheets.
   6. Installation instructions.

C. Shop drawings:
   1. Include identification and sizes of pull boxes.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. Regulatory requirements:
   1. Outlet boxes shall comply with all applicable standards of:
      a. JIC.
      b. NEC.
      c. NEMA.
      d. UL.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING

A. As specified in Section 26_05_00.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Plastic coated boxes:
      a. Rob Roy.
      b. OCAL.
   2. Cast device boxes:
      a. Appleton.
      b. Crouse - Hinds.
      c. OZ/Gedney.
   3. Formed steel enclosures:
      a. Hoffman.
      b. Thomas and Betts.
      c. Stahlin.
      d. Rittal.
   4. Stainless steel enclosures:
      a. Hoffman.
      b. Stahlin.
      c. Rittal.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Cast device boxes:
   1. Construction:
      a. With internal green ground screw.
      b. Furnished with a suitable gasketed cover.
      c. With integral cast mounting lugs when surface mounted.
      d. Conduit sizes range from 3/4 inch to 1 inch.
      e. Tapered threaded hubs with integral bushing.
   2. Malleable iron boxes:
      a. Conforming to ASTM A47 Grade 32510.

B. Plastic coated cast device boxes:
   1. Construction:
      a. With internal green ground screw.
      b. Furnished with a suitable gasketed cover.
      c. With integral cast mounting lugs when surface mounted.
      d. Conduit sizes range from 3/4 inch to 1 inch.
      e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
      f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
      g. With pressure sealing sleeve to protect the connection with conduit.

C. Formed steel enclosures:
   1. Steel:
      a. NEMA Type 12.
      b. Fabricated from 14-gauge steel, minimum.
      c. All seams continuously welded ground smooth.
      d. Door:
         1) Rolled lip around 3 sides.
         2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
      e. Neoprene door gasket to provide a watertight, dusttight, oiltight seal:
         1) Attached with an adhesive.
         2) Retained by a retaining strip.
      f. Fabricate all external removable hardware for clamping the door to the enclosure body from zinc-plated heavy gauge steel:
         1) With a hasp and staple for padlocking.
      g. Provide large enclosures with door and body stiffeners for extra rigidity.
      h. No holes or knockouts.
      i. Finish:
         1) ANSI-61 gray electrostatically applied polyester powder inside and out over cleaned and primed surfaces.
         2) White electrostatically applied polyester powder mounting plate.
      j. Heavy gauge steel external mounting brackets when surface mounted.
   2. Stainless steel:
      a. NEMA Type 4X:
         1) Boxes in locations subject to flooding or temporary submersion:
            a) NEMA Type 6.
      b. Fabricated from 14-gauge Type 316 stainless steel.
      c. All seams continuously welded.
      d. Door:
         1) Rolled lip around 3 sides.
         2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
      e. Neoprene door gasket to provide a watertight seal:
         1) Attached with an adhesive.
         2) Retained by a retaining strip.
      f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
         1) With a hasp and staple for padlocking.
      g. Provide large enclosures with door and body stiffeners for extra rigidity.
      h. No holes or knockouts.

i. Finish:
    1) Brushed.
j. Stainless steel external mounting brackets when surface mounted.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Fasteners:
1. Electroplated or stainless steel in boxes with wiring devices.
2. Screws, nuts, bolts, and other threaded fasteners:
    a. Stainless steel.

B. Provide breather and drain fittings where appropriate.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. General:
1. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 26_05_00.
2. Provide outlet box materials to match the conduit system:
    a. GRC - Cast ferrous boxes.
    b. PCS - PVC coated cast ferrous boxes.
3. Solid type gang boxes:
    a. For more than 2 devices.
    b. For barriered outlets.
4. Support all wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
    a. Use machined spacers to maintain air space; built-up washers are not acceptable.
    b. Use stainless steel or nylon materials for spacers.
5. Use cast malleable iron boxes when box must support other devices.

6. Boxes serving luminaires or devices:
   a. Use as pull boxes wherever possible.
7. Size boxes in accordance with NEC requirements and to provide sufficient room for the future components and cables indicated on the Drawings.
8. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.

C. Outlet boxes:
   1. Locate outlet boxes as indicated on the Drawings:
      a. Adjust locations so as not to conflict with structural requirements or other trades.
   2. Use deep threaded-hub malleable iron boxes:
      a. To act as a pull box for conductors in a conduit system.
      b. Accommodate wiring devices.
   3. Use deep threaded-hub plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the conduit system is PVC coated steel.
   4. Outlet boxes may be used as junction boxes wherever possible.

D. Pull boxes and junction boxes:
   1. Size pull boxes in accordance with NEC requirements and to provide sufficient room for any future conduits and cables as indicated on the Drawings.
   2. Install pull boxes such that access to them is not restricted.

E. For boxes not indicated:
   1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 26_05_00.
   2. Outlet, switch, and junction boxes where surface mounted in exposed locations:
      a. Cast ferrous boxes with mounting lugs, zinc, or cadmium plating finish.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 26_05_00.

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_05_44

DUCT BANKS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Electrical underground duct banks.
   2. Duct bank installation requirements.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 03_20_00 - Concrete Reinforcing.
   4. Section 03_30_00 - Cast-In-Place Concrete.
   5. Section 26_05_33 - Conduits.
   6. Section 26_05_00 - Common Work Results for Electrical.
   7. Section 31_23_17 - Trenching.

1.02 REFERENCES

A. As specified in Section 26_05_00.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

1.04 SYSTEM DESCRIPTION

A. Provide trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.

B. Provide reinforced concrete duct banks for all conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
   1. PVC conduit spacers.
   2. Detectable underground marking tape.
   3. Pull line.

C. Provide applicable submittal documents as specified in:
   1. Section 03_20_00.
   2. Section 03_30_00.
   3. Section 31_23_17.

D. Shop drawings:
    1. Submit site plan drawings of duct banks including underground profiles indicating all underground utilities.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Conduit spacers:
    1. One of the following or equal:
        a. Carlon Snap-Loc.
        b. Cantex.
        c. Osburn Associates, Inc.

B. Detectable underground marking tape:
    1. One of the following or equal:
        a. Blackburn Manufacturing Company.
        b. Pro-Line Safety Products.
        c. Panduit.

C. Pull line:
    1. One of the following or equal:
        a. Arnco.
        b. Greenlee.

c. Osburn Associates, Inc.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Provide conduit as specified in Section 26_05_33:
   1. Use duct suitable for use with 90-degree Celsius rated conductors.

B. Provide reinforcing steel as specified in Section 03_20_00:
   1. Provide minimum Number 4 reinforcing steel.

2.04 MANUFACTURED UNITS

A. Conduit spacers:
   1. Provide conduit spacers recommended by the conduit manufacturer or specified above.
   2. Saddle type.
   3. Non-metallic, non-corrosive, non-conductive.
   4. Interlocking type:
      a. Vertical interlocking.
      b. Horizontal interlocking.
   5. Suitable for concrete encasement.
   6. Molded-in rebar holder.
   7. Accommodates 2-inch through 6-inch conduit sizes.
   8. Relieves the conduit from both horizontal and vertical stresses.

B. Pull line:
   1. Minimum 1/4-inch wide, flat design.
   2. Polyester.
   3. Minimum pulling strength 1,200 pounds.

C. Detectable marking tape:
   1. Provide a detectable tape, locatable by a cable or metal detector from above the undisturbed grade.
   2. Aluminum core laminated between polyethylene film.
   3. Six-inch wide red tape imprinted with black lettering "CAUTION - BURIED ELECTRIC UTILITIES".

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES

A. Concrete mix requirements as specified in Section 03_30_00.

B. Provide a red-oxide conduit encasement coloring agent as specified in Section 03_30_00.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Duct banks:
   1. Install duct banks encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
   2. Damage minimization:
      a. Conduit should not be left exposed in an open trench longer than is necessary.
      b. Protect all underground duct banks against damage during pouring of concrete or backfilling.
   3. All plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
   4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system as indicated on the Drawings.
      a.
   5. Install pull line in spare conduits:
      a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
      b. Cap above ground spare conduit risers at each end with screw-on conduit caps.

C. Trenching:
   1. Perform trenching as specified in Section 31_23_17.
   2. Trench must be uniformly graded with the bottom, rock free and covered with select material.
   3. Whenever possible, use the walls of the trench as forms for concrete encasement:
      a. Forms are required where the soil is not self-supporting.
   4. Avoid damaging existing ducts, conduits, cables, and other utilities.

D. Duct spacing:
   1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 2 inches, unless otherwise indicated on the Drawings.

2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
   a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
      1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
         a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
3. Spacers shall not be located at the center of a bend:
   a. Locate spacer in the tangent, free of the coupling on fabricated bends.
   b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.

E. Concrete:
1. Install concrete as specified in Section 03_30_00.
2. Provide nonferrous tie wires to prevent displacement of the conduits during pouring of concrete:
   a. Tie wire shall not act as a substitute for spacers.
3. Install minimum 3-inch cover around conduit and rebar.
4. Consolidation of encasement concrete around duct banks shall be by hand pudding, with no mechanical vibration.
5. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.

F. Marking tape:
1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

G. For conduit installations beneath building slabs:
1. Install steel reinforced concrete duct banks under all building slabs as indicated on the Drawings:
   a. Concrete for encasement under building slabs need not be colored red.
   b. For duct banks crossing under building footers or foundations, install the top of the duct bank a minimum of 12 inches below the footer.
   c. Where duct banks enter through building walls, foundation walls, stem walls, etc. make connections as indicated on the Drawings.
   d. Where duct banks terminate with conduit risers entering building walls, install an expansion/deflection fitting or a flat-wise elbow (elbow parallel to building wall) in order to accommodate differential movement between the conduits and structure.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.11 PROTECTION

A. As specified in Section 26_05_00.

B. Provide shoring and pumping to protect the excavation and safety of workers.

C. Protect excavations with barricades as required by applicable safety regulations.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_05_53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Identification of electrical equipment, devices, and components.
   2. Material, manufacturing, and installation requirements for identification devices.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 - Common Work Results for Electrical.
   4. Section 26_05_33 - Conduits.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

1.04 SYSTEM DESCRIPTION

A. Nameplates:
   1. Provide a nameplate for each piece of electrical equipment and devices, control panel and control panel components.
   2. Provide all nameplates of identical style, color, and material throughout the facility.
   3. Device nameplates information:
      a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.

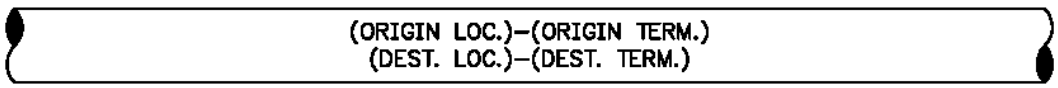
B. Wire numbers:
   1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
      a. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
      b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
      c. Internal panel wires on a common terminal shall have the same wire number.
      d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations

beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:

1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers in Section 26_05_33.

2. Provide the following wiring numbering schemes throughout the project for field wires between process control module, (PCM), vendor control panels, (VCP), motor control centers, (MCC), field starters, field instruments, etc.

OR



Where:

ORIGIN LOC.	= Designation for originating panel or device
ORIGIN TERM.	= Terminal designation at originating panel or device
DEST. LOC.	= Designation for destination panel or device
DEST. TERM.	= Terminal designation at destination panel or device or PLC

I/O address at destination panel:

a. Identify equipment and field instruments as the origin.
b. PCMs are always identified as the destination.
c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments, and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g. T1, T2, T3, etc.).
f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: The following PLC I/O numbering scheme is typical for Allen-Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):
    1) Discrete Point: W:X:Y/Z
    Analog Point: W:X:Y.Z
    Where:
    W = I for input, O for output
    X = PLC number (1, 2, 3…)
    Y = Slot number (01, 02, 03…)
    Z = Terminal number (00, 01, 02…) for a discrete point or a word number for an analog point (1, 2, 3…)

g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g. C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g. C0010A).

3. **Case 1**: Vendor control panel (VCP) to process control module (PCM):
Field wire number/label: A-B/C-D
A = Vendor control panel number without hyphen (VCP#)
B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)
C = Process control module number without hyphen (PCM#)
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

Examples: VCP#-10/PCM#-I:1:01/01
VCP#-10/PCM#-O:1:10/07
VCP#-10/PCM#-C0100

4. **Case 2**: Field instrument to process control module (PCM):
Field wire number/label: E-F/C-D
C = Process control module number without hyphen (PCM#)
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
E = Field mounted instrument tag and loop numbers without hyphen (EDV#)
F = Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

Examples: TIT#-2,3/PCM#-I:1:01.1
TSH#-1/PCM#-I:2:01/00

5. **Case 3**: Motor control center (MCC) to process control module (PCM):
Field wire number/label: G-B/C-D
B = Terminal number within Motor Control Center (manufacturer's or vendor's standard terminal number)
C = Process control module without hyphen (PCM#)
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
G = Actual starter designation in the motor control center without hyphen (MMS#)

Examples: MMS#-10/PCM#-I:1:01/01
MMS#-10/PCM#-O:1:10/07
MMS#-10/PCM#-C0100

6. **Case 4**: Motor control center (MCC) to vendor control panel (VCP):
Field wire number/label: G-B/A-B
A = Vendor control panel number without hyphen (VCP#)
B = Terminal number within motor control center or vendor control panel (manufacturer's or vendors standard terminal number)

G = Actual starter designation in the motor control center without hyphen (MMS#)

Example: MMS#-X2/VCP#-10

7. **Case 5**: Motor leads to a motor control center (MCC):
Field wire number/label: H-I/G-B
B = Terminal number within motor control center (manufacturer's standard terminal number)
G = Actual starter designation in the motor control center without hyphen (MMS#)
H = Equipment tag and loop number without hyphen (PMP#)
I = Motor manufacturer's standard motor lead identification (e.g. T1, T2, T3, etc.)

Example: PMP-#-T3/MMS#-T3

8. **Case 6**: Remote or separately mounted starter or variable frequency drive (VFD) to process control module (PCM):
Field wire number/label: J-B/C-D
B = Terminal number within starter or variable frequency drive (manufacturer's standard terminal number)
C = Process control module number without hyphen (VCP#)
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
J = Starter or variable frequency drive tag and loop number without hyphen (MMS#)

Examples: MMS#-10/PCM#-I:1:01/01
MMS#-10/PCM#-O:2:10/07
MMS#-10/PCM#-C0010

9. Identify all spare conductors as required for other field wires with an "S" prefix:

Example: S MMS#-10/PCM#-C011

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
1. Nameplates:
   a. Color.
   b. Size:
      1) Outside dimensions.
      2) Lettering.
   c. Material.
   d. Mounting means.
2. Nameplate schedule:
   a. Show exact wording for each nameplate.
   b. Include nameplate and letter sizes.

3. Wire numbers:
    a. Manufacturer's catalog data for wire labels and label printer.

C. Record documents:
    1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

1.08 PROJECT SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nameplates and signs:
    1. One of the following or equal:
        a. Brady.
        b. Seton.

B. Conductor and cable markers:
    1. Heat-shrinkable tubing:
        a. One of the following or equal:
            1) Raychem.
            2) Brady.
            3) Thomas & Betts.
            4) Kroy.

C. Conduit and raceway markers:
    1. One of the following or equal:
        a. Almetek: Mini Tags.
        b. Lapp Group: Maxi System.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Nameplates:
   1. Fabricated from white-center and red face or black-center, white face laminated plastic engraving stock:
      a. 3/32-inch thick material.
      b. Two-ply.
      c. With chamfered edges.
      d. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
         1) No characters smaller than 1/8-inch in height.

B. Signs:
   1. Automatic equipment and high voltage signs:
      a. Suitable for exterior use.
      b. In accordance with OSHA regulations.

C. Conductor and cable markers:
   1. Machine printed black characters on white tubing.
   2. Ten point type or larger.

D. Conduit and raceway markers:
   1. Non-metallic:
      a. UV resistant holder and letters.
      b. Black letters on yellow background.
      c. Minimum letter height: 1/2-inch.
      d. Adhesive labels are not acceptable.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Nameplates:
   1. Provide all nameplates for control panel operator devices (e.g. pushbuttons, selector switches, pilot lights, etc.):
      a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Nameplates:
   1. Attach nameplates to equipment with rivets, bolts, or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
   2. On NEMA Type 4, NEMA Type 4X, enclosures, use epoxy-based cement to attach nameplates.
   3. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:
      a. Misaligned or crooked nameplates shall be remounted, or provide new enclosures at the discretion of the Engineer.

C. Conductor and cable markers:
   1. Apply all conductor and cable markers before termination.
   2. Heat-shrinkable tubing:
      a. Tubing shall be shrunk using a heat gun that produces low temperature heated air.
      b. Tubing shall be tight on the wire after it has been heated.
      c. Characters shall face the open panel and shall read from left to right or top to bottom.
      d. Marker shall start within 1/32 inch of the end of the stripped insulation point.

D. Conduit markers:
   1. Furnish and install conduit markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system.
   2. Mark conduits at the following locations:
      a. Each end of conduits that are greater than 10 feet in length.
      b. Where the conduit penetrates a wall or structure.
      c. Where the conduit emerges from the ground, slab, etc.
      d. The middle of conduits that are 10 feet or less in length.
   3. Mark conduits after the conduits have been fully painted.
   4. Position conduit markers so that they are easily read from the floor.
   5. Attach non-metallic conduit markers with nylon cable ties:
      a. Provide ultraviolet resistant cable ties for conduit markers exposed to direct sunlight.
   6. Mark conduits before construction review by Engineer for punch list purposes.
   7. Label intrinsically safe conduits in accordance with the requirements of the NEC.

E. Signs and labeling:
   1. Furnish and install warning signs on equipment that has more than one source of power.
      a. Warning signs to identify every panel and circuit number of the disconnecting means of all external power sources.
   2. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
      a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. Replace any nameplates, signs, conductor markers, cable markers, or raceway labels that in the sole opinion of the Engineer do not meet the Engineer's aesthetic requirements.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_05_74

ELECTRICAL SYSTEM STUDIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Short-circuit fault analysis study.
   2. Protective device coordination study.
   3. Arc-flash hazard study.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 141 - IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (Red Book).
   2. 242 - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).
   3. 315 - IEEE Standards Electrical and Electronics Graphic and Letter Symbols and Reference Designations.
   4. 399 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis (Brown Book).
   5. 902 - IEEE Guide for Maintenance, Operation and Safety on Industrial and Commercial Power Systems (Yellow Book).
   6. 1015 - IEEE Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems - Corrigendum 1 (Blue Book).
   7. 1584 - IEEE Guide for Performing Arc Flash Hazard Calculations.

C. National Fire Protection Association (NFPA):
   1. 70E - Standard for Electrical Safety in the Workplace.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

1.04 SYSTEM DESCRIPTION

A. General study requirements:
   1. Scope:
      a. The short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall include all equipment in the power distribution system including, but not limited to:
         1) Utility equipment.
         2) Circuit breakers.
         3) Automatic transfer switches.
         4) Generators.
         5) Transformers:
            a) Including all dry-type transformers.
         6) Freestanding variable frequency drives and starters.
         7) Disconnect switches.
         8) Motors.
         9) Panelboards:
            a) Including all 240- and 208-volt systems.
         10) Vendor control panels.
         11) HVAC equipment.
      b. Study scenarios:
         1) The studies shall include all possible electrical system configurations, for example:
            a) Operation on normal (utility) source.
            b) Operation on generator source.
   2. Obtain, for all equipment, the required data for preparation of the study including, but not limited to:
      a. Transformer kilovolt-ampere (kVA) and impedances.
      b. Generator impedances.
      c. Generator decrement curves.
      d. Bus withstand ratings.
      e. Cable and bus data.
      f. Protective device taps, time dials, instantaneous pickups, and time-delay settings.
   3. Obtain the Electric Utility information on the minimum and maximum available fault current, minimum and maximum utility impedances, utility protective device settings including manufacturer and model number, interrupting ratings, X/R ratios, and model information one level above the point of connection:
      a. Utility tolerances and voltage variations.
   4. The individual performing the studies shall visit the site and collect all necessary field data in order to perform and complete comprehensive electrical system studies.
   5. Obtain equipment layouts and configurations from the manufacturer's final submittal requirements and project layout drawings as required.
   6. Bus and conductor data:
      a. Use impedances of the actual installed or specified conductors, unless otherwise indicated.
      b. Use cable and bus impedances calculated at 25 degrees Celsius, unless otherwise indicated.
      c. Use 600-volt cable reactance based on typical dimensions of actual installed or specified conductors, unless otherwise indicated.
      d. Use bus withstand values for all equipment having buses.

7. Motors:
   a. Each motor shall be individually modeled:
      1) Grouping of motors for fault contribution current is not acceptable.
   b. Motors with variable frequency drives may be assumed to have no contribution to fault current.
8. Use the equipment, bus, and device designations as indicated on the Drawings for all studies.

B. Short-circuit fault analysis study additional requirements:
   1. The short-circuit fault analysis shall be performed and submitted in 2 phases:
      a. Initial short-circuit fault analysis:
         1) Based on the Contract Documents and Electric Utility information.
         2) The initial short-circuit fault analysis study shall indicate the estimated available short-circuit current at the line side terminals of each piece of equipment covered by the scope of the study.
         3) Provide a list of assumptions used in the initial study.
      b. Final short-circuit fault analysis:
         1) The final short-circuit fault analysis shall modify the initial analysis as follows:
            a) Utilize the actual equipment provided on the project.
            b) Utilize conductor lengths based on installation.
   2. Calculate 3-phase bolted fault, line-to-line fault, line-to-ground fault, double line-to-ground fault, short-circuit 1/2 cycle momentary symmetrical and asymmetrical RMS, 1-1/2 to 4 cycle interrupting symmetrical RMS, and 30-cycle steady-state short-circuit current values at each piece of equipment in the distribution system.
   3. Evaluate bus bracing, short-circuit ratings, fuse interrupting capacity and circuit-breaker-adjusted interrupting capacities against the fault currents, and calculate X/R values:
      a. Identify and document all devices and equipment as either inadequate or acceptable.
   4. Calculate line-to-ground and double line-to-ground momentary short-circuit values at all buses having ground-fault devices.
   5. Provide calculation methods, assumptions, one-line diagrams, and source impedance data, including utility X/R ratios, typical values, recommendations, and areas of concern.

C. Protective device coordination study additional requirements:
   1. Furnish protective device settings for all functions indicated on the Drawings including, but not limited to.
   2. Provide log-log form time-current curves (TCCs) graphically indicating the coordination proposed for the system:
      a. Include with each TCC a complete title and one-line diagram with legend identifying the specific portion of the system covered by the particular TCC:
         1) Typical TCCs for identical portions of the system, such as motor circuits, are acceptable as allowed by the Engineer.
      b. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics:
         1) These details can be included on the TCC.

c. Include a detailed description of each protective device tap, time dial, pickup, instantaneous, and time delay settings:
    1) These details can be included on the TCC.
3. TCCs shall include all equipment in the power distribution system where required to demonstrate coordination. Include utility relay and fuse characteristics low-voltage equipment circuit breaker trip device characteristics, transformer characteristics, motor and generator characteristics, and characteristics of other system load protective devices:
    a. Include all devices down to the largest branch circuit and largest feeder circuit breaker in 480 volt power panels, main breaker in branch panelboards.
    b. Provide ground fault TCCs with all adjustable settings for ground fault protective devices.
    c. Include manufacturing tolerances and damage bands in plotted fuse and circuit breaker characteristics.
    d. On the TCCs, show transformer full load currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and transformer damage curves.
    e. Cable damage curves.
    f. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed based on the short-circuit fault analysis study.
4. Site generation: When site generation (including cogeneration, standby, and emergency generators) is part of the electrical system, include phase and ground coordination of the generator protective devices:
    a. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices.
5. Suggest modifications or additions to equipment rating or settings in a tabulated form.

D. Arc-flash hazard study additional requirements:
1. Include the calculated arc-flash boundary and incident energy (calories/square centimeter) at each piece of equipment in the distribution system:
    a. Perform study with 15 percent arcing fault variation as defined by IEEE 1584.
    b. Perform arc-flash calculations at minimum and maximum utility and generator fault contributions.
    c. Perform arc-flash calculations for both the line side and load side of the switchgear, switchboard, motor control center, and panelboard main breakers.
    d. Perform arc-flash calculations for all short-circuit scenarios with all motors on for 3 to 5 cycles and with all motors off.
    e. Protective device clearing time shall be limited to 2 seconds, maximum.
2. Provide executive summary of the study results:
    a. Provide summary based upon worst case results.
3. Provide a detailed written discussion and explanation of the tabulated outputs:
    a. Include all scenarios.
4. Provide alternative device settings to allow the Owner to select the desired functionality of the system:
    a. Minimize the arc-flash energy by selective trip and time settings for equipment maintenance purposes.

b. Identify the arc-flash energy based upon the criteria of maintaining coordination and selectivity of the protective devices.

E. Electrical system study meetings:
1. The individual conducting the short-circuit fault analysis, protective device coordination, and the arc-flash hazard studies shall meet with the Owner and Engineer 3 times.
2. The purpose of the 3 meetings is as follows:
a. Initial meeting:
1) Meet with the Owner and Engineer to discuss the scope of the studies.
2) Discuss the Owner's operational requirements for both normal operation and maintenance.
b. Preliminary results meeting:
1) This meeting will be held after the studies have been completed, reviewed, and accepted by the Engineer.
2) The purpose of this meeting is to inform the Owner of the results of the study and impacts on normal operation and maintenance including:
a) Protective device coordination problems and recommended solutions.
b) Explanation of the arc-flash hazard study results and its potential impact on operations.
c) Recommendations for reduction of arc-flash category levels including reduction of protective device settings or changes in operational practices.
c. Final meeting:
1) Discuss changes to the studies based on the previous meeting.
2) Discuss with the Owner how changes to the electrical system may change the arc-flash hazard category.
3) Deliver the final electrical system studies report.
3. The meetings will be at the Owner's facility:
a. Provide a minimum of 3-weeks notice to the Owner and Engineer in advance of the projected meeting date.
b. Submit a draft of the meeting agenda when each meeting is requested.
4. Meeting materials:
a. Prepare and provide the following materials:
1) Meeting agenda. Include, at a minimum, the scope of the meeting, estimated time length for the meeting, and meeting goals.
2) 4 copies of the project one-line diagrams for the initial meeting.
3) 4 copies of the submitted studies.

F. By virtue of the fact that this is a professional study, the Owner reserves the right to modify the requirements of the study to comply with its operational requirements. The protective device coordination study and the arc-flash hazard study shall be modified based on the results of the meetings with the Owner.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Initial studies and reports:
   1. Include the following in the initial short-circuit current report:
      a. List of all devices included in the studies.
      b. A description of all operating scenarios.
      c. Form and format of arc-flash labels.

C. Final studies and reports:
   1. Format and quantity:
      a. Provide 6 bound copies of all final reports.
      b. Provide 3 complete sets of electronic files on CD or DVD media, including the electrical system model(s), configuration files, custom libraries, and any other files used to perform the studies and produce the reports. Also provide an electronic version of the bound reports in PDF format.
      c. Provide the number of copies specified in Section 01_33_00.
   2. Include the sections below in the final report:
      a. Copies of correspondence and data obtained from the electric utility company.
      b. Letter certifying the inspection and verification of existing equipment.
      c. One-line diagrams:
         1) The following information shall be included at a minimum:
            a) Motor horsepower.
            b) Transformer data:
               (1) kVA.
               (2) Configuration.
            c) Cable data:
               (1) Insulation.
               (2) Size.
               (3) Length.
         2) One-line diagrams shall be fully legible at 11-inch by 17-inch size.
      d. Include in the short-circuit fault analysis study:
         1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
         2) Normal system connections and those that result in maximum fault conditions.
         3) Tabulation of circuit breaker, fuse, and other protective device ratings compared to maximum calculated short-circuit duties.
         4) Fault current calculations for the cases run including a definition of terms and guide for interpretation of computer software printouts.
      e. Protective device coordination study shall include:
         1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
         2) List all requirements used in the selection and setting criteria for any protective devices.
         3) Manufacturer’s time-current curves for circuit breakers, fuses, motor circuit protectors, and other protective devices for all new equipment.
         4) TCCs graphically indicating the coordination proposed for the system on log-log graphs. All copies shall be in color.
         5) Tabulation of relay, fuse, circuit breaker, and other protective devices in graphical form with a one-line diagram to display area coordination.
         6) Where coordination could not be achieved, an explanation shall be included in the report to support the statement along with

recommendations to improve coordination. Recommended equipment modifications or settings shall be in a tabulated form.

f. Include in the arc-flash hazard study:
   1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
   2) Normal system connections and those that result in maximum arc-flash conditions.
   3) Arc-flash raw data, calculations, and assumptions.
   4) Arc-flash label data:
      a) Identifying the content of each label.
      b) Identifying the location of each label.

D. Certification:
   1. Submit written certification, sealed and signed by the professional engineer conducting the study, equipment supplier, and electrical subcontractor stating that the data used in the study is correct.

E. Submit the credentials of the individual(s) performing the study and the individual in responsible charge of the study.

F. The Engineer will review all studies and reports. After review, the Engineer will make recommendations and/or require changes to be made to the short-circuit fault analysis, protective device coordination, or arc-flash hazard studies. These changes shall be provided as part of the scope of work.

G. Submit course outline for Owner's training.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. Qualifications of the entity responsible for electrical system studies:
   1. The studies shall be performed, stamped, and signed by a professional engineer registered in the state where the project is located.
   2. A minimum of 5 years of experience in power system analysis is required for the individual in responsible charge of the studies.
   3. The short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall be performed with the aid of a digital computer program:
      a. Point-to-point calculations are not acceptable.

C. The study shall be performed by an independent firm.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT/SITE CONDITIONS (NOT USED)

1.09 SEQUENCING

A. Submit the initial short-circuit fault analysis study before submittal of any electrical equipment.

B. Initial electrical system study meeting.

C. Submit the preliminary short-circuit fault analysis, protective device coordination, and arc-flash hazard studies.

D. Second electrical system study meeting for preliminary results.

E. Final arc-flash meeting and final short-circuit fault analysis, protective device coordination, and arc-flash hazard studies.

F. Label equipment with approved arc-flash labels.

G. Owner's training.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Electrical system study software: One of the following or equal:
  1. ETAP by Operation Technology Inc.
  2. Powertools by SKM Systems Analysis.
  3. Paladin DesignBase by Power Analytics Corporation.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Arc-flash hazard labels:
  1. Dimensions:
     a. Minimum 5 inches by 3.5 inches.
  2. Materials:
     a. Polyester with polyvinyl polymer over-laminate.
     b. Self-adhesive.
     c. Resistant to:
        1) UV.
        2) Chemicals and common cleaning solvents.
        3) Scuffing.
        4) Wide temperature changes.

3. Contents:
   a. Short-circuit bus identification.
   b. Calculated incident energy (calories/square centimeter) range:
      1) Based on worst-case study results.
   c. Arc-flash protection boundary.
   d. Shock hazard boundary:
      1) The Contractor may provide separate labels for indication of the shock hazard boundary.
   e. Description of the combined level of personnel protective equipment.
4. Color scheme:
   a. For locations above 40 calories/square centimeter:
      1) White label with red “DANGER” strip across the top.
      2) Black lettering.
   b. For locations below 40 calories/square centimeter:
      1) White label with orange “WARNING” strip across the top.
      2) Black lettering.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. After review and acceptance of the arc-flash hazard study by the Engineer, install all arc-flash hazard labels:
1. Install labels at all locations required by NFPA, ANSI, or IEEE standards.
2. At a minimum, install labels in the following locations:
   a. The front of each main or incoming service compartment.
   b. The front of each accessible auxiliary or conductor compartment.
   c. Each panelboard covered by the study.
   d. Each control panel, individual starter or VFD, or other equipment covered by the scope of the study.
3. Install labels prior to equipment energization.

C. After review and acceptance of the arc-flash hazard study and protective device coordination study by the Engineer, adjust protective device settings per final study prior to equipment energization.
   1. Devices that require power for configuration may be set during energization, but before any subfed loads are energized.
   2. Ensure that settings for upstream equipment are set prior to energizing downstream devices.

3.04 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

B. The individual performing the arc-flash hazard study shall direct the installation of the arc-flash hazard labels:
   1. Remove and replace any improperly applied labels.
   2. Repair the equipment finish damaged by removal of any label.
   3. Install labels level or plumb across the entire dimension of the label.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_08_50

FIELD ELECTRICAL ACCEPTANCE TESTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Responsibilities for testing the electrical installation.
   2. Adjusting and calibration.
   3. Acceptance tests.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 - Common Work Results for Electrical.
   4. Section 26_05_26 - Grounding and Bonding.

C. Copyright information:
   1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc (NETA). See NETA publication ATS for details.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. American National Standards Institute (ANSI).

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
   2. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
   3. 95 - IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2300 V and Above) With High Direct Voltage.
   4. 421.3 - IEEE Standard for High-Potential Test Requirement for Excitation Systems for Synchronous Machines.
   5. 450 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
   6. 1106 - IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.
   7. 1188 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.
   8. C57.13 - IEEE Standard Requirements for Instrument Transformers.
   9. C57.13.1 – IEEE Guide for Field Testing of Relaying Current Transformers.
   10. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.

11. C57.104 - IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.

D. Insulated Cable Engineer's Association (ICEA).

E. InterNational Electrical Testing Association (NETA).
   1. ATS-2009 Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.

F. International Electrotechnical Commission (IEC).

G. Manufacturer's testing recommendations and instruction manuals.

H. National Fire Protection Association (NFPA):
   1. 70 – National Electrical Code (NEC).
   2. 110 - Standard for Emergency and Standby Power Systems.

I. National Institute of Standards and Technology (NIST).

J. Specification sections for the electrical equipment being tested.

K. Shop drawings.

1.03 DEFINITIONS

A. As specified in Sections 01_75_17 and 26_05_00.

B. Specific definitions:
   1. Testing laboratory: The organization performing acceptance tests.

1.04 SYSTEM DESCRIPTION

A. Testing of all electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.

B. Conduct all tests in the presence of the Engineer or the Engineer's representative:
   1. Engineer will witness all visual, mechanical and electrical tests, and inspections.

C. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.

D. Responsibilities:
   1. Contractor responsibilities:
      a. Ensure that all resources are made available for testing, and that all testing requirements are met.
   2. Electrical subcontractor responsibilities:
      a. Perform routine tests during installation.
      b. Demonstrate operation of electrical equipment.
      c. Commission the electrical installation.

d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:
1) Providing electrical power as required.
2) Operating of electrical equipment in conjunction with testing of other equipment.
3) Activating and shutting down electrical circuits.
4) Making and recording electrical measurements.
5) Replacing blown fuses.
6) Installing temporary jumpers.

3. Testing laboratory responsibilities:
a. Perform all acceptance tests specified in this Section.
b. Provide all required equipment, materials, labor, and technical support during acceptance tests.

E. Upon completion of testing or calibration, attach a label to all serviced devices:
1. The label shall indicate the date serviced and the company that performed the service.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. LAN cable test form:
1. LAN cable test reports:
a. Submit 3 copies of test reports showing the results of all tests specified in this Section:
1) Test type.
2) Test location.
3) Test date.
4) Cable number.
5) Cable length.
6) Certification that the cable meets or exceeds the specified standard.
b. Furnish hard copy and electronic copy for all traces.

C. Manufacturers’ testing procedures:
1. Submit manufacturers’ recommended testing procedures and acceptable test results for review by the Engineer.

D. Test report:
1. Include the following:
a. Summary of Project.
b. Description of equipment tested.
c. Description of tests performed.
d. Test results.
e. Conclusions and recommendations.
f. Completed test forms.
g. List of test equipment used and calibration dates.
h. LAN cable test reports.

E. Testing laboratory qualifications:
1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
1) Corporate history and references.
2) Resume of individual performing test.
3) Equipment list and test calibration data.

F. Division of responsibilities:
1. Submit a list identifying who is responsible for performing each portion of the testing.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. Testing laboratory qualifications:
1. The testing laboratory may be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
2. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

1.07 DELIVERY, STORAGE, AND PROTECTION (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING

A. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.

B. Perform testing in the following sequence:
1. Perform routine tests as the equipment is installed including:
a. Insulation-resistance tests.
b. Continuity tests.
c. Rotational tests.
2. Adjusting and preliminary calibration.
3. Acceptance tests.
4. Demonstration.
5. Commissioning and plant start-up.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Test instrument calibration:
   1. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy.
   2. The accuracy shall be traceable to the NIST in an unbroken chain.
   3. Calibrate instruments in accordance with the following frequency schedule:
      a. Field instruments: 6 months maximum.
      b. Laboratory instruments: 12 months maximum.
      c. Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
   4. Dated calibration labels shall be visible on all test equipment.
   5. Maintain an up-to-date instrument calibration record for each test instrument:
      a. The records shall show the date and results of each calibration or test.
   6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.

B. Do not begin testing until the following conditions have been met:
   1. All instruments required are available and in proper operating condition.
   2. All required dispensable materials such as solvents, rags, and brushes are available.
   3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.
   4. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
   5. Data sheets to record all test results are available.

C. Engine generator tests:
   1. The following individuals must be present and remain at the site during the entire field testing of the engine generator:
      a. Manufacturer’s field engineer for the voltage regulator.
      b. Manufacturer’s field engineer for the governor and governor controller.
      c. Manufacturer’s field engineer for the switchgear.
      d. Load bank operator.
      e. Electrical contractor.

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. Dry type transformers:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with the Contract Documents.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, and grounding.
      d. Verify that resilient mounts are free and that any shipping brackets have been removed.
      e. Inspect equipment for cleanliness.
      f. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low-resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
      g. Verify that as-left tap connections are as specified.
   2. Electrical tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
         1) Apply voltage in accordance with manufacturer’s published data.
            a) Refer to NETA ATS tables in the absence of manufacturer’s published data.
      c. Calculate dielectric absorption ration or polarization index.
      d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral after energization and before loading.
   3. Test values:
      a. Compare bolted connection resistance values to values of similar connections:
         1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
      b. Bolt-torque levels shall be in accordance with manufacturer’s published data:
         1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
      c. Tap connections are left as found unless otherwise specified.
      d. Minimum insulation-resistance values of transformer insulation shall be in accordance with manufacturer’s published data:
         1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
         2) Investigate insulation values less than the allowable minimum.

e. The dielectric absorption ratio or polarization index shall not be less than 1.0.
f. Turns-ratio results should not deviate more than 1/2 percent from either the adjacent coils or calculated ratio.
g. Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.

B. Low voltage cables, 600 volt maximum:
1. Visual and mechanical inspection:
a. Compare cable data with the Drawings and Specifications.
b. Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.
c. Inspect bolted electrical connections for high resistance by 1 of the following methods:
1) Use of low-resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
d. Inspect compression applied connectors for correct cable match and indentation.
e. Inspect for correct identification and arrangement.
f. Inspect cable jacket insulation and condition.
2. Electrical tests:
a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
b. Perform insulation resistance test on each conductor with respect to ground and adjacent conductors:
1) Applied potential shall be 500 volts dc for 300 volt rated cable and 1,000 volts dc for 600 volt rated cable.
2) Test duration shall be 1 minute.
c. Perform continuity tests to insure correct cable connection.
d. Verify uniform resistance of parallel conductors.
3. Test values:
a. Compare bolted connection resistance values to values of similar connections:
1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Insulation-resistance values shall be in accordance with manufacturer's published data:
1) Refer to NETA ATS tables in the absence of manufacturer's published data.
2) Investigate values of insulation-resistance less than the allowable minimum.
c. Cable shall exhibit continuity.
d. Investigate deviations in resistance between parallel conductors.

C. Low voltage molded case and insulated case circuit breakers:
1. Visual and mechanical inspection:
a. Compare equipment nameplate data with the Contract Documents.
b. Inspect physical and mechanical condition.
c. Inspect anchorage and alignment.

d. Verify that all maintenance devices are available for servicing and operating the breaker.
e. Verify the unit is clean.
f. Verify the arc chutes are intact.
g. Inspect moving and stationary contacts for condition and alignment.
h. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.
i. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism in accordance with manufacturers published data.
j. Operate circuit breaker to ensure smooth operation.
k. Inspect bolted electrical connections for high resistance by one of the following methods:
    1) Use of low-resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
l. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
m. Verify cell fit and element alignment.
n. Verify racking mechanism operation.
o. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
p. Perform adjustments for final protective device settings in accordance with the coordination study.
q. Record as-found and as-left operation counter readings.

2. Electrical tests:
    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    b. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
        1) Apply voltage in accordance with manufacturer's published data.
        2) Refer to NETA ATS tables in the absence of manufacturer's published data.
    c. Perform a contact/pole-resistance test.
    d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:
        1) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
    e. Determine long-time pickup and delay by primary current injection.
    f. Determine short-time pickup and delay by primary current injection.
    g. Determine ground-fault pickup and delay by primary current injection.
    h. Determine instantaneous pickup value by primary current injection.
    i. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
    j. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function and trip unit battery condition:
        1) Reset all trip logs and indicators.
    k. Verify operation of charging mechanism.

3. Test values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer’s published data:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   c. Insulation-resistance values shall be in accordance with manufacturer’s published data:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
      2) Investigate values of insulation-resistance less than the allowable minimum.
   d. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer’s published data:
      1) If manufacturer’s data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
   e. Insulation-resistance values of control wiring shall not be less than 2 megohms.
   f. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer’s published time-current characteristic tolerance band including adjustment factors:
      1) If manufacturer’s curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
   g. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer’s published time-current tolerance band.
   h. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer’s published time-current tolerance band.
   i. Instantaneous pickup values shall be as specified and within manufacturer’s published tolerances:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   j. Pickup values and trip characteristics shall be within manufacturer’s published tolerances.
   k. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer’s published data:
      1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   l. Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.
   m. The charging mechanism shall operate in accordance with manufacturer’s published data.

D. Grounding systems:
   1. Visual and mechanical inspection:
      a. Inspect ground system for compliance with that indicated on the Drawings, specified in Specifications, and in the NEC.
      b. Inspect physical and mechanical condition.

c. Inspect bolted electrical connections for high resistance using one of the following methods:
   1) Use of low-resistance ohmmeter.
   2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
      a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
d. Inspect anchorage.

2. Electrical tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.
   c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points.
3. Test values:
   a. Grounding system electrical and mechanical connections shall be free of corrosion.
   b. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   c. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   d. The resistance between the main grounding electrode and ground shall be as specified in Section 26_05_26. Investigate point-to-point resistance values that exceed 0.5 ohm.

E. Rotating machinery:
1. Visual and mechanical inspection:
   a. Compare equipment nameplate information with the Contract Documents.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, and grounding.
   d. Inspect air baffles, filter media, cooling fans, slip rings, brushes, brush rigging, and shaft current discharge devices.
   e. Inspect bolted electrical connections for high resistance using one of the following methods:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
         a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
   f. Perform special tests such as gap spacing and machine alignment if applicable.
   g. Manually rotate the rotor and check for problems with the bearings or shaft.
   h. Rotate the shaft and measure and record the shaft extension runout.
   i. Verify correct application of appropriate lubrication and lubrication systems.

j. Verify that resistance temperature detector (RTD) circuits conform to that indicated on the Drawings.

2. Electrical tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform insulation-resistance test in accordance with IEEE 43:
      1) On motors 200 horsepower and smaller, test duration shall be 1 minute. Calculate dielectric absorption ratio.
      2) On motors larger than 200 horsepower, test duration shall be 10 minutes. Calculate polarization index.
   c. Perform dc dielectric withstand voltage tests on machines rated at 2,300 volts and greater in accordance with IEEE 95.
      1) IEEE 95 for dc dielectric withstand voltage tests.
      2) NEMA MG1 for ac dielectric withstand voltage tests.
   d. Perform phase-to-phase stator resistance test on machines rated at 2,300 volts and greater.
   e. Perform insulation-resistance test on insulated bearings in accordance with manufacturer's published data.
   f. Test surge protection devices as specified in this Section.
   g. Test motor starter as specified in this Section.
   h. Perform resistance tests on resistance temperature detector (RTD) circuits.
   i. Verify operation of motor space heater.
   j. Perform a rotation test to ensure correct shaft rotation.
   k. Measure running current and evaluate relative to load conditions and nameplate full-load amperes.
3. Test values:
   a. Inspection:
      1) Air baffles shall be clean and installed in accordance with the manufacturer's published data.
      2) Filter media shall be clean and installed in accordance with the manufacturer's published data.
      3) Cooling fans shall operate.
      4) Slip ring alignment shall be within manufacturer's published tolerances.
      5) Brush alignment shall be within manufacturer's published tolerances.
      6) Brush rigging shall be within manufacturer's published tolerances.
   b. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   c. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   d. Air-gap spacing and machine alignment shall be in accordance with manufacturer's published data.
   e. The recommended minimum insulation-resistance ($IR_{1\ min}$) test results in megohms shall be as specified in this Section.
      1) The polarization index value shall not be less than 2.0.
      2) The dielectric absorption ratio shall not be less than 1.4.

f. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
g. Investigate phase-to-phase stator resistance values that deviate by more than 10 percent.
h. Power factor or dissipation factor values shall be compared to manufacturer's published data:
   1) In the absence of manufacturer's published data compare values of similar machines.
i. Tip-up values shall indicate no significant increase in power factor.
j. If no evidence of distress, insulation failure, or waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, the test specimen is considered to have passed the test.
k. Bearing insulation-resistance measurements shall be within manufacturer's published tolerances:
   1) In the absence of manufacturer's published data compare values of similar machines.
l. Test results of surge protection devices shall be as specified in this Section.
m. Test results of motor starter equipment shall be as specified in this Section.
n. RTD circuits shall conform to the design intent and machine protection device manufacturer's published data.
o. Heaters shall be operational.
p. Vibration amplitudes shall not exceed values in NETA ATS tables:
   1) If values exceed those in the NETA ATS tables, perform a complete vibration analysis.
q. Machine rotation should match required rotation of connected load.
r. Running phase-to-phase voltages should be within 1.0 percent. Running currents shall be balanced and proportional to load condition and nameplate data.

F. Variable frequency drive systems:
1. Visual and mechanical inspection:
   a. Compare equipment nameplate data with the Contract Documents.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, and grounding.
   d. Verify the unit is clean.
   e. Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
   f. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
   g. Motor running protection:
      1) Verify drive overcurrent setpoints are correct for their application.
      2) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
      3) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.
   h. Inspect bolted electrical connections for high resistance using one of the following methods:
      1) Use of low-resistance ohmmeter.

2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
   a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

i. Verify correct fuse sizing in accordance with manufacturer's published data.

j. Perform visual and mechanical inspection of input circuit breaker as specified in this Section.

2. Electrical tests:
   a. Perform resistance measurements through bolted connections with low resistance ohmmeter.
   b. Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
   c. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:
      1) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
   d. Test for the following parameters in accordance with relay calibration procedures specified in this Section or as recommended by the manufacturer:
      1) Input phase loss protection.
      2) Input overvoltage protection.
      3) Output phase rotation.
      4) Overtemperature protection.
      5) Direct current overvoltage protection.
      6) Overfrequency protection.
      7) Drive overload protection.
      8) Fault alarm outputs.
   e. Perform continuity tests on bonding conductors as specified in this Section.
   f. Perform start-up of drive in accordance with manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.
   g. Perform operational tests by initiating control devices:
      1) Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
      2) Verify operation of drive from remote start/stop and speed control signals.
   h. Perform electrical tests of input circuit breaker as specified in this Section.

3. Test values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Overload test trip times at 300 percent of overload element rating shall be in accordance with manufacturer's published time-current curve.

d. Test values for input circuit breaker shall be as specified in this Section.
e. Insulation-resistance values for control wiring shall not be less than 2.0 megohms.
f. Relay calibration results shall be as specified in this Section.
g. Continuity of bonding conductors shall be as specified in this Section.
h. Control devices shall perform in accordance with system requirements.
i. Operational tests shall conform to system design requirements.

G. Surge arresters, low-voltage:
1. Visual and mechanical inspection:
a. Compare equipment nameplate data with the Contract Documents.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify the arresters are clean.
e. Inspect bolted electrical connections for high resistance using one of the following methods:
1) Use of low-resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
f. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
g. Verify that stroke counter is correctly mounted and electrically connected, if applicable.
h. Record stroke counter reading.
2. Electrical tests:
a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
b. Perform an insulation-resistance test on each arrester, phase terminal- to- ground:
1) Apply voltage in accordance with manufacturers published data.
2) Refer to NETA ATS tables in the absence of manufacturer’s published data.
c. Test grounding connection as specified in this Section.
3. Test values:
a. Compare bolted connection resistance values to values of similar connections:
1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Bolt-torque levels shall be in accordance with manufacturer’s published data:
1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
c. Insulation-resistance values shall be in accordance with manufacturer’s published data:
1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
2) Investigate insulation values less than the allowable minimum.
d. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.

H. Single Engine generator:

1. Visual and mechanical inspection:
   a. Compare equipment nameplate data with the Contract Documents.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, and grounding.
   d. Verify the unit is clean.
2. Electrical and mechanical tests:
   a. Perform insulation-resistance tests in accordance with IEEE 43:
      1) Machines larger than 150 kilowatts: Test duration shall be 10 minutes. Calculate polarization index.
      2) Machines 150 kilowatts and less: Test duration shall be 1 minute. Calculate the dielectric-absorption rate.
   b. Test protective relay devices as specified in this Section.
   c. Verify phase rotation, phasing, and synchronized operation as required by the application.
   d. Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
   e. Perform vibration test for each main bearing cap.
   f. Conduct performance test in accordance with NFPA 110.
   g. Verify correct functioning of governor and regulator.
   h. Load bank testing:
      1) Provide a resistive load bank to test the operation of the engine generator.
      2) Load bank shall be capable of loading the engine generator to its full nameplate kilowatt rating at unity power factor.
      3) Load steps shall simulate the plant load steps used in sizing the engine generator.
         a) Record voltage and frequency response at each step with a data logging instrument that has an 8 millisecond response time.
      4) Test run at full nameplate kilowatt rating for a minimum of 4 hours:
         a) Record at 10 minute intervals:
            (1) Voltage.
            (2) Frequency.
            (3) Current.
            (4) Power factor.
            (5) Engine oil pressure.
            (6) Engine oil temperature.
            (7) Air inlet temperature.
            (8) Radiator discharge temperature.
            (9) Engine coolant temperature.
            (10) Vibration levels at each main bearing cap.
3. Test values:
   a. Anchorage, alignment, and grounding should be in accordance with manufacturer’s published data and system design.
   b. The dielectric absorption ratio or polarization index shall be compared to previously obtained results and should not be less than 1.0. The recommended minimum insulation ($IR_{1\ min}$) test results in megohms shall be corrected to 40 degrees Celsius and read as follows:
      1) $IR_{1\ min}$ equals kilovolt + 1 for most windings made before 1970, all field windings, and others not described below.
         a) Kilovolt is the rated machine terminal-to-terminal voltage in rms kilovolt.

2) $IR_{1\ min}$ equals 100 megohms for most dc armature and ac windings built after 1970 (form-wound coils).
3) $IR_{1\ min}$ equals 5 megohms for most machines and random-wound stator coils and form-wound coils rated below 1 kilovolt.
   a) Dielectric withstand voltage and surge comparison tests shall not be performed on machines having lower values than those indicated above.

c. The polarization index value shall not be less than 2.0.
d. The dielectric absorption ratio shall not be less than 1.4.
e. Protective relay device test results shall be as specified in this Section.
f. Phase rotation, phasing, and synchronizing shall be in accordance with system design requirements.
g. Low oil pressure, over temperature, over speed, and other protection features shall operate in accordance with manufacturer's published data and system design requirements.
h. Vibration levels shall be in accordance with manufacturer's published data and shall be compared to baseline data.
i. Performance tests shall conform to manufacturer's published data and NFPA 110.
j. Governor and voltage regulator shall operate in accordance with manufacturer's published data and system design requirements:
   1) Steady state voltage regulation shall be within 0.5 percent of set point.
   2) The output voltage of the generator shall not fall below 10 percent of the power system nominal rating for more than 5 seconds.
   3) The output voltage of the generators shall not exceed the power system nominal rating at any time.
   4) Steady state frequency regulation shall be within 59.5 hertz to 60.5 hertz
   5) Frequency variations shall not exceed 2 hertz from 60 hertz for more than 2 seconds.

I. Automatic transfer switches:
1. Visual and mechanical inspection:
   a. Compare equipment nameplate data with the Contract Documents.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, grounding, and required clearances.
   d. Verify the unit is clean.
   e. Lubrication requirements:
      1) Verify appropriate lubrication on moving current-carrying parts.
      2) Verify appropriate lubrication on moving and sliding surfaces.
   f. Verify that manual transfer warnings are attached and visible.
   g. Verify tightness of all control connections.
   h. Inspect bolted electrical connections for high resistance using one of the following methods:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench:
         a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
   i. Perform manual transfer operation.

j. Verify positive mechanical interlocking between normal and alternate sources.

2. Electrical tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential shall be 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:
      1) For units with solid-state components or for control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.
   c. Perform a contact/pole-resistance test.
   d. Verify settings and operation of control devices.
   e. Calibrate and set all relays and timers as specified in this Section.
   f. Verify phase rotation, phasing, and synchronized operation as required by the application.
   g. Perform automatic transfer tests:
      1) Simulate loss of normal power.
      2) Return to normal power.
      3) Simulate loss of emergency power.
      4) Simulate all forms of single-phase conditions.
   h. Verify correct operation and timing of the following functions:
      1) Normal source voltage-sensing relays.
      2) Engine start sequence.
      3) Time delay upon transfer.
      4) Alternate source voltage-sensing relays.
      5) Automatic transfer operation.
      6) Interlocks and limit switch function.
      7) Time delay and retransfer upon normal power restoration.
      8) Engine cool down and shutdown feature.
3. Test values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Insulation-resistance values of control wiring shall not be less than 2 meghoms.
   d. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
      1) If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   e. Control devices shall operate in accordance with manufacturer's published data.
   f. Relay test results shall be as specified in this Section.
   g. Phase rotation, phasing, and synchronization shall be as specified in the system design specifications.

h. Automatic transfers shall operate in accordance with manufacturer’s design.
i. Operation and timing shall be in accordance with manufacturer’s and system design requirements.

J. Direct-current systems, batteries, flooded lead-acid:
1. Visual and mechanical inspection:
a. Verify that battery area ventilation system is operable.
b. Verify existence of suitable eyewash equipment.
c. Compare equipment nameplate data with the Contract Documents.
d. Inspect physical and mechanical condition.
e. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
f. Verify electrolyte level. Measure electrolyte specific gravity and temperature levels.
g. Verify presence of flame arresters.
h. Verify the units are clean.
i. Inspect spill containment installation.
j. Verify application of an oxide inhibitor on battery terminal connections.
k. Inspect bolted electrical connections for high resistance using one of the following methods:
1) Use of low resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method.
a) Refer to manufacturer’s instructions for proper foot-pound levels NETA ATS tables.
2. Electrical tests:
a. Perform resistance measurements through all bolted connections with a low-resistance ohmmeter.
b. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
c. Verify all charger functions and alarms.
d. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
e. Measure intercell connection resistances.
f. Perform internal ohmic measurement tests.
g. Perform a load test in accordance with manufacturer's published data or IEEE 450.
h. Measure the battery system voltage from positive-to-ground and negative-to-ground.
3. Test values:
4. Electrolyte level and specific gravity shall be within normal limits.
a. Compare bolted connection resistance values to values of similar connections:
1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Bolt-torque levels shall be in accordance with manufacturer's published data:
1) Refer to NETA ATS tables in the absence of manufacturer's published data.

5. Test values - electrical:
    a. Compare bolted connection resistance values to values of similar connections:
        1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Charger float and equalize voltage levels shall be in accordance with battery manufacturer's published data.
    c. The results of charger functions and alarms shall be in accordance with manufacturer's published data.
    d. Cell voltages shall be within 0.05 volt of each other or in accordance with manufacturer's published data.
    e. Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells in a fully charged state.
    f. Results of load tests shall be in accordance with manufacturer's published data or IEEE 450.
    g. Voltage measured from positive to ground shall be equal in magnitude to the voltage measured from negative to ground.

K. Direct-current systems, chargers:
1. Visual and mechanical inspection:
    a. Compare equipment nameplate data with the Contract Documents.
    b. Inspect for physical and mechanical condition.
    c. Inspect anchorage, alignment, and grounding.
    d. Verify the unit is clean.
    e. Inspect all bolted electrical connections for high resistance using one of the following methods:
        1) Use of low resistance ohmmeter.
        2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
            a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
    f. Inspect filter and tank capacitors.
    g. Verify operation of cooling fans and presence of filters.
2. Electrical tests:
    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    b. Verify float voltage, equalize voltage, and high voltage shutdown settings.
    c. Verify current limit.
    d. Verify correct load sharing (parallel chargers).
    e. Verify calibration of meters as specified in this Section.
    f. Verify operation of alarms.
    g. Measure and record input and output voltage and current.
    h. Measure and record ac ripple current and voltage imposed on the battery.
    i. Perform full-load testing of charger.
3. Test values:
    a. Compare bolted connection resistance values to values of similar connections:
        1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Bolt-torque levels shall be in accordance with manufacturer’s published data:
    1) Refer to NETA ATS tables in the absence of manufacturer’s published data.

4. Test values - electrical:
    a. Compare bolted connection resistance values to values of similar connections:
        1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Float and equalize voltage settings shall be in accordance with the battery manufacturer’s published data.
    c. Current limit shall be within manufacturer’s recommended maximum.
    d. Results of load sharing between parallel chargers shall be in accordance with system design specifications.
    e. Results of meter calibration shall be as specified in this Section.
    f. Results of alarm operation shall be in accordance with manufacturer’s published data and system design.
    g. Input and output voltage shall be in accordance with manufacturer’s published data.
    h. AC ripple current and voltage imposed on the battery shall be in accordance with manufacturer’s published data.
    i. Charger shall be capable of manufacturer’s specified full load.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 26_05_00.

B. After the acceptance tests have been completed, dispose of all testing expendables, vacuum all cabinets, and sweep clean all surrounding areas.

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_22_14

DRY-TYPE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Enclosed dry-type transformers:
      a. Rated 1 to 1,000 kilovolt-amperes, single and 3-phase.
      b. Primary voltage 600 volts and below.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 – Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. American National Standards Institute (ANSI):
   1. C57.96 – Distribution and Power Transformers, Guide for Loading Dry-Type.
   2. 389 - IEEE Recommended Practice for Testing Electronics Transformers and Inductors.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. C57.12.01 - Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin Encapsulated Windings.

D. National Electrical Manufacturers Association (NEMA):
   1. TP-1 - 2002 - Guide for Determining Energy Efficiency for Distribution Transformers.
   2. TP-2 - Standard Test Method for Measuring the Energy Consumption of Distribution Transformers.

E. Underwriters Laboratory (UL):
   1. 1561 - Standard for Dry-Type General Purpose and Power Transformers.

F. U.S. Department of Energy (DOE):
   1. 10 CFR Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

1.04 SYSTEM DESCRIPTIONS

A. Provide 3-phase or 1-phase, 60 hertz dry-type with voltage ratings, kilovolt-ampere capacities, and connections as indicated on the Drawings:
   1. Transformers shall provide full capacity at the Project elevation and environmental conditions as specified in Section 26_05_00 after all derating factors have been applied.
   2. Suitable for continuous operation at full rating with normal life expectancy in accordance with ANSI C57.96.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
   1. Catalog cut sheets.
   2. Nameplate data.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
   4. Inrush current.
   5. Insulation system and temperature constraints.
   6. Number and rating of taps.
   7. Sound levels.
   8. Connection diagrams:
      a. Primary.
      b. Secondary.
   9. BIL rating.
   10. Required clearances.
   11. Percent impedance.
   12. Efficiency.
   13. Certification of full capacity capability at the Project elevation and ambient conditions.
   14. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 26_05_00:
      a. Manufacturer’s statement of seismic qualification with substantiating test data.
      b. Manufacturer’s special seismic certification with substantiating test data.

C. Installation instructions:
   1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
   2. For equipment installed in structures designated as seismic design category A or B:
      a. Provide manufacturer’s installation instructions and anchoring details for connecting equipment to supports and structures.
   3. For equipment installed in structures designated as seismic design category C, D, E, or F:
      a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 26_05_00.

b. Submit anchoring drawings with supporting calculations.
c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
1. General Electric.
2. Jefferson.
3. Schneider Electric/Square D.
4. Eaton/Cutler-Hammer.
5. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Cores:
1. Non-aging, grain-oriented silicon steel.
2. Magnetic flux densities below the saturation point.

B. Windings:
 1. High-grade magnet wire.
 2. Impregnated assembly with non-hydroscopic, thermo-setting varnish:
 a. Cured to reduce hot-spots and seal out moisture.
 3. Material electrical grade:
 a. Copper.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. General:
 1. 10 kilovolts BIL for 600-volt class windings.
 2. Sound levels, in accordance with ANSI 389 test conditions, not to exceed:

Kilovolt-Amperes Range	Audible Sound Level (db)
1-9	40
10-50	45
51-150	50
151-300	55
301-500	60
501-700	62
701-1000	64

 3. Taps:
 a. 15 kilovolt-amperes and less:
 1) Two 5 percent full capacity primary taps below rated voltage.
 b. 25 kilovolt-amperes and larger:
 1) Four 2.5 percent full capacity primary taps below rated voltage.
 2) Two 2.5 percent full capacity primary taps above rated voltage.
 c. Operated by a tap changer handle or tap jumpers accessible through a panel.
 4. Terminals:
 a. UL listed for either copper or aluminum conductors.
 b. Rated for 75 degrees Celsius.
 5. Daily overload capacities, at rated voltage and without reduction in life, in accordance with ANSI C57.96.

B. Energy efficient transformers 15 kilovolt-amperes and larger:
 1. Insulation class: 220 degrees Celsius.
 2. Temperature rise: 115 degrees Celsius, except as noted below:
 a. 150-degree Celsius rise for dry-type transformers located in motor control centers.
 3. Efficiency:
 a. In accordance with DOE 10 CFR Part 431.

C. Enclosures:
 1. Heavy gauge steel:
 a. Indoor: NEMA Type 2.
 2. Louvers to limit coil temperature rise to the value stated above, and case temperature rise to 50 degrees Celsius.

3. Built-in vibration dampeners to isolate the core and coils from the enclosure:
    a. Neoprene vibration pads and sleeves.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Nameplates:
  1. Non-corrosive metal or UL listed non-metallic:
    a. Stamped, engraved or printed with the following information:
      1) Phases.
      2) Frequency.
      3) Kilovolt-ampere rating.
      4) Voltage ratings.
      5) Temperature rise.
      6) Impedance.
      7) Insulation class.
      8) BIL rating.
      9) Connection diagram.
      10) Weight.
      11) Manufacturer.
      12) The identification “transformer”.
      13) Classes of cooling.
      14) Tap voltage(s).
      15) Vector diagram.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finish to consist of de-greasing, phosphate cleaning, and an electrodeposited manufacturer’s standard gray enamel rust-inhibiting paint.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:
   1. Floor mounted, as indicated on the Drawings.
   2. Install where not in direct contact with building structure.
   3. Install on single layer vibration pad under the entire mounting surface.
      a. Manufacturers: The following or equal:
         1) Korfund.
   4. Make any necessary connections to the enclosure with liquidtight flexible conduit having neoprene gaskets and insulated ground bushings.
   5. Ground the enclosure:
      a. To an equipment ground conductor in the conduit.
      b. To the facility grounding electrode system.
   6. Floor mounted transformers:
      a. Install transformers on 3-1/2-inch housekeeping pads.
      b. Install transformers with adequate space from walls or other enclosures for proper ventilation in accordance with the manufacturer's recommendations.

3.04 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

B. Factory tests:
   1. Applied voltage test to each winding and from each winding to the core:
      a. 600-volt class winding 4.5 kilovolt.
   2. Induced voltage test at 2 times normal voltage and 400 hertz for 1,080 cycles.
   3. Voltage ratio and polarity.
   4. Sound level, performed in a test room with ambient sound level not exceeding 24 db.
   5. Perform all tests in accordance with UL 1561.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

3.09 ADJUSTING

A. Set the transformer taps as required to obtain nominal output voltage on the secondary terminals.

3.10 CLEANING

A. As specified in Section 26_05_00.

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_24_16

PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Panelboards serving feeder circuits and branch circuits.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 - Common Work Results for Electrical.
   4. Section 26_05_53 - Identification for Electrical Systems.
   5. Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
   6. Section 26_43_14 - Surge Protective Devices.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. Underwriter's Laboratories, Inc. (UL):
   1. 67 - Standard for Panelboards.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

1.04 SYSTEM DESCRIPTION

A. Circuit breaker panelboards as indicated in the panelboard schedules, one-lines, and where indicated on the Drawings:
   1. Service voltage and configuration as indicated on the panel schedules.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
   1. Manufacturer of panelboard.
   2. Bill of material.
   3. Assembly ratings including:
      a. Voltage.
      b. Phase.
      c. Continuous current.
      d. Short circuit interrupting rating.
   4. NEMA enclosure type.
   5. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.

6. Furnish circuit breaker submittals as specified in Section 26_28_01.
7. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 26_05_00:
    a. Manufacturer’s statement of seismic qualification with substantiating test data.
    b. Manufacturer’s special seismic certification with substantiating test data.

C. Shop drawings:
1. Drawings to contain:
    a. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
        1) Height.
        2) Length.
        3) Width.
    b. Weight.
    c. Anchoring locations.
    d. Breaker layout drawing with dimensions:
        1) Location of the main, branches, solid neutral, and ground.
    e. Conduit entry/exit locations.
        1) Identify all conduit entry/exit locations and restrictions.
    f. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for every panelboard.

D. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
2. For equipment installed in structures designated as seismic design category A or B:
    a. Provide manufacturer’s installation instructions and anchoring details for connecting equipment to supports and structures.
3. For equipment installed in structures designated as seismic design category C, D, E, or F:
    a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 26_05_00.
    b. Submit anchoring drawings with supporting calculations.
    c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

E. Operations and maintenance manual:
1. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:
    a. Including but not limited to:
        1) Instruction narratives and bulletins.
        2) Renewal parts lists.
        3) Time-current curves for all devices.

F. Calculations:
1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic requirements at the Project Site.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. Panelboards shall be UL listed and labeled.
   1. Where indicated as service entrance equipment, panelboards shall be UL labeled and listed “Suitable for Service Entrance.”

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Eaton/Cutler-Hammer.
   2. General Electric Company.
   3. Schneider Electric/Square D Company.

B. Circuit breakers:
   1. Same manufacturer as the panelboard.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Provide panelboards with:
   1. Molded-case circuit breakers with trip ratings as shown on the panel schedules.
   2. Spares and spaces for future circuit breakers in panels as shown on the panel schedules.

B. Short circuit rating:
   1. Provide panelboards with short-circuit ratings as indicated on the Drawings:
   2. Testing method in accordance with UL 67.
   3. Mark each panelboard with its maximum short circuit rating at the supply voltage.
   4. Panelboards shall be fully rated.

2.06 COMPONENTS

A. Enclosure:

   1. NEMA enclosure type as indicated on the Drawings.
      a. Where not indicated on the Drawings, as specified in Section 26_05_00 for the installed location.
   2. Minimum width: 20 inches.
   3. Gutter space in accordance with the NEC:
      a. Minimum of 4 inches of gutter space.
   4. Dead-front, no live parts when the panelboard is in service.
   5. Enclose entire panelboard bus assembly in a corrosion resistant galvanized steel cabinet.
   6. 4-piece front to provide ease of wiring access.
   7. Lockable, hinged door over the protective devices with a flush, cylinder tumbler-type lock with catch and door pull.
      a. Minimum 2 keys per panelboard.
      b. Key all panelboard locks alike.
   8. Circuit directory frame and card on the inside of the door.
   9. Door-in-door construction consists of a one-piece front with 2 doors:
      a. The smaller door provides access to all device handles and rating labels and shall be lockable.
      b. The larger door provides access to all conductors and wiring terminals.
   10. Interior design such that replacement of circuit breakers does not require disturbing adjacent units or removal of the main bus connectors.

B. Bus:
   1. General:
      a. Tin-plated copper.
   2. Phase bus:
      a. Full size and height without reduction.
      b. Sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 50 degrees Celsius:
         1) Limit current density to less than 1,000 amps per square inch.
      c. Insulate all current carrying parts from ground and phase-to-phase with a high dielectric strength insulator.
   3. Ground bus:
      a. Copper, solidly bonded.

4. Neutral bus:
   a. Provide where indicated on the Drawings.
   b. 100 percent rated.
   c. Provide lugs for each outgoing feeder requiring a neutral connection.
5. Provide insulation barriers over the vertical bus behind the dead front shield to provide increased safety during field service.

C. Lugs:
1. UL listed for copper and aluminum wire:
   a. Provide lugs rated for 75-degree Celsius terminations.
   b. Provide bolted or compression main lug terminations as required for the incoming cable size.

D. Circuit breakers: As specified in Section 26_28_01 and as indicated on the Drawings:
1. Provide all circuit breakers with bolt-on connections:
   a. Plug-in circuit breakers are not allowed.

2.07 ACCESSORIES

A. Surge protective devices:
1. Furnish panelboards with surge protective devices as indicated on the Drawings.
2. As specified in Section 26_43_14.

B. Nameplates:
1. As specified in Section 26_05_53.
2. Install on outside of door.
3. Indicating:
   a. Panel designation.
   b. Voltage.
   c. Number of phases and configuration.

C. Circuit identification labels:
1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.
2. Type all information on the cards using designations in the panel schedules.
3. Laminated on both sides.

D. Pad locking mechanism:
1. Provide a pad locking attachment to allow circuit breakers to be locked in the off position.
2. At a minimum, provide 1 mechanism per panelboard:
   a. Provide multiple mechanisms if required to accommodate all circuit breaker frame sizes in the panelboard.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finish stand-alone panelboards with a primer, rust-resistant phosphate undercoat, and 2 coats of oven-baked enamel with manufacturer’s standard gray.

B. Finish panelboards mounted in motor control centers to match the motor control center finish and color.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:
1. Surface, flush or MCC mounted as indicated on the Drawings.
2. Mount rigidly to structural members with exposed surfaces plumb and level to within 1/32 inch.
3. Perform work in accordance with the manufacturer’s instructions and shop drawings.
4. Provide all brackets, hangers, supports, and hardware for mounting as required.
5. In all NEMA Type 4 and NEMA Type 4X locations, mount panelboards on 7/8-inch deep stainless steel preformed channel, with channel running vertically from top to bottom of panelboard:
   a. Use only stainless steel mounting hardware.
6. Mount panelboard so that top operating handle is not more than 6 feet-7 inches above the operating floor.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

B. Factory testing:
1. Perform standard factory tests on the panelboards:
2. Test in accordance with the latest version of NEMA and UL standards.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 26_05_00.

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES

A. Circuiting within the panelboard shall match the panel schedules as indicated on the Drawings.

B. Provide typewritten schedule in each panelboard.

END OF SECTION

SECTION 26_27_26

WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Switches.
   2. Receptacles.
   3. Plates.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. Federal Specifications (FS):
   1. W-C 596 - Connector, Electrical, Power, General Specification for.
   2. W-S 896/2 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).

C. National Electrical Manufacturers Association (NEMA):
   1. WD1 - General Color Requirements for Wiring Devices.
   2. ICS 5 - Industrial Control and Systems, Control Circuit and Pilot Devices.
   3. OS1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
   4. WD6 - Wiring Devices Dimensional Specifications.

D. Underwriters Laboratories Inc. (UL):
   1. 20 - General Use Snap Switches.
   2. 498 - Standard for Attachment Plugs and Receptacles.
   3. 514D - Cover Plates for Flush-Mounted Wiring Devices.
   4. 943 - Ground-Fault Circuit-Interrupters.
   5. 1472 - Solid State Dimming Controls.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

B. Specific definitions:
   1. GFCI: Ground fault circuit interrupter.

1.04 SYSTEM DESCRIPTION

A. Switches, receptacles, and plates as indicated on the Drawings wired and operable to form a complete system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
   1. Catalog cut sheets.

C. Shop drawings:
   1. Engraving schedule:
      a. Furnish complete engraving schedule for engraved nameplates.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. Wiring devices shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Switches:
   1. One of the following or equal:
      a. Hubbell.
      b. Leviton.
      c. Cooper Wiring Devices.

B. Receptacles:
   1. General purpose receptacles: One of the following or equal:
      a. Hubbell.
      b. Leviton.
      c. Cooper Wiring Devices.

C. Plates:
   1. General location: The following or equal:
      a. Pass and Seymour.
      b. Cooper Wiring Devices.
   2. Wet or corrosive areas: One of the following or equal:
      a. Hubbell.
      b. Cooper Wiring Devices.
      c. Thomas and Betts.
      d. Pass and Seymour.
   3. In-use covers: One of the following or equal:
      a. TayMac.
      b. Cooper Wiring Devices.
      c. Pass and Seymour.
      d. Thomas and Betts.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Switches:
   1. General:
      a. 120-277 VAC.
      b. 20 ampere.
      c. Listed in accordance with UL 20.
      d. Designed and constructed in accordance with FS W-S-896/2.
      e. Back and side wired unless otherwise indicated.
      f. Integral grounding terminal.
      g. Totally enclosed:
         1) Color-coded body with color corresponding to ampere rating.
      h. Provide switches with the operator style and contact arrangement as indicated on the Drawings and as required for proper operation.
      i. Color:
         1) Ivory in finished areas.
         2) Brown in all other areas.
   2. General purpose switches:
      a. Toggle type.

B. Receptacles:
   1. General purpose receptacles:
      a. Single or duplex as indicated on the Drawings.
      b. 125 VAC.
      c. 20 ampere or as indicated on the Drawings.
      d. NEMA Type 5-20R configuration for 20 ampere receptacles.
      e. Other NEMA configurations as indicated on the Drawings.

f. Listed in accordance with UL 498.
g. Designed and constructed in accordance with FS W-C-596.
h. Back and side wired.
i. One-piece, rivet-less mounting strap.
j. Color:
   1) Ivory in finished areas.
   2) Brown in all other areas.
   3) Orange when powered by an UPS.

2. Ground fault interrupter receptacles (GFCI):
   a. 125 VAC.
   b. 20 ampere.
   c. Trip level 4-6 milliampere.
   d. Individual and feed through protection.
   e. UL 943 and UL 498 listed.
   f. NEMA Type 5-20R configuration.
   g. For damp or wet locations:
      1) Weather resistant, in accordance with UL 498.

C. Plates:
   1. General location:
      a. Type 302 or 304 stainless steel.
      b. Brushed satin finish.
      c. Minimum thickness: 0.032 inches.
      d. Rectangular or square shape.
      e. Engraving:
         1) Engrave each switch plate with the following:
            a) Area served.
            b) Panelboard and Circuit.
         2) Engrave each receptacle plate with the following:
            a) Panelboard and Circuit.
         3) Treat engraving to improve visibility.
         4) Characters shall be block letter pantograph engraved with a minimum character height of 1/8-inch.
      f. Coordinate the number of gangs, number, and type of openings with the specific location.
   2. Outdoor and wet areas requiring NEMA Type 4 or NEMA Type 4X enclosures:
      a. General:
         1) UL listed for wet locations.
         2) Gasketed.
         3) Die cast metal:
            a) Match material to box material.
      b. Switches:
         1) Lever operated:
            a) Provide toggle switch.
      c. Receptacles:
         1) Weather proof in-use cover:
            a) Die cast metal construction with electrostatic powder coating for corrosion resistance.
            b) Gasketed.
            c) Lockable.
            d) UL listed and in accordance with NEC.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Mounting heights:
   1. Process and production areas:
      a. Switches and receptacles 48 inches from finished floor to top of plate.
   2. Offices and finished areas:
      a. Switches: 48 inches from finished floor to top of plate.
      b. Receptacles: 18 inches from finished floor to center of plate.

C. Switches:
   1. Over 300 Volts:
      a. Where switches used in systems of more than 300 volts between conductors, are to be ganged in outlet boxes, provide switches having no exposed live parts or use barriers between the individual switches.

D. Receptacles:
   1. Provide GFCI receptacles as indicated on the Drawings.
      a. Provide weather resistant GFCI receptacles in all wet or damp areas.
         1) As specified in Section 26_05_00, or in accordance with the NEC.
   2. Mount non-weatherproof receptacles vertically:
      a. Ground slot down.
   3. Mount weatherproof receptacles horizontally:
      a. Neutral slot up.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_28_01

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
  1. Low voltage molded case circuit breakers.

B. Related sections:
  1. Section 01_33_00 - Submittal Procedures.
  2. Section 01_75_17 - Commissioning.
  3. Section 26_05_00 - Common Work Results for Electrical.
  4. Section 26_05_74 - Electrical System Studies.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. National Electrical Manufacturers Association (NEMA):
  1. AB 3. - Molded Case Circuit Breakers and Their Application.

C. Underwriter's Laboratories (UL):
  1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
  2. 943 - Ground Fault Circuit Interrupters.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

B. In accordance with UL 489.

1.04 SYSTEM DESCRIPTION

A. Molded case thermal magnetic or motor circuit protector type circuit breakers as indicated on the Drawings and connected to form a completed system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
  1. Catalog cut sheets.
  2. Manufacturer's time-current curves for all molded case circuit breakers furnished.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. Low voltage molded case circuit breakers shall be UL listed and labeled.

C. Where indicated on the drawings, the circuit breaker shall be UL labeled and listed "Suitable for Service Entrance".

1.07 DELIVERY, STORAGE AND HANDLING

A. As specified in Section 26_05_00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Eaton/Cutler-Hammer.
   2. General Electric Company.
   3. Schneider Electric/Square D Company.
   4. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. Conforming to UL 489.

2. Operating mechanism:
   a. Quick-make, quick-break, non-welding silver alloy contacts.
   b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
   c. Mechanically trip free from the handle.
   d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
   e. Lockable in the "OFF" position.
3. Arc extinction:
   a. In arc chutes.
4. Voltage and current ratings:
   a. Minimum ratings as indicated on the Drawings.
   b. Minimum frame size 100A.
5. Interrupting ratings:
   a. Minimum ratings as indicated on the Drawings.
   b. Modify as required to meet requirements of the short circuit fault analysis - as specified in Section 26_05_74.
   c. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.)

B. Motor circuit protectors:
   1. Instantaneous only circuit breaker as part of a listed combination motor controller.
   2. Each pole continuously adjustable in a linear scale with ‘LO’ and ‘HI’ settings factory calibrated.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Terminals:
   1. Line and load terminals suitable for the conductor type, size, and number of conductors in accordance with UL 489.

B. Case:
   1. Molded polyester glass reinforced.
   2. Ratings clearly marked.

C. Trip units:
   1. Provide thermal magnetic or solid-state trip units as indicated on the Drawings.
   2. Thermal magnetic:
      a. Instantaneous short circuit protection.
      b. Inverse time delay overload.
      c. Ambient or enclosure compensated by means of a bimetallic element.
   3. Solid state:
      a. With the following settings as indicated on the Drawings.
         1) Adjustable long time current setting.
         2) Adjustable long time delay.
         3) Adjustable short time pickup.
         4) Adjustable short time delay.
         5) Adjustable instantaneous pickup.

6) Adjustable ground fault pickup as indicated on the Drawings.
7) Adjustable ground fault delay as indicated on the Drawings.

D. Molded case circuit breakers for use in panelboards:
1. Bolt-on type.
a. Plug-in type breakers are not acceptable.
2. Ground fault trip devices as indicated on the Drawings.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Test breakers in accordance with:
1. UL 489.
2. Manufacturer’s standard testing procedures.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install breakers to correspond to the accepted shop drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

3.09 ADJUSTING

A. Adjust trip settings in accordance with Protective Device Coordination Study as accepted by the Engineer and in accordance with manufacturer’s recommendations.

B. Adjust motor circuit protectors in accordance with NEC and the manufacturer’s recommendation based on the nameplate values of the installed motor.

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_29_25

VARIABLE FREQUENCY DRIVES 60 – 500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Clean power 18 pulse variable frequency drives (VFD), 60 to 500 horsepower for control of standard NEMA Design B squirrel cage induction motors.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 - Common Work Results for Electrical.
   4. Section 26_05_09 - Low Voltage Motors Up To 500 Horsepower.
   5. Section 26_05_18 - 600-Volt or Less Wires and Cables.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. National Electrical Manufacturers Association (NEMA):
   1. MGI, Part 31 - Motors with higher peak voltage capability.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. 519 - IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

D. Underwriters' Laboratories (UL):
   1. 50 - Standards for Enclosures for Electrical Equipment.
   2. 508A - Standard for Safety for Industrial Control Panels.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Each VFD system shall consist of all components required to meet the performance, protection, safety, testing, and certification criteria of this Section.
   2. The VFD system:
      a. Is a fully integrated package.
      b. Includes all material necessary to interconnect VFD system elements, even if shipped separately.
   3. Any modifications to a standard product necessary to meet this Section shall be made only by the VFD manufacturer.

4. Each VFD shall be completely factory pre-wired, assembled, and then tested as a complete package by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.
5. The VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics:
   a. The VFD manufacturer shall furnish equipment necessary to mitigate potential damage to motor insulation.
   b. Coordinate bearing protection methods with the supplier of the driven equipment.
   c. Motors as specified in Section 26_05_09.

B. Performance:
1. Operating envelope:
   a. Speed and torque requirements:
      1) Provide a variable torque or constant torque VFD as required by the driven load.
      2) The VFD shall be capable of producing a variable alternating voltage/frequency output to provide continuous operation over the 40 to 110 percent (25 to 66 Hertz) speed range.
   b. Current requirements:
      1) Provide 100 percent of rated output current on a continuous basis.
      2) Variable torque VFD:
         a) Minimum 110 percent current overload for 1 minute.
      3) Constant torque VFD:
         a) Minimum 150 percent current overload for 1 minute.
2. Harmonics:
   a. The VFD shall comply with IEEE 519 for total harmonic and current distortion calculations and measurements. The VFD shall meet the following distortion limits:
      1) Voltage harmonics: Individual or simultaneous operation of the VFD(s) shall not add more than 3 percent total harmonic voltage distortion THD, while operating from the utility source or more than 5 percent total harmonic voltage distortion while operating from standby generation at the input terminals of the VFD system.
      2) Current harmonics: The maximum allowable total harmonic current distortion limit, TDD, for each VFD shall not exceed 5 percent as measured at the input terminals of the VFD system.
3. Efficiency:
   a. VFD system minimum efficiency shall be 93 percent at rated kilowatt output of the VFD. VFD system efficiency shall be calculated as follows:

$$Efficiency\ (\%) = \frac{Power\ (Load)}{Power\ (Supply)}\ x\ 100$$

   b. Power:
      1) Load power is the total 3-phase power measured at the output terminals of the drive system, including output filters.
      2) Supply power is the total power measured at the input terminals of the VFD including input filters, line reactors, phase shifting

transformer, harmonic distortion attenuation equipment, and auxiliary equipment (e.g., controls, fans) for complete system operation.

4. Total power factor:
    a. Minimum of 0.96 lagging across the entire speed range.
    b. Under no operating conditions shall the VFD have a leading power factor.
5. Frequency accuracy:
    a. Minimum of within 0.01 percent.
6. Speed regulation:
    a. Minimum of within 0.5 percent across the entire speed range.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00:
   1. Custom prepared by the VFD manufacturer and specific for the equipment furnished.

B. Product data:
   1. Manufacturer of the VFD.
   2. Manufacturer of all components of the VFD.
   3. Dimensions:
       a. Height.
       b. Width.
       c. Depth.
   4. Weight.
   5. Nameplate schedule.
   6. Bill of material.
   7. Ratings:
       a. Voltage.
       b. Phase.
       c. Input current.
       d. Output current.
       e. Interrupting rating.
       f. Momentary current rating.
   8. Catalog cut sheets for major components.
   9. Surge protection data.
   10. Design data:
       a. Efficiency and power factor values.
       b. Certification that the drive is sized for the full nameplate motor horsepower and current (at rated RPM) of the driven load at the installed altitude.
       c. Certification that based upon VFD design, cable length to motor, and motor dielectric insulation level that the VFD will not damage motor insulation due to carrier frequency, reflected wave, dv/dt, or other VFD produced characteristics.
       d. Certification that all electronic circuits and printed circuit boards are conformably coated.
   11. List of recommended spare parts.
   12. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 26_05_00:
       a. Manufacturer’s statement of seismic qualification with substantiating test data.
       b. Manufacturer’s special seismic certification with substantiating test data.

C. Shop drawings:
   1. Complete plan and elevation drawings showing:
      a. All dimensions.
      b. Panel, sub-panel, and component layout indexed to the bill of material.
      c. Conduit connections.
      d. Required clearance around equipment.
   2. Block diagram showing the basic control and protection systems identifying the protection, control, trip and alarm functions, the reference signals and commands and the auxiliary devices.
   3. Complete schematic, wiring and interconnection diagrams showing connections to both internal and external devices:
      a. Wiring diagrams shall include terminal number and wire numbers.
   4. Complete 1-line and 3-line diagrams including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system:
      a. Device electrical ratings shall be clearly indicated on the Drawings.

D. Installation instructions:
   1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
   2. For equipment installed in structures designated as seismic design category A or B:
      a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
   3. For equipment installed in structures designated as seismic design category C, D, E, or F:
      a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 26_05_00.
      b. Submit anchoring drawings with supporting calculations.
      c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

E. Calculations:
   1. Harmonic study:
      a. A preliminary harmonic analysis shall be performed. A power system short circuit ratio of 20 shall be used. All VFDs shall be assumed to be operating at maximum speed and maximum load. The short circuit current (ISC) utilized for the harmonic analysis calculations is defined as:
         1) ISC = 20 * (Sum Total Full Load Amps of all VFDs).
      b. A separate harmonic analysis shall be performed based on the standby generator system. Coordinate with the generator manufacturer and the VFD manufacturer so the actual characteristics for the generator supplied, or existing, for this Project are used in the harmonic analysis.
   2. Detailed calculations or details of the actual physical testing performed on the VFD to prove the VFD is suitable for the seismic conditions at the Project Site.

F. Test forms and reports:
   1. Submit complete factory acceptance test procedures and all forms used during the test.
      a. For VFD units less than 250 horsepower, provide certified test results for the actual VFD being furnished or prototype units. For VFD units 250 horsepower and larger, provide certified test results for the actual VFD being furnished.
      b. Provide the following certified test reports:
         1) Efficiency at rated power output and output frequency of 60 hertz.
         2) Power factor at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent speed.
         3) Harmonics at the input terminals of the VFD at 100 percent speed and 100 percent load.
            a) Voltage distortion: Measure individual harmonics up to and including the 50th harmonic and total harmonic distortion.
            b) Current distortion: Measure individual harmonics up to and including the 50th harmonic and total demand distortion.
      c. Submit complete field acceptance test procedures and all forms used during the test:
         1) Certification that the actual measured harmonic distortion for both voltage and current is within the specification limits at the installed site.
         2) Certification that the actual measured peak voltage at the motor terminations is less than 90 percent of the motor insulation dielectric withstand level.

G. Record documents:
   1. Certified record documents of all equipment with information listed above.

H. Manufacturer's field reports:
   1. Certification letter from the VFD manufacturer that the VFD(s) has been inspected and installed in accordance with the manufacturer's requirements.
   2. Report listing the setting of all VFD adjustable parameters and their values after start-up.

I. Operation and maintenance manuals:
   1. Spare parts list with supplier names and part numbers.
   2. Start-up and commissioning instructions and data.
   3. Complete bill of material indexed to the drawings, identifying the catalog or part numbers, manufacturer, and quantities of components of the VFD system.
   4. Operating manuals:
      a. Submit operating instructions and a maintenance manual presenting full details for care and maintenance of each model of VFD provided under this Contract.
   5. Operating instructions:
      a. The written descriptions shall detail the operational functions of all controls on the front panel including keypad functions and parameters.
   6. Maintenance manual:
      a. Furnish maintenance manuals with instructions covering all details pertaining to care and maintenance of all equipment as well as identifying all parts.

b. Manuals shall include but are not limited to the following:
   1) Adjustment and test instructions covering the steps involved in the initial test, adjustment, and start-up procedures.
   2) Detailed control instructions that outline the purpose and operation of every control device used in normal operation.
   3) All schematic wiring and external diagrams:
      a) Furnish drawings in a fully legible reduced 11-inch by 17-inch format.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. Qualifications:
   1. Any third party certification, safety, or protection requirements shall be applied to the VFD system as a whole. Certification or protection of system elements or individual components by themselves is not acceptable.
   2. VFDs shall be UL 508C listed and labeled.
   3. VFD systems (packaged VFD panels) shall be UL 508A listed and labeled.
   4. VFDs shall be manufactured by the VFD manufacturer at its own facility, which shall have a quality assurance program that is certified in accordance with ISO 9001.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

B. Ship VFDs to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize on site off-loading equipment:
   1. VFDs shall be delivered to the site pre-assembled and wired.
   2. Ship each VFD with 2 tamperproof accelerometers that record the maximum shock and vibration experienced by the VFD during shipping and handling.

C. Furnish temporary equipment heaters within the VFD to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING

A. Conduct factory acceptance test and submit certified test results for Engineer’s review.

B. Ship equipment to Project Site after successful completion of factory acceptance test.

C. Assemble equipment in the field.

D. Conduct field acceptance tests including harmonic testing and submit results for Engineer’s review.

E. Submit manufacturer's certification that equipment has been properly installed and is fully functional for Engineer's review.

F. Conduct Owner's training sessions.

G. Commissioning and process start-up as specified in Section 01_75_17.

1.10 SCHEDULING

A. As specified in Section 26_05_00.

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

B. The VFD manufacturer shall be responsible for start-up of the VFDs in the presence of the equipment suppliers, Contractor, Engineer, and Owner.

1.13 OWNERS INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. As specified in Section 26_05_00.

B. Maintenance service: Manufacturer shall describe the field service system available to support the proposed VFD system. As a minimum describe:
   1. Type of technical support available (e.g., system engineering and technician).
   2. Location of field service personnel.
   3. Field service daily rates in dollars per hour and dollars per day.
   4. Guaranteed response times to service requests.

C. Spare parts:
   1. The following spare parts shall be furnished:
      a. 1 complete VFD of each size furnished.
      b. Any special dedicated tools for emergency service and troubleshooting.
      c. All hardware and software required for configuration, maintenance, troubleshooting and inquiry of all drive parameters.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Eaton/Cutler-Hammer.
   2. Allen-Bradley.
   3. Schneider-Electric/Square D.
   4. General Electric.
   5. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. General:
   1. Sinusoidal pulse width modulated, (PWM), voltage source type drive shall consist of the following:
      a. Input line reactors.
      b. Integral phase shifting auto-transformer:
         1) Converts 3-phase utility power to 3 sets of 3 power circuits with each set phase shifted and powering its own 3-phase bridge rectifier.
      c. Direct current link with capacitors.
      d. Minimum 18-pulse diode rectifier section consisting of 3 three-phase bridge rectifiers.
         1) Specifically designed as a system to share currents between the bridges to within 1 percent.
      e. Insulated gate bipolar transistor (IGBT), inverter section.
      f. Microprocessor based controls.
      g. Load reactors.
   2. VFDs that have an active input section for either harmonic or voltage control are not acceptable.

B. Ratings:
   1. Voltage:
      a. Input voltage: 480 Volts plus or minus 10 percent, 3-phase 60 hertz.
   2. Short-circuit rating:
      a. 65 kA RMS symmetrical.

C. Operational features:
   1. Protective features:
      a. Include the following protective features:
         1) Motor overload protection.
         2) Instantaneous overcurrent.
         3) Instantaneous overvoltage.
         4) Undervoltage.
         5) Power unit overtemperature.
         6) Phase loss.
         7) VFD output short circuit.
         8) VFD output ground fault.
         9) Blown fuse.
   2. Control mode:
      a. The VFD shall operate in a either a constant volts/hertz or sensorless vector mode. Selectable using the programming keypad.
   3. Frequency control:
      a. Minimum of 3 selectable skip frequencies with adjustable bandwidths.
      b. Programmable minimum frequency.
      c. Programmable maximum frequency.

4. Acceleration/Deceleration:
    a. Separately adjustable acceleration and deceleration rates.
    b. Each rate shall be adjustable from 0.01 to 1,800 seconds.
5. Spinning load:
    a. Capable of determining the speed and direction of a spinning load, “catch” the load and accelerate or decelerate it without damage to the load.
6. Programmable loss of signal:
    a. Upon loss of reference speed signal the VFD shall be programmable to either stop, maintain current speed, or default to preselected speed.
7. Power interrupt ridethrough:
    a. Capable of continuous operation in the event of a power loss of 5 cycles or less.
8. Hardwired inputs and outputs:
    a. Manufacturer’s standard number the following:
        1) Analog inputs.
            a) Configurable as either 0 to 10 volts or 4 to 20 milliamperes.
        2) Analog outputs.
            a) Programmable 4 to 20 milliamperes isolated.
        3) Discrete inputs.
            a) Programmable.
        4) Discrete outputs.
            a) Programmable.
            b) Form C relay contacts.
        5) Potentiometer 3-wire input.
    b. Provide additional inputs and outputs as required to meet the control functions indicated on the Drawings.
9. Diagnostics:
    a. Minimum of 4 fault conditions in memory on a first in - first out basis.
    b. Operating frequency, drive status and power mode shall also be stored at the time of the fault.
    c. Fault memory shall be maintained in the event of a power outage.
    d. The fault memory shall be accessible via RS-232, RS-422, or RS-485.
10. Automatic restart:
    a. User selectable, automatic restart feature allowing the VFD to restart following a momentary power failure or other VFD fault:
        1) Programmable for up to 9 automatic restart attempts with an adjustable time delay between restart attempts.

2.06 COMPONENTS

A. Enclosure:
1. NEMA Type 12 enclosure.
2. Provide cooling devices required to maintain the VFD within the manufacturer’s specified temperature limits for the Project conditions:
    a. Provide cooling device alarm.

B. Power disconnect:
1. Flange mounted thermal magnetic circuit breaker:
    a. Lockable in the OFF position.

C. Phase shifting transformer:
1. Auto-transformer.

2. Integral part of the VFD assembly and factory mounted and wired within the VFD enclosure.
3. Rated for rectifier duty.
4. Copper or aluminum windings with 180-degree Celsius insulation.

D. Reactors:
1. Provide 3 percent output load reactors.
2. Provide input line reactors.

E. Keypad:
1. Furnished with a keypad for programming and control.
2. Password security to protect drive parameters.
3. Mounted on the door of the VFD.
4. Back-lit LCD with a minimum of 2 lines of a minimum of 16 characters each.
5. Programming and display features language: English.
6. Capable of displaying the following parameters:
   a. Speed (percent).
   b. Input current (Amperes).
   c. Output current (Amperes).
   d. Output frequency (Hertz).
   e. Input voltage.
   f. Output voltage.
   g. Total 3-phase kilowatt.
   h. Kilowatt hour meter.
   i. Elapsed run time meter.
   j. Revolutions per minute.
   k. Direct current bus voltage.
7. In addition to all keys required for programming, the keypad shall have the following:
   a. Automatic/Manual selector.
   b. Start pushbutton.
   c. Stop pushbutton.
   d. Jog pushbutton.
   e. Speed increment.
   f. Speed decrement.
   g. Forward/Reverse selector.
   h. RUN indicator.
   i. PROGRAM indicator.
   j. FAULT indicator.
   k. DRIVE READY indicator.
   l. Diagnostics.
8. Provide the VFD with the hardwired controls indicated on the Drawings.

F. Control power transformer:
1. Furnish a control power transformer mounted and wired inside the drive enclosure:
   a. Primary and secondary fusing.
2. Size the transformer to supply power to all VFD controls and options as well as any external devices indicated on the Drawings including the motor winding heater.

2.07 ACCESSORIES

A. Surge protection:
   1. Metal oxide varistors:
      a. Provide protection for the VFD against:
         1) Line transients: 5,000 volt peak minimum.
         2) Line to ground transients: 7,000 peak minimum.

B. Conformal coating:
   1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as protection against moisture, dust, temperature extremes, and chemicals such as H_2S and chlorine.

C. Air filters:
   1. Mounted on the outside of the VFD enclosure:
      a. Replaceable without requiring that the VFD be turned off or the door opened.
   2. Located on the front or top of the VFD enclosure.
      a. Side or rear mounted air filters are not acceptable.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Enclosure finish shall be manufacturer's standard gray.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:
   1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories needed to complete installation of the VFD (free-standing or within motor control center).
   2. Assemble and install the VFD in the locations and with the layouts indicated on the Drawings.
   3. Perform Work in accordance with the manufacturer's instructions and shop drawings.

4. Furnish components, and equipment as required to complete the installation.
5. Replace any hardware lost or damaged during the installation or handling to provide a complete installation.
6. Install free-standing enclosures on 3-1/2-inch raised concrete housekeeping pad:
    a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
    b. Weld and/or bolt the VFD frame to the leveling channels.
7. Provide openings in top or bottom of the VFD (free-standing or within motor control center) enclosure for conduit only, no additional openings will be allowed:
    a. Improperly cut holes will require that the entire panel be replaced:
        1) No hole closers or patches will be allowed.
8. Bundle circuits together and terminate in each unit:
    a. Tie with nylon wire ties. As specified in Section 26_05_18.
    b. Label all wires at each end with wire numbers shown on the approved Control Drawings.
    c. All connections to and from the VFD (free-standing or within motor control center) enclosure must be made via terminal blocks.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

B. Factory testing:
1. Owner and Engineer will witness the factory acceptance test as specified in Section 26_05_00.
2. General:
    a. All VFDs furnished under this Section shall be tested and inspected as specified below.
    b. The testing procedures specified are the minimum acceptable requirements. The manufacturer may perform additional tests at its discretion.
3. Failure of any component during testing requires replacement of the faulted component and a complete retest.
4. Testing sequence:
    a. Submit a detailed test procedure for the VFD factory test:
        1) A minimum of 8 weeks in advance of the proposed testing date.
        2) No tests shall be performed until the test procedure is reviewed and accepted by the Engineer.
5. Component tests:
    a. Preliminary inspection:
        1) Verify that all components are correct.
        2) Verify that all connections are properly torqued.

b. Printed circuit boards:
   1) Test each printed circuit board per the manufacturer's standard testing procedure.
c. Wiring:
   1) Control and power wiring continuity verified point-to-point.
   2) Hi-pot power and control wiring at manufacturer's recommended levels.
   3) Verify ground bond resistance.
d. Load testing:
   1) No load testing in accordance with the manufacturer's standard factory test procedure.
   2) Full load testing:
      a) Test each VFD and all control logic with a representative motor or dynamometer load to simulate field operation conditions at 25 percent, 50 percent, and 100 percent full load current.
      b) Tests shall be conducted in a manner in which the inverter (IGBT) section supplies all the output power (kw) of the VFD system. Control strategies using a contactor or other means of bypassing the VFD when operating at the line frequency shall not be permitted.
      c) Tests shall be conducted using a minimum output frequency of 60 Hertz, and a minimum switching frequency of 2.5 kHz.

C. Owner training:
   1. As specified in Sections 01_75_17 and 26_05_00.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

B. Provide the services of a VFD manufacturer representative for start-up assistance and training:
   1. Inspection and field adjustment:
      a. Supervise the following and submit written certification that the equipment and controls have been properly installed, aligned, adjusted, and readied for operation.
   2. Start-up field testing:
      a. Provide technical direction for testing, checkout, and startup of the VFD equipment in the field.
      b. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.
      c. Compliance with the following specified parameters shall be verified by the VFD manufacturer:
         1) Motor terminal voltage:
            a) Make field measurements at the motor connection box.
            b) Make measurements of the full speed range of the VFD.
            c) Make measurements with a recording type oscilloscope.
         2) Harmonics:
            a) Make field measurements at the input terminals of the VFD with and without the VFD in operation.
            b) Harmonic testing shall include utility power as well as generator standby power.

c) Make measurements with a recording type harmonic analyzer displaying individual and total harmonic currents and voltages:
(1) Record currents and voltages for a minimum of 10 minutes.
(2) Analyzers using snapshots are not acceptable.

3.09 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

B. Provide the services of a VFD manufacturer factory technician to make all drive parameter and protective device settings:
1. Protective device settings provided by the VFD manufacturer in accordance with the manufacturer of the driven equipment requirements.
2. Provide documentation of VFD settings included but not limited to:
a. Minimum speed.
b. Maximum speed.
c. Skip speeds.
d. Current limit.
e. Acceleration time.
f. Deceleration time.
g. Carrier frequency.

3.10 CLEANING

A. As specified in Section 26_05_00.

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_32_14

SINGLE DIESEL FUELED ENGINE GENERATOR ABOVE 200 KW

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Packaged automatic "standby" diesel engine generator systems.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_41_00 - Regulatory Requirements.
   3. Section 01_75_17 - Commissioning.
   4. Section 26_05_00 - Common Work Results for Electrical.
   5. Section 26_05_53 - Identification for Electrical Systems.
   6. Section 26_05_74 - Electrical System Studies.
   7. Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
   8. Section 26_08_50 - Field Electrical Acceptance Tests.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. ASTM International (ASTM):
   1. A106 - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).
   2. MG-1 - Motor and Generators.

D. National Fire Protection Association (NFPA):
   1. 30 - Flammable and Combustible Liquids Code.
   2. 37 - Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.
   3. 110 - Standard for Emergency and Standby Power Systems.
   4. 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities.

E. Underwriters Laboratories (UL):
   1. 142 - Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids.
   2. 2200 - Standard for Stationary Engine Generator Assemblies.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

B. NEMA:
   1. Type 4X enclosure in accordance with NEMA 250.

C. Specific definitions:
   1. Standby rated duty: Continuous operation for the duration of any power outage of a utility power source.

1.04 SYSTEM DESCRIPTION

A. Provide a complete automatic diesel engine driven generator system, with all necessary components and accessories to make a complete and operating standby power supply.
   1. Coordinate the generator control system with the transfer equipment specified in the Electrical Specifications and as indicated on the Drawings.

B. Provide such minor details of electrical, plumbing, or mechanical work not specified or indicated on the Drawings, which are necessary for the successful operation of the diesel engine-driven generator required by these Specifications.

C. Description of operation:

D. Step sequence:
   1. Step 1:
      a. 30 kVA lighting transformer.
      b. HVAC unit.
   2. Step 2:
      a. 100 horsepower distribution pump.
   3. Step 3:
      a. 200 horsepower well pump.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
   1. General:
      a. Manufacturer of:
         1) Engine.
         2) Generator.
         3) Governor.
         4) Voltage regulator.
         5) Generator control panel.
         6) Radiator.
         7) Battery charger.
         8) Batteries.
         9) Silencer.
         10) Enclosure.
         11) Fuel storage tank.
      b. Wet weight of engine generator system:
         1) List weight of fuel separately.
      c. Dimensions of engine generator system:
         1) Length.
         2) Width.

3) Height.
d. Type and grade of fuel recommended.
e. Fuel oil consumption at:
1) 50 percent load.
2) 75 percent load.
3) 100 percent load.
f. Type and grade lubricating oil recommended.
g. Amount of lubricating oil required per oil change.
h. Normal lubricating oil consumption.
i. Recommended lubricating oil change periods:
1) By hours run.
2) By time.
j. Heat rejection by engine generator to the room area.
k. Time interval from start-up contact closure until full load capabilities are available.

2. Engine:
a. Number of cylinders, bore, stroke, and piston speed.
b. Displacement in cubic inches.
c. Compression ratio.
d. Engine RPM at 60 hertz.
e. Combustion air required.
f. Cooling air required.
g. Size of exhaust outlet.
h. Gauges.
i. Jacket water heater:
1) Rating.
2) Voltage and phase requirements.

3. Emissions:
a. Certification of EPA compliance.
b. Other exhaust emissions as required by the local air quality management district issuing the permit for the engine generator system.
c. Reported at rated speed and load as measured by SAE J177 and J215 or ISO 8178 recommended practices.

4. Generator (alternator):
a. Rated output:
1) kW standby.
2) power factor.
3) Voltage.
4) Current.
b. Number of poles.
c. Number of leads and wires per lead.
d. Pitch.
e. Stator and field ratings including temperature rise at full and overload conditions.
f. Insulation system:
1) Insulation class.
2) Stator rise.
3) Rotor rise.
4) Heat dissipated (kW).
5) Air flow (m^3/min).
g. Impedances (per unit and ohms):
1) Synchronous reactance - direct axis (X_d).

2) Synchronous reactance - quadrature axis (X_q).
3) Transient reactance - saturated (X'_d).
4) Subtransient reactance - direct axis (X''_d).
5) Subtransient reactance - quadrature axis (X''_q).
6) Negative sequence reactance (X_2).
7) Zero sequence reactance (X_0).

h. Time constants:
1) Open circuit transient – direct axis.
2) Short circuit transient – direct axis.
3) Open circuit subtransient – direct axis.
4) Short circuit subtransient – direct axis.
5) Open circuit subtransient – quadrature axis.
6) Short circuit subtransient – quadrature axis.
7) Exciter time constant.
8) Armature short circuit.

i. Short circuit ratio.
j. Stator resistance.
k. Field resistance.
l. I^2t or K (heating time constant).
m. Voltage and frequency variation and duration with the step application and removal of 25 percent, 50 percent, 75 percent, and 100 percent of resistive load maximum.
n. Generator efficiency at:
1) 25 percent load.
2) 50 percent load.
3) 75 percent load.
4) 100 percent load.

o. Generator output characteristic curves:
1) Open circuit.
2) Short circuit.
3) Zero power factor.
4) Air gap.

p. Reactive capability curve.
q. Certified published engine horsepower curves showing manufacturer's engine rating for generator set standby and prime power application.
r. Decrement curve.
s. Thermal damage curve.

5. Governor.
6. Voltage regulator.
7. Generator control panel:
a. Dimensions:
1) Length.
2) Width.
3) Height.
4) Weight.

b. Power requirements.
c. Controls.
d. NEMA enclosure rating.

8. Space and ambient temperature requirements.

9. Battery system:
   a. Battery charger:
      1) Dimensions:
         a) Length.
         b) Width.
         c) Height.
         d) Weight.
      2) Input power requirements.
   b. Batteries:
      1) Number.
      2) Dimensions:
         a) Length.
         b) Width.
         c) Height.
         d) Weight.
      3) Amount of electrolyte.
      4) Enclosure or rack.
10. Silencer:
   a. Grade.
   b. Dimensions:
      1) Length.
      2) Width.
      3) Height.
      4) Weight.
11. Free field mechanical noise level at 23 feet. Provide overall decibels (dBA) rating referenced at 20 μPa.
12. Exhaust sound level in dBA at 5 feet from discharge end of silencer.
13. Recommended spare parts and special tools lists, specifying quantity of each item.
14. Drop-over enclosure:
   a. Dimensions:
      1) Length.
      2) Width.
      3) Height.
      4) Weight.
   b. Materials.
   c. Power requirements.
   d. Acoustic rating.
   e. Door locations and access requirements.
   f. Finish.

C. Shop drawings:
1. Provide detailed dimensional and to-scale layout drawings including:
   a. A single drawing incorporating all equipment furnished:
      1) Submittals that consist solely of individual drawings for each component and require that these sheets be compiled by the Engineer, in order to view the entire piece of equipment, are not acceptable.
   b. Drop-over enclosure size and details, where specified:
      1) Height, width, depth, clearances, power requirements, anchoring details for the drop-over enclosure.

2) Interconnection drawings for remote radiator including mechanical, plumbing, and electrical.

c. Conduit stub-out locations.

2. Detailed electrical wiring diagrams of the engine and generator including:
   a. Engine interconnection terminal box.
   b. Generator interconnection terminal box.
   c. Fuel system.
   d. All interfaces between the engine driven generator skid and the transfer equipment.
   e. All wire numbers and terminal block identifications:
      1) Wire numbers are to correspond to the wire number on the equipment.
      2) All wires are to be numbered.
   f. Complete interior and exterior control panel layout:
      1) Scaled.
      2) With device descriptions.
      3) With nameplates.
3. Piping connection and instrumentation diagrams.
4. Mounting and installation drawings:
   a. Detailing mounting requirements for the Project Site seismic requirements as specified in Section 26_05_00.
   b. Prepared and sealed by a registered structural professional engineer in the state where the Project is being constructed.

D. Operation and maintenance manuals:
1. Submit operating instructions and a maintenance manual presenting full details for care and maintenance of equipment of every nature furnished and/or installed under this Section.
2. Operating manual:
   a. The manual must detail the operational functions of all normally used controls that have been placed on the front of the control equipment.
   b. Standard operational manuals normally furnished by the manufacturer.
3. Maintenance manual:
   a. Printed and bound instructions covering all details pertaining to care and maintenance of all equipment as well as data identifying all parts.
   b. These manuals must include but are not limited to the following:
      1) Electrical controls:
         a) Adjustment and test instructions covering the steps involved in the initial test, adjustment, and start-up procedures.
         b) Detailed control instructions, which outline the purpose and operation of every control device used in normal operation.
         c) Description of the sequence of operation that outlines the steps the controls follow during normal power failure and normal power return conditions.
         d) All schematic, wiring, and external diagrams. Also, internal device wiring and schematic diagrams for all sub-assemblies used in the equipment:
            (1) Drawing to be furnished in a reduced 11-inch by 17-inch format and shall be fully legible at that drawing size.
            (2) Engine and generator:

e) Repair parts manuals normally furnished by the manufacturer.
   (1) Detailing all parts and sub-assemblies, which are available as repair parts.

2) Shop maintenance manuals:
   a) Provide 1 shop manual on-site that is equivalent to the manual used by factory-authorized shop repair personnel.
   b) Manuals for the following equipment:
      (1) Engine.
      (2) Radiator.
      (3) Generator.
      (4) Engine generator control panel.

c. Material safety data sheets:
   1) Complete MSDS forms for all substances.
   2) Located in O&M manual.
   3) Include separate manual labeled MSDS with additional copies of all MSDS forms.

4. Warranty Data.
5. Maintenance Contract information (if applicable).

E. Test reports:
   1. Furnish complete test reports as specified in this Section.

F. Certificates:
   1. Certification of the emissions performance of the generator set engine by the engine manufacturer.
   2. Certification that a torsional analysis between the engine and generator has been completed.
   3. Seismic certification, as required.
   4. Upon completion of installation, manufacturer must issue a certification of compliance with the Contract Documents.

G. Calculations:
   1. Complete loading calculations to support the recommended size of the engine-generator based upon actual facility loads and specified maximum allowable voltage drop.
   2. Supply documentation identifying the maximum static pressure acceptable for the radiator fan. It is the manufacturer’s responsibility to then provide calculations as part of the layout drawings, to ensure that the transition ductwork at the discharge of the radiator does not exceed the maximum static pressure acceptable for the radiator fan.
   3. Submit exhaust system silencer noise attenuation curves.
   4. Structural support system, mounting, and seismic calculations to be signed and stamped by a licensed structural professional engineer, registered in the state where the Project is located:
      a. Vibration isolator selection calculations.
      b. Vibration isolator anchoring calculations.
      c. Exhaust silencer structural support calculations on indoor applications.
   5. Submit factory certification of the radiator ambient capability.
   6. Submit exhaust system pressure loss calculations:
      a. Include piping, fittings, silencer, and rain cap in loss calculations on indoor applications.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. Manufacturer qualifications:
   1. The manufacturer of the engine, generator, and all major items of auxiliary equipment must be in current production of such equipment.
   2. A factory authorized parts and service facility located within 100 miles of the Project Site.
   3. Manufacturer is responsible for furnishing, testing, installation supervising, testing, and guaranteeing the system.

C. Regulatory requirements:
   1. In accordance with NFPA-110 Type 10 (ten second) transfer requirements.
   2. Fuel tanks:
      a. UL listed.
      b. Primary and secondary tanks shall be tested under pressure per the manufacturer's recommendation to check for leaks.
      c. Comply with the following, if applicable:
         1) NFPA 30 – Flammable and Combustible Liquids.
         2) NFPA 37 – Standard for Installation and Use of Stationary Combustible and Gas Turbines.
         3) NFPA 110 – Standard for Emergency and Standby Power Systems.
   3. Regulations of the Fire Prevention Bureau of the fire department having jurisdiction.
   4. Fire Code as specified in Section 01_41_00.
   5. Other applicable state and local codes.
   6. EPA approved.
   7. Requirements of local Air Quality Management District or Air Pollution Control District.
   8. Comply with the Specifications that may be in excess of, and not contrary to, the regulations.

D. The generator set(s) shall be manufactured to the applicable specifications on file with UL and labeled with the UL 2200 mark.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

B. Furnish the generator skid with removable lifting and jacking angles, eye bolts, etc., attached to the structural base to facilitate unloading and move-in operations.

C. Provisions on skid for the use of "Multiton" type rollers for moving the generator skid into position and then removal of the "Multiton" rollers and then for setting the engine generator skid in place.

D. Provide the services of a manufacturer's authorized representative to:
   1. Be present at the jobsite when the engine-driven generator arrives:
      a. Act as an advisor in assisting the Contractor regarding the unloading and move-in operations.
   2. Coordinate the delivery of the shipment with the Contractor.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING

A. Complete factory prototype and factory production tests in accordance with NFPA 110 before equipment is shipped.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Furnish the following spare parts:
   1. Three sets of lube oil filters, fuel filters, and gaskets.
   2. Two sets of air filters.
   3. Two spare lamps of each different lamp type.
   4. Two fuses (for each control circuit).
   5. One set of crankcase breather filters, when used.

B. Special tools: Furnish a set of specialty tools necessary for routine maintenance of the equipment.
   1. Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following list of manufacturers is a general guideline and makes no statement as to the capability of the manufacturer to meet the Specification requirements. The burden of proof of conformance with these Specifications lies with the Contractor and manufacturer. The Contractor must make special written application to use other than these named manufacturers:
   1. Engine generators:
      a. One of the following or equal:
         1) Caterpillar.
         2) Cummins Power Generation.
         3) MTU Onsite Energy.
   2. Governor:
      a. One of the following or equal:
         1) Woodward.

2) Isochronous electronic by engine manufacturer.
3. Drop-over enclosure:
   a. One of the following or equal:
      1) D.T.S.
      2) Engine-generator manufacturer's equivalent.
4. Base mounted fuel tank:
   a. One of the following or equal:
      1) Pryco.
      2) Tramont.
      3) Engine-generator manufacturer's equivalent.

B. Exhaust system:
1. One of the following or equal:
   a. Silencer:
      1) GTE Industries.
      2) Harco Manufacturing.
      3) Silex Innovations.
   b. Corrugated, flexible engine connector:
      1) DME.
      2) GTE Industries.
      3) Engine-generator manufacturer's equivalent.
   c. Expansion joint:
      1) DME Inc.
      2) GTE Industries.
   d. Exhaust pipe insulation:
      1) As specified in Section 40_05_06.55.
   e. Expansion joint insulation:
      1) Pittsburgh-Corning/JPS Composite Materials Corp., Temp-Mat.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Characteristics of assembled unit:
1. The engine-driven generator consists of a diesel engine directly coupled to an electric generator providing electric power.
2. The engine shall start, attain full speed, voltage, and assume full load within a maximum of 10 seconds, with jacket water at 85 degrees Fahrenheit.
3. Furnish the engine-driven generator on a steel sub-base to support engine, generator, and accessories as a unit:
   a. Base: Welded construction.
   b. Engine direct connected through a flexible coupling to a single bearing generator.
   c. System free of injurious torsional and bending vibrations within a speed range from 10 percent below to 10 percent above synchronous speed.
   d. Engine-driven generator balanced such that the peak-to-peak amplitude of vibration velocity in any direction does not exceed the engine or generator manufacturer's published limits.

e. If shims are required under the feet of the generator for alignment purposes, use 1-piece laminated shim stock that covers at least 90 percent of the foot.
f. Provide a complete assembled engine-driven generator skid requiring only field electrical and mechanical connections.

4. Connections to engine-driven generator skid:
   a. Flexible connections are required on all connections to the engine generator.
   b. These connections include but are not limited to:
      1) Exhaust.
      2) Fuel lines.
      3) Radiator discharge air ductwork.
   c. The length of all flexible connections to exceed the flexible connector manufacturer's minimum length recommendations for the diameter used and for the misalignment as measured after installation.

B. Generator system performance requirements:
1. Power output rating:
   a. Minimum kilowatts and voltage as indicated on the Drawings.
   b. 0.8 power factor.
   c. 3-phase, 4-wire, 60 hertz.
   d. In accordance with NEMA MG-1 temperature rise limits.
2. It is the manufacturer's responsibility to properly size the engine generator based upon site conditions and actual loads:
   a. Allowable voltage drop: 15 percent.
   b. The Drawings and Specifications indicate a minimum size that the Engineer has determined based upon non-certified information.
   c. No increase in Contract amount will be considered if the equipment size needs to be increased to meet the load requirements after bids have been submitted.
   d. Provide all changes to the electrical system as required as a result of manufacturers sizing including but not limited to:
      1) Conduit.
      2) Wire: Provide Nehr-McGrath calculations to verify appropriate cable sizing in accordance with NEC when additional wire is required.
      3) Circuit breakers.
      4) Transfer equipment.
3. Regulatory requirements:
   a. Specifically designed to meet the discharge of gaseous pollutants to the atmosphere as required by the EPA statute and local agency issuing the permit for the engine generator system.

2.06 COMPONENTS

A. Engine generator base:
1. Support system:
   a. Bolt the engine-driven generator to steel pads that are an integral part of structural support base.
   b. Vibration isolators shall be provided with the engine-driven generator and be installed between the engine generator and structural support base or between the base and the floor:
      1) As recommended by the isolator manufacturer.

2) Located for equal load distribution and deflection per isolator.
3) Designed for the load and seismic conditions as identified for the site.

B. Engine:
1. Full compression ignition, 4-cycle, turbocharged, and aftercooled meeting the required emissions rating.
2. The rated net horsepower of the engine with all accessories, including radiator fan, must not be less than that required to produce the minimum specified generator capacity at site altitude and maximum ambient temperature.
3. Equipped and designed as follows:
a. Spin-on type replaceable lube oil filters.
b. Spin-on type replaceable fuel filters.
c. Heat treated forged steel crankshaft:
1) Dynamically balanced.
d. Forged steel connecting rods.
e. Crankshaft driven gear type lubricating pump.
f. Electric fuel shut-off valve.
g. Engine air cleaner: Dry type replaceable filter.
h. 12- or 24-VDC positive engagement solenoid shift-starting motor:
1) The starting equipment must include the necessary devices to prevent an overcrank and lockout if the starter pinion fails to engage the flywheel ring gear on the initial crank attempt.
2) This starter disconnect shall electronically sense the speed of the flywheel and when the flywheel setpoint speed has been reached, the electronic control signals the starter disconnect to disengage.
i. Oil level dip stick and oil drain pipe with valve and pipe plug:
1) Oil drainpipe and valve are to extend 3 inches beyond edge of engine base.
j. Engines requiring glow plugs are not acceptable.
k. Crankcase breather filter for engines not equipped with EPA Tier certified engine's crankcase emissions control equipment:
1) Provide crankcase ventilation system with coalescing filter/trap for blowby:
a) Coalescing filter to be replaceable.
2) If engine manufacturer recommends an open crankcase breather system, route outlet of breather filter to outside at 3 inches above grade and away from engine components:
a) Provide on breather outlet Nelson "EcoVent" or equal, sized to match engine breather flow.
3) If engine manufacturer recommends a closed crankcase breather system, provide integral crankcase pressure regulator with an automatic internal filter bypass and bypass indicator:
a) Racor Model CCV 4500 or equal.

C. Governor:
1. Isochronous type to maintain engine speed:
a. Within 0.5 percent for steady state conditions.
b. Suitable for use on diesel engines.
c. Electronic governor control of fuel.
d. Suitable for automatic, unattended starts.
e. Speed sensing failure circuit to signal actuator to close if speed pick-up signal is lost.

f. With speed pick-up sensor.
g. With capabilities of local speed settings.
h. Adjustable acceleration rate control from 0 to 8 seconds.
i. Personnel guards over all exposed moving parts.
j. Equipped with a continuous duty shutdown system for normal remote stopping.

D. Engine jacket water heater:
1. Provide an in-line thermostat that disconnects power when coolant temperature exceeds the manufacturers' suggested setpoint.
2. Contacts from an oil pressure switch or control panel contacts disconnect the heater power when the engine is running.
3. Provided with shutoff valves and unions to allow heater replacement without draining the cooling system.
4. Make all water heater connections with high temperature silicon type hoses and constant torque hose clamps.
5. Size heater such that the engine block temperature is maintained at 85 degrees Fahrenheit at the specified minimum ambient temperature.
6. Connect water heater and thermostat to the engine to minimize heated water circulation through the radiator circuit.
7. Power supply:
   a. Water heaters smaller than 3,000 watts shall be 120 volts, 1-phase.
   b. Heaters 3,000 watts shall and larger be 460 volts, 1-phase.

E. Alternator (generator):
1. Brushless synchronous alternator.
2. Re-connectable 12 lead if available.
3. Self-ventilated.
4. Full amortisseur windings.
5. 2/3 pitch windings, skewed for smooth voltage waveform.
6. With permanent magnet generator pilot exciter.
7. Drip-proof enclosure.
8. Protected against corrosion.
9. Single bearing design.
   a. Alternators over 2,000 kW may be two bearing design.
10. Insulation:
    a. Insulated for continuous operation at 40 degrees Celsius ambient temperature.
    b. Class F (105 degrees Celsius rise by resistance) for medium voltage or Class H (125 degrees Celsius rise by resistance) for low voltage generators.
    c. Vacuum impregnated with epoxy varnish to be fungus resistant per MIL I-24092.
    d. Multiple dipped and baked with a non-hygroscopic varnish with a final dip of epoxy.
11. Terminate alternator power leads using compression lugs on an insulator and bus bar system within the alternator junction box:
    a. These terminations must not require any taping to complete the connection.

b. Provide a ground terminal inside the junction box to terminate the ground cables between the alternator to the automatic transfer equipment ground bus:
    1) Minimum size of the equipment-grounding conductor: 12-1/2 percent of the size of the phase conductors.
12. 120 VAC integral alternator winding heaters.
13. Maximum balanced telephone interference factor not to exceed 50.
14. Designed to supply power to the non-linear loads as specified and as indicated on the Drawings:

F. Alternator digital voltage regulator:
1. Located in the engine control panel.
2. Performance requirements:
    a. Maintain the steady state voltage within 1 percent:
        1) From 40 degrees Fahrenheit to 120 degrees Fahrenheit.
        2) From no load to full load conditions.
3. Constant volts per hertz characteristics with under frequency roll-off for better transient response.
4. Static type.
5. Sized to match the power requirements of the exciter circuit and power from the permanent magnet generator pilot exciter.
6. Include manual control to adjust voltage drop, voltage level, and voltage gain.
7. With 3-phase sensing.
8. Sealed from the environment and isolated from the load to prevent tracking when connected to SCR loads.
9. Include loss of sensing shutdown to protect the generator against uncontrolled voltage output when the sensing circuit to the regulator is opened.
10. Shut down regulator when the sensing circuit to the regulator does not have continuity.
11. Include over-excitation shutdown to protect the generator against thermal damage caused by prolonged field forcing.

G. Exhaust system:
1. General:
    a. Provide a complete exhaust system following as indicated on the Drawings and as specified.
    b. Back pressure:
        1) Provide components such that the maximum back-pressure in the exhaust system including piping and silencer is less than the maximum allowable back-pressure published by the engine manufacturer, measured at the exhaust manifold header:
            a) Reduce back-pressure when recommended by the engine manufacturer.
    c. Provide each exhaust manifold header with a plugged, tapped connection for the attachment of a test manometer.
2. Exhaust silencer:
    a. Heavy-duty industrial type fabricated of welded steel with ported tubes and snubbing chambers, and a rating meeting the specified sound attenuation.
    b. Mounting: As indicated on the Drawings.
    c. End connections: Steel flanges with Class 150-pound drilling pattern.

d. Shell:
   1) Sufficiently heavy and reinforced to eliminate excessive vibration, stress, or deflection and to support all operating loads with the silencer at elevated temperatures and insulated as specified.
   2) Loads include insulation weight and connecting piping.
e. Drain: Provide threaded, plugged condensate drain.
f. Sound attenuation: Attain the following minimum sound attenuation at the listed octave band center frequencies with the engine at full load:

Frequency (Hz)	63	125	250	500	1,000	2,000	4,000	8,000
Attenuation (dB)	39	42	42	40	38	38	38	38

g. Supports: Provide shell lug supports suitable for supporting and mounting the silencer as indicated on the Drawings; support design to account for elevated temperatures under insulated shell.
h. Insulate as specified for engine exhaust piping in Section 40_05_06.55.
i. Pressure drop not to exceed manufacturer’s recommendation at maximum engine rating.

H. Radiator and cooling system:
   1. Unit mounted:
      a. Furnish a skid mounted closed type radiator system for the engine driven generator:
      b. Sized and selected by engine manufacturer to cool the engine and turbo charge aftercooler under ambient conditions.
      c. Provide all necessary coolant specifically suitable for the location and conditions of service throughout the year:
      d. Ship both the engine and the radiator with the coolant installed.
I. Generator control panel:
   1. Microprocessor-based control system that is designed to provide automatic starting, monitoring, protection, and control functions for the generator set.
   2. Mounted on the generator set:
      a. Provide vibration isolation:
         1) Prototype tested to verify the durability of all components in the system under the vibration conditions encountered.
   3. Control system features and functions:
      a. Control switches:
         1) Mode selector switch:
            a) Provide a rotary switch or control panel keypads with status indicators.
            b) The mode select switch initiates the following control modes:
            c) RUN or Manual position:
               (1) Generator set starts, and accelerates to rated speed and voltage.
            d) OFF or STOP position:
               (1) Generator set immediately stops, bypassing all time delays.
            e) AUTO position:
               (1) Generator set accepts a signal from a remote device to start and accelerate to rated speed and voltage.
         2) EMERGENCY STOP switch:
            a) Red “mushroom-head” pushbutton.
            b) Activating the emergency stop switch causes the engine to immediately stop, and be locked out from automatic restarting.

3) RESET switch:
   a) Clears all faults and allow restarting the engine generator after it has shut down for any fault condition.
4) PANEL LAMP switch or automatic display panel illumination.

b. AC output metering: Provide the control system with metering including the following features and functions:
   1) Provide digital metering:
      a) 1.0 percent accuracy.
   2) Voltmeter:
      a) RMS voltage.
      b) Line-to-line.
      c) Line-to-neutral.
   3) Ammeter:
      a) RMS current.
   4) Frequency.
   5) Power Factor.
   6) Kilowatts (kW):
      a) kW-hours.
      b) Output kW.
   7) Kilovars (kVars):
      a) kVar-hours.
      b) Output kVar.

c. Generator alarm and status display:
   1) Provide high-intensity LED alarm and status indication lamps. Functions indicated include:
      a) Red alarm-indicating lamps.
      b) Red common shutdown lamp.
      c) Green lamp to indicate the engine generator is running at rated frequency and voltage based on actual sensed voltage and frequency on the output terminals of the generator set.
      d) Flashing red lamp to indicate that the control is not in automatic state.
      e) Amber common warning indication lamp.
   2) Display the following alarm and shutdown conditions on an alphanumeric digital display panel:
      a) Low oil pressure (alarm).
      b) Low oil pressure (shutdown).
      c) Oil pressure sender failure (alarm or indication).
      d) Low coolant temperature (alarm).
      e) High coolant temperature (alarm).
      f) High coolant temperature (shutdown).
      g) Engine temperature sender failure (alarm or indication).
      h) Low coolant level (alarm or shutdown – selectable).
      i) Fail to crank (shutdown).
      j) Fail to start/overcrank (shutdown).
      k) Overspeed (shutdown).
      l) Low DC battery voltage (alarm).
      m) High DC battery voltage (alarm).
      n) High AC voltage (shutdown).
      o) Low AC voltage (shutdown).
      p) Under frequency (programmable for alarm or shutdown).
      q) Overcurrent (programmed for warning or shutdown).

r) Short circuit – circuit breaker function (trip).
s) Emergency stop (shutdown).

d. Engine status monitoring:
   1) Display the following status conditions on an alphanumeric digital display panel:
      a) Engine oil pressure (pounds per square inch or kilopascal).
      b) Engine coolant temperature (degrees Fahrenheit or Celsius).
      c) Engine speed (revolutions per minute).
      d) Number of start attempts.
      e) Battery voltage (DC volts).
e. Data logging and display provision:
   1) Log the last 10 warning or shutdown indications on the engine generator.
   2) Monitor the total load on the generator:
      a) Maintain data logs of total operating hours at specific load levels ranging from 0 to 110 percent of rated load, in 10 percent increments.
      b) Display total hours of operation at less than 30 percent load and total hours of operation at more than 90 percent of rated load.
   3) The control system to log:
      a) Total number of operating hours.
      b) Total kW hours.
      c) Total control operational hours.
f. Engine control functions:
   1) Provide a cycle cranking system, which allows for user selected crank time, rest time, and number of cycles:
      a) Initial settings shall be for 3 cranking periods of 15 seconds each, with 15-second rest period between cranking periods.
   2) Provide an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this Specification, including adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting.
   3) Provide time delay start (adjustable 0 to 300 seconds) and time delay stop (adjustable 0 to 600 seconds) functions.
g. Battery monitoring system:
   1) Initiate alarms when the DC control and starting voltage is outside the manufacturers tolerances.
   2) Disable the low voltage limit during engine cranking (starter engaged).
   3) Monitor DC voltage as load is applied to the battery, to detect impending battery failure or deteriorated battery condition.
h. Remote control interface:
   1) Provide a minimum of 4 programmable output relays:
      a) Configurable for any alarm, shutdown, or status condition.
   2) Provide a minimum of 4 programmable inputs:
      a) Label as indicated on the Drawings.
      b) Labels shall match other control labels.

J. Battery system:
   1. Installed on the engine-driven generator skid.

2. Provide extra flexible minimum 4/0 welding cable to make the connection between the battery and the engine:
    a. Proper compression lugs and tooling must be used to terminate these cables.
3. Provide a 12- or 24-volt lead acid recombination no maintenance engine start battery system:
    a. The battery shall have sufficient capacity, at the minimum and maximum temperature specified, to provide the specified cranking periods.
    b. Provide battery capacity in order to supply power to the following:
        1) DC lighting.
4. Charger:
    a. Sized to provide sufficient power to both fully charge a drained battery.
    b. Location: On the engine skid.
    c. DC ammeter and DC voltmeter.
    d. On-Off switch.
    e. Solid-state device with adjustable float voltage control.
    f. Constant voltage design with current limit.
    g. With an equalize switch which will allow the battery to be overcharged for maintenance purposes or an automatic charging cycle that has an equalize period.
    h. Designed to meet the charge, float, and equalize requirement of the battery furnished.
    i. Overload and short circuit protection.

2.07 ACCESSORIES

A. Fuel system:
1. Engine fuel pump:
    a. Positive displacement pump.
    b. Capable of 5-foot lift minimum.
2. Base mounted fuel tank:
    a. Unit mounted base tank with the capacity to hold 12 hours of fuel with the engine generator set operating at full load.
    b. UL 142 listed tank with secondary containment rupture basin.
    c. Construction:
        1) Reinforced steel channel system.
        2) Minimum thickness of 7-gauge for channels.
        3) Minimum 12-gauge for tank construction.
    d. Provide tank baffle to separate hot fuel return from cooler supply fuel.
    e. Connections:
        1) 1.25-inch minimum vents:
            a) Pipe vent outside any room or enclosure containing the generator set, using Schedule 40 black steel pipe.
        2) Two-inch minimum fill connection.
        3) Two-inch minimum main fuel storage level gauge.
        4) 1.25-inch minimum low fuel level alarm with level switch connected to control panel.
        5) 0.5-inch minimum fuel supply with dip tube.
        6) 0.5-inch minimum fuel return with dip tube.
    f. Rupture basin level switch and alarm.
    g. Finish:
        1) Interior: Treated to inhibit corrosion until fuel is added.

2) Exterior: Epoxy coating with urethane top coat.

h. Ancillary equipment:
   1) Provide the following base tank accessories as required by NFPA 30 for project application:
      a) Low fuel level float switch, set at 50 percent.
      b) High fuel level / overfill prevention, audible alarm, set at 90 percent.
      c) Overfill prevention valve on tank fill port, set at 95 percent.
      d) Fill port drop tube to within 6 inches of the bottom of the tank.
      e) Spill containment bucket or basin around fill port.
      f) Interstitial monitoring float switch (leak detection).
      g) Normal vents, extended 13 feet above grade, flame arrester caps.
      h) Emergency vents, on tank and containment basin.
      i) Provisions for connection of grounding conductor.
      j) Tank calibration chart in inches to gallons.

i. Warning signage:
   1) No Smoking.
   2) Flammable Liquids.
   3) Diesel Fuel.
   4) NFPA 704 Placards.

B. Drop-over enclosure:
   1. Provide enclosure to protect engine, generator, starting system, batteries, and other specified accessories from weather exposure.
   2. Meet seismic and wind requirements at the Project Site.
   3. Construction:
      a. Minimum 14 gauge steel panel thickness.
      b. All panels and members hot dip galvanized after fabrication.
      c. Enclosure removable to allow for maintenance.
      d. Fitted with lockable latches.
      e. Stainless steel latches and hinges.
   4. Finishing: Factory or shop finished in epoxy and urethane coating system as specified in Section 09_96_01.
   5. Noise reduction:
      a. Provide acoustical insulation and acoustical enclosure ventilation louvers and fan discharge silencers as necessary to achieve a measured sound pressure level of 75 dBA when measured at 23 feet from the enclosure.
      b. Protect acoustical insulation with perforated metal covers and plastic bagging to prevent damage from abrasion or weather elements.
      c. Provide an exhaust silencer matched to the enclosure to reduce the overall noise emissions level of the engine/generator assembly to the levels required above.

C. Wiring:
   1. All external wiring connections to and from the engine and alternator shall be made via two engine mounted junction boxes:
      a. One box shall be used for all control and DC power connections.
      b. The other box shall be used for the alternator output connections:
         1) The alternator output breaker may be used for these connections.

2. Enclose wiring in an NEC approved and recognized conduit system selected and sized by the engine generator manufacturer:
    a. Suitable for the temperatures, vibrations, and conditions on the engine-driven generator skid.
3. Control wiring shall terminate on terminal blocks in the control junction box:
    a. All connections shall be made to terminal blocks:
        1) 600 volt rated.
        2) Wires terminated on box with compression type ring type lugs, installed with proper tooling.
        3) Terminal blocks shall be numbered.
        4) All wiring in terminal box both internal and field connections shall be routed in plastic wire duct.
4. Terminate alternator output connection wires using solderless compression type lugs when connecting to bus bar:
    a. Lug manufacturer’s termination methods and tools must be used.
5. Splices are not allowed:
    a. All connections are to be made at the terminal blocks in the control junction boxes.

D. Miscellaneous engine generator skid items:
1. Provide the following items:
    a. Sectionalized drip pans.
    b. Rain shields for exhaust lines.
    c. Roof jacks.

E. Generator output circuit breaker:
1. Engine generator skid mounted and line side connected to alternator.
2. Manually resettable.
3. Line current sensing.
4. Inverse time versus current response.
5. Sized and coordinated to protect the generator from damage from overload and/or short circuit:
    a. Coordinated with downstream devices:
        1) As specified in Section 26_05_74.
6. Breakers shall be as specified in Section 26_28_01.
7. Provide breakers with proper number of lugs to match cables as indicated on the Drawings.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. General:
   1. Install the equipment as indicated on the Drawings.
   2. Perform all Work in accordance with manufacturer's instructions and shop drawings.
   3. Before start-up, furnish written certification that the entire installation and all connections, both mechanical and electrical, have been inspected and are proper and consistent with the Drawings and Specifications.

C. Installation shall be by personnel experienced and regularly engaged in field installation of power generation systems:
   1. Make all field mechanical and electrical connections.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

B. Design prototype tests as follows:
   1. Use design prototypes similar to the equipment specified in this Section for testing, and not the actual equipment for the Project.
   2. Minimum testing requirements:
      a. In accordance with NFPA.
      b. Maximum power in kW.
      c. Maximum starting kilovolt-ampere at 35 percent instantaneous voltage dip.
      d. Alternator temperature rise:
         1) By embedded thermocouple.
         2) By resistance method.
         3) In accordance with NEMA MG1-22.40 and 16.40.
      e. Governor speed regulation under steady state and transient conditions.
      f. Fuel consumption at 25 percent, 50 percent, 75 percent, and 100 percent load.
      g. Harmonic analysis, voltage wave form deviation, and telephone influence factor.
      h. Cooling airflow.
      i. Torsional analysis testing to verify that the generator set is free of harmful torsional stresses.
      j. Endurance testing.

k. A certified copy of the test results will be furnished to the Owner.

C. Test each engine generator under varying loads with all machine safety guards and exhaust system in place.

D. Test the complete engine generator system at full load and rated power factor with a reactive load bank in the manufacturer’s factory:
1. Tests shall include:
    a. Radiator.
    b. Engine control panel.
    c. Single-step load pickup.
    d. Transient and steady-state governing.
    e. Safety shutdown device testing.
    f. Rated power.
    g. Maximum power.
2. During the tests, re-circulate the radiator cooling air through the radiator as necessary to test the system under the maximum ambient conditions specified in this Section.
3. Run the unit for 2 hours with the following recordings made hourly:
    a. Frequency.
    b. Voltage.
    c. Amperage.
    d. Kilowatts.
    e. Room temperature measured at the generator end of the unit.
    f. Radiator air inlet temperature.
    g. Coolant temperature.
    h. Oil pressure.
4. Record the following items:
    a. Time required for the engine/generator to start and reach rated voltage and frequency in seconds.
    b. Maximum block load capabilities of the unit.
    c. Point at which overtemperature shutdown occurs.
    d. Point at which overspeed shutdown occurs.
    e. Point at which low oil pressure shutdown occurs:
    f. Point at which overcrank shutdown occurs.
    g. Low water temperature alarm.
    h. Low fuel level alarm.
    i. Fuel leak alarm.
    j. Overvoltage alarm and shutdown.
    k. Undervoltage alarm and shutdown.
    l. Under frequency alarm and shutdown.
    m. Low battery voltage alarm.
5. Furnish a certified copy of the test results to the Owner:
    a. Record any minor adjustments made during the test.
    b. If major changes, as determined by the Engineer, are made, the 2-hour test must be repeated.

E. Owner training:
1. As specified in Sections 01_75_17 and 26_05_00.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

B. Provide the services of a manufacturer's representative for the following:
   1. Before start-up, furnish written certification that the entire installation and all connections, both mechanical and electrical, have been inspected and are proper and consistent with all Drawings and Specifications.
   2. Furnish the services of factory-certified technicians during the start-up and adjustment period to make sure all items furnished are in proper operating condition:
      a. Engine technician must be completely knowledgeable in the operation, maintenance, and start-up of the mechanical system.
      b. Electrical technician must be completely knowledgeable in the operation, maintenance, and start-up of the electrical system.
      c. These technicians to instruct the Owner's personnel regarding the operation and maintenance of all items supplied:
         1) Supply written handouts during the training period, and these handouts should be suitable for future reference after the training period is completed.
      d. Furnish a written report after the start-up:
         1) Report must state that the installation is complete and satisfactory.
         2) List the items requiring additional attention.

C. Manufacturer to perform installation check, start-up, and load test.

D. Certify that fuel, lubricating oil, and antifreeze conform with the manufacturer's recommendations under the environmental conditions present.

E. Check accessories that normally function while the equipment is in standby mode for proper operation, before cranking the engine:
   1. These accessories include but are not limited to:
      a. Jacket water heaters.
      b. Fuel heaters, when used.
      c. Battery charger.
      d. Generator strip heaters, when used.

F. Start-up under manual mode:
   1. Check for the following items:
      a. Exhaust leaks.
      b. External path for exhaust gases.
      c. Cooling airflow.
      d. Movement during starting and stopping.
      e. Vibration during running.
      f. Normal and emergency line-to-line voltage and phase rotation.

G. Perform field acceptance tests as specified in Section 26_08_50.

3.09 ADJUSTING

A. Make adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_36_24

TRANSFER SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Transfer switches.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. Underwriters Laboratories (UL):
   1. UL 1008 Transfer Switch Equipment.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

B. Specific definitions:
   1. ATS: Automatic transfer switch.
   2. MTS: Manually initiated, electrically operated transfer switch.

1.04 SYSTEM DESCRIPTION

A. Provide transfer switches capable of transferring load circuits from utility power to standby power and back.

B. ATS sequence of operation:
   1. When the voltage of any normal source phase drops below 80 percent and after an adjustable time delay (0 to 6 seconds minimum), the transfer switch shall start the standby generator.
   2. When standby voltage reaches 90 percent of nominal, and frequency is within 2 Hertz of nominal, following an adjustable time delay (0 to 10 seconds), the switch shall transfer to standby power.
   3. When normal power has been restored to 90 percent of nominal on all phases, following an adjustable time delay (0 to 30 minutes), the switch shall retransfer to normal power.
      a. If the standby source fails during this time delay, the switch shall automatically retransfer to normal power.
      b. The switch shall have an adjustable delay transition timer (0 to 5 minutes) for the load disconnect position.

4. Following an adjustable generator cool-down timer (0 to 60 minutes), the switch shall stop the generator.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
   1. Manufacturer of transfer switch.
   2. Manufacturer of all component parts of the ATS.
   3. Dimensions:
      a. Width.
      b. Length.
      c. Height.
      d. Weight.
   4. Bill of material.
   5. Description of operation.
   6. Ratings:
      a. Voltage.
      b. Phase.
      c. Current.
      d. Number of poles.
   7. List of recommended spare parts.
   8. For equipment installed in structures designated as Seismic Design Category C, D, E, or F, submit the following as specified in Section 26_05_00:
      a. Manufacturer’s statement of seismic qualification with substantiating test data.
      b. Manufacturer’s special seismic certification with substantiating test data.

C. Shop drawings:
   1. Layout drawings:
      a. Furnish full-dimension and to-scale equipment layout drawings which include:
         1) Plan, front, and side views.
         2) Sub-panels.
         3) Interior panels.
         4) Top and bottom conduit windows.
   2. Complete electrical wiring diagrams:
      a. Point-to-point connections.
      b. Indicate wire numbers.
   3. Complete interface and connection diagrams.

D. Installation instructions:
   1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
   2. For equipment installed in structures designated as Seismic Design Category A or B:
      a. Provide manufacturer’s installation instructions and anchoring details for connecting equipment to supports and structures.

3. For equipment installed in structures designated as Seismic Design Category C, D, E, or F:
    a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 26_05_00.
    b. Submit anchoring drawings with supporting calculations.
    c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

E. Operation and maintenance manuals:
1. Operating instructions:
    a. Printed and framed instruction chart suitable for wall hanging.
    b. Detail the operational functions of all transfer switch controls.
2. Maintenance manual:
    a. Furnish maintenance manuals with instructions covering maintenance of all equipment and data identifying all parts.
    b. Furnish all information needed to maintain the transfer switch including, but not limited to, the following:
        1) Instructions for testing, adjustment, and start-up.
        2) Detailed control instructions that outline the purpose and operation of every control device used in normal operation.
        3) Description of the sequence of operation that outlines the steps that follow normal power failure, transfer to standby power, return to normal power, and fault conditions.
        4) Schematics and wiring:
            a) Furnished in a reduced 11-inch-by-17-inch fully legible format.
        5) Report listing the installed setting of all adjustable parameters for the automatic transfer system.

F. Test forms and reports:
1. Submit complete factory acceptance test procedures and all forms used during the test.
2. Manufacturer to furnish certified report after the factory tests.
3. Manufacturer to furnish written report after start-up:
    a. Report must state that the installation is complete and satisfactory, or list items requiring additional attention and a proposal for the corrective actions.
    b. If the items require attention after the initial start-up, a final report is required stating that the installation is complete and satisfactory.

G. Calculations:
1. Detailed calculations or details of the actual physical testing performed on the transfer switch to prove the transfer switch is suitable for the seismic requirements at the Project Site.

H. Warranty.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. Transfer switches shall be UL listed and labeled.
   1. Where indicated on the Drawings the transfer switch shall be UL labeled and listed “Suitable for Service Entrance”.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

B. Ship the transfer switch to the job site on a dedicated air-ride vehicle that will allow the Contractor to utilize on-site off-loading equipment.

C. Furnish temporary equipment heaters within the transfer switch to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Transfer switch: One of the following or equal:
   1. GE Zenith Controls, Inc.
   2. Russelectric Inc.
   3. Eaton/Cutler-Hammer.
   4. ASCO.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. General:
   1. Capable of switching all classes of load.
   2. Rated for continuous duty when installed in a non-ventilated enclosure.
   3. Provide circuit breakers or contactors rated for continuous duty.
   4. Minimum transfer time for delayed transition ATS: 1 second.
   5. Capable of transferring successfully in either direction with 70 percent of rated voltage applied to the terminals.
   6. Provide automatic transfer switches with provisions for manual operation under no load.

B. Electrical ratings:
   1. Voltage, configuration, and amp ratings as indicated on the Drawings.
   2. Withstand and close into fault ratings in accordance with UL 1008.

C. Contacts:
   1. Mechanically held.
   2. Mechanically interlocked to prevent normal and standby sources from being closed at the same time.
   3. Silver alloy construction.
   4. Neutral contact, when indicated on the Drawings:
      a. Same ratings as the phase contacts.
      b. Break last and make first operation.

D. Controls:
   1. ATS shall have 3-phase over-voltage, under-voltage, over-frequency, and under-frequency on both normal and standby sources.
   2. Control panel:
      a. Microprocessor based.
      b. 4-line, 20-character LCD display. Displayed data shall include:
         1) Normal and standby source parameters.
         2) Diagnostic information.
         3) Switch and timer status.
      c. Keypad for making all ATS settings and operating parameters.
         1) All settings shall be password protected.
      d. LED display of the following:
         1) Normal source available.
         2) Connected to normal source.
         3) Standby source available.
         4) Connected to standby source.
      e. Provisions for testing ATS operation by simulating a normal source failure.
      f. Generator exerciser:
         1) Programmable to start the generator on a daily, weekly, monthly, or yearly basis for an adjustable period of time.
         2) Load or no load selectable.
            a) When load is selected, ATS will transfer to the generator for the duration of the exercise period. Re-transfer back and cool down the generator.
            b) When no load is selected, the ATS will run the generator for the duration of the exercise period and then stop the generator.

3. Status and control contacts:
   a. Generator start/stop contact:
      1) Single-pole, double-throw.
      2) Rated for 5 amps at 30 VDC.
   b. Status contacts:
      1) Single-pole, double-throw.
      2) Rated for 10 amps at 250 VAC.
      3) Provide contacts for the following:
         a) Normal source available.
         b) Normal source failure.
         c) Connected to normal source.
         d) Standby source available.
         e) Standby source failure.
         f) Connected to standby source.

E. Enclosure:
   1. NEMA 12.

F. Bypass-isolation switch:
   1. Provide a bypass-isolation transfer switch to allow electrical bypass and isolation of the ATS:
      a. Bypass of the load to either normal or standby source with complete isolation of the automatic transfer switch shall be possible.
      b. The load shall not be interrupted during bypass or isolation functions.
         1) Configurations that include load break contacts causing load interruption are not acceptable.
         2) Bypass-isolation contacts shall not be in the circuit except during bypass-isolation operation.
      c. All operations shall be possible with the enclosure door closed.
   2. The isolation handle shall have 3 positions: Automatic, Test, and Isolate:
      a. The Test position shall permit electrical testing of the automatic transfer switch without load interruption.
      b. The Isolate position shall completely isolate the transfer switch from both sources and load without actual removal of the line or load conductors:
         1) Allows for removal of the transfer switch.
      c. While in the Test or Isolate positions, the bypass-isolation switch shall function as a manual transfer switch:
         1) Manual transfer shall be independent of the transfer switch position, including transfer switch removal.
         2) Reconnection of load terminals shall not be required.
      d. Operating speed of the bypass-isolation switch contacts shall be independent of the speed of the isolation handle.
   3. Furnished with a diagnostic instruction plate located on the enclosure door including the following indication lights:
      a. Normal source available.
      b. Emergency source available.
      c. Bypass switch in normal position.
      d. Bypass switch in emergency position.
      e. Automatic transfer switch in test position.
      f. Automatic transfer switch isolated.
      g. Automatic transfer switch inhibited.
      h. Automatic transfer switch operator disconnect switch "OFF."

i. Automatic transfer switch in normal position.
j. Automatic transfer switch in emergency position.

4. Furnish an independent engine start circuit:
   a. Automatically starts the generator in bypass-normal/ATS isolated configuration and allows immediate selection of the standby source.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

3.04 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

B. Factory testing:
   1. Complete factory test to verify proper operation of all timers, settings, and operation.
   2. In accordance with UL-1008.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 26_05_00.

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_41_01

LIGHTNING PROTECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Design and installation of a complete lightning protection system.
   2. Materials and components for the lightning protection system.

B. Related sections:
   1. Section 01_31_19 - Project Meetings.
   2. Section 01_33_00 - Submittal Procedures.
   3. Section 01_75_17 - Commissioning.
   4. Section 01_77_00 - Closeout Procedures.
   5. Section 01_81_04 - Wind Design Criteria.
   6. Section 26_05_00 - Common Work Results for Electrical.
   7. Section 26_05_26 - Grounding and Bonding.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. Lightning Protection Institute (LPI).

C. National Fire Protection Association (NFPA):
   1. 780 - Standard for the Installation of Lightning Protection Systems.

D. Underwriters Laboratories, Inc. (UL):
   1. 96 - Standard for Lightning Protection Components.
   2. 96A - Standard for Installation Requirements for Lightning Protection Systems.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

B. Specific definitions:
   1. LPI: Lightning Protection Institute.

1.04 SYSTEM DESCRIPTION

A. Retain the services of a lightning protection contractor to design, furnish, and install a complete lightning protection system, connected to the facility grounding system.

B. Lightning protection system: NFPA 780; Class I UL 96A; master labeled system(s) protecting the structures and facilities consisting of:
   1. Air terminals on roof(s).
   2. Bonding of structure, water tank, and other metal objects.
   3. Grounding electrodes.

4. Interconnecting conductors.

C. Connect the lightning protection system to the facility grounding electrode:
   1. Provide common ground connections as necessary to the electric and telephone service conductors and radio antennas.

D. The installing contractor is responsible for all costs associated with UL inspection of the lightning protection system, including any costs associated with re-inspection necessary to obtain the UL 96A Master Label.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
   1. Provide samples and pertinent catalog data for:
      a. Air terminals.
      b. Conductors.
      c. Connectors.
      d. Accessories.
      e. Include dimensions and materials of each component, and include indication of listing in accordance with UL 96.

C. Shop drawings:
   1. Including but not limited to:
      a. Layout of air terminals with the respective configuration of the zone of protection.
      b. Grounding electrodes, and bonding connections to structure and other metal objects.
      c. Type, size and locations for:
         1) Terminal.
         2) Electrode.
         3) Conductor.
      d. Conductor routing details.
      e. Connection details.
      f. Termination details.
      g. Applicable air terminal and other calculations.
   2. Details showing installation of air terminals, conductors, and connectors.

D. Certificates:
   1. Submit 2 notarized photocopies of the completed Application for UL Master Label for each lightning protection system.
   2. Submit written confirmation of having obtained UL Master Label for each lightning protection system.
   3. Photocopy of UL Installers' Certificate(s) for installation of lightning protection systems.
   4. Written confirmation regarding the system manufacturer's and the system installer's membership in the Lightning Protection Institute.
   5. Proof of the manufacturer and installer having been UL-listed and LPI-certified] for at least 5 years.

E. Record Documents:
   1. Provide Record Documents as specified in Sections 01_77_00 and 26_05_00.

2. Accurately record actual locations of air terminals, grounding electrodes, bonding connections, and routing of system conductors.
3. Manufacturer's installation instructions.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. Conform to the requirements of the UL and NFPA standards for lightning protection systems:
   1. Components shall be listed in accordance with UL 96.

C. Manufacturer’s qualifications:
   1. Company specializing in lightning protection equipment with minimum 5 years experience and a fully certified manufacturer member of the Lightning Protection Institute.

D. Installers qualifications: Authorized installer for manufacturer with minimum 5 years experience and member of the Lightning Protection Institute and LPI-certified installer for installation of lightning protection systems

E. The lightning protection system shall meet the applicable requirements of NFPA 780.

F. Upon completion of installation the lightning protection contractor to have the building lightning system physically inspected by UL and furnish a UL Master Label for the building:
   1. Application for the UL Master Label without a physical inspection by UL is unacceptable.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING

A. Pre-installation conference:
   1. Convene a pre-installation conference **3** weeks before commencing the Work of this Section, as specified in Sections 01_31_19 and 26_05_00.

B. Coordinate Work with other trades to ensure neat, correct, and unobtrusive installation.

C. Coordinate the Work of this Section with roofing and exterior and interior finish installations.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Erico.
   2. Thompson Lightning Protection, Inc.
   3. Harger Lightning and Grounding.
   4. VFC, Inc.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Air terminals:
   1. Material: Aluminum.
   2. Size: 3/8-inch by 18-inch minimum extending a minimum of 12 inches above the object to be protected.
   3. On flat or walkable roofs, provide air terminals with:
      a. Mushroom type blunt tip incapable of impalement if fallen upon.
      b. Spring mounted and capable of being pushed flush to the roof.
   4. Air terminal bases:
      a. Cast bronze with bolt pressure cable connections securely mounted with stainless steel screws and bolts.

B. Ground rods:
   1. As specified in Section 26_05_26.

C. Ground plate: Copper.

D. Conductors:
   1. Perimeters:
      a. Aluminum.
   2. Down conductors:
      a. Copper.
   3. At least 32 strands of 17 gauge or larger copper wire weighing not less than 215 pounds per 1000 feet.
   4. UL listed for the application.
   5. Cable fasteners:
      a. Electrolytically compatible with conductors and mounting surface:
         1) Spaced in accordance with LPI and NFPA requirements.

E. Connectors and splicers: Aluminum:
   1. Make connections between dissimilar metals with approved bimetallic connectors.

F. Miscellaneous materials:
   1. Copper of type and size recommended by the manufacturer of the lightning protection system.
   2. Stainless steel bolts, screws, and other threaded fasteners.

G. System: Aluminum components for aluminum roofing, compatible with aluminum roofing materials; mechanical connectors and transition joints between aluminum and copper, suitable, properly installed by trained personnel.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

A. It is the responsibility of the lightning protection subcontractor to review the electrical system design, and provide any and all additional equipment and materials needed in order to construct a master labeled UL lightning protection system.

B. Verify that surfaces are ready to receive work.

C. Protect elements surrounding Work of this Section from damage or disfiguration.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Install systems in accordance with manufacturer's instructions unless otherwise specified in this Section.

C. Installation must be made under the supervision of and by an LPI certified master installer.

D. Conductor installations:
   1. Install the lightning protection roof system(s) grounding and bending conductors exposed on flat roof areas and concealed at ridge roof areas.
   2. Install main downleads completely concealed and sleeved.
   3. Other than for the purpose of protecting downlead conductors from damage up to 6 feet above grade level, do not use exposed conduits to conceal the downleads on the exterior of the building outside walls.
   4. Use minimum 1-inch PVC conduits to protect lightning system conductors from damage.

E. Clearances: Assure 6-foot minimum distance required by NEC:
   1. From lightning rod conductors to non-current-carrying metal parts of electrical equipment unless they are bonded to the rods.
   2. From lightning system conductors to open conductors of communication systems.
   3. From lightning protection grounding electrodes to electrodes of other grounding systems.

F. Extend air terminals a minimum of 12 inches above object to be protected.

G. Maintain horizontal or downward coursing of main conductor and ensure that bends have at least an 8-inch radius and that no bend of a conductor forms an included angle of less than 90 degrees.

H. Install ground electrodes not less than 1 foot below grade and not less than 2 feet from foundation walls.

I. Interconnection of metals:
   1. Bond all metal bodies within 6 feet of the conductor to the system with approved fittings and conductor.
   2. Connections between dissimilar metals shall be made with approved bimetallic connections.
   3. Bond metal bodies of inductance located within 6 feet of a conductor or object with secondary bonds.

J. Bond all isolated metallic bodies at or below the roof subject to inductance and within 6 feet of lightning protection system conductors.

K. Provide necessary common grounds between the lightning protections system and the electric and telephone service entrance wires, TV and radio antenna grounds.

L. Ensure that air terminals are installed to withstand calculated wind force due to 100 miles per hour winds or as specified in Section 01_81_04, whichever is greater with a 1.3 gust factor without structural damage and without damage to integrity of the lightning protection system.

M. Protect down conductors entering corrosive soil against corrosion by a protective coating for not less than 3 feet above grade level and for the entire length below grade level until connection to the ground ring and rods.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00:

B. Provide the services of UL to physically inspect the entire lightning protection system and issue the UL Master Label:
   1. Furnish UL Master Label as evidence that the installation has met with UL 96A code requirements.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_43_14

SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. High-energy surge protective devices.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 - Common Work Results for Electrical.
   4. Section 26_08_50 - Field Electrical Acceptance Tests.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. C62.41 – Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits.
   2. C62.45 –Guide on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
   3. C62.62- Standard Test Specifications for Surge Protective Devices for Low Voltage AC Power Circuits.

C. Underwriters Laboratory:
   1. 1449, 4th Edition, Standard for Surge Protective Devices.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

B. Specific definitions:
   1. SPD: Surge protective device.
   2. SAD: Silicon avalanche diode.
   3. MOV: Metal oxide varistor.
   4. MCOV: Maximum continuous operating voltage.
   5. I_n: Nominal discharge current.
   6. VPR: Voltage protection rating.
   7. SCCR: Short circuit current rating.

1.04 SYSTEM DESCRIPTION

A. Surge protective devices as an integral component of the electrical equipment or externally mounted as indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
   1. Furnish complete product data confirming detailed compliance or exception statements to all provisions of this Section.
   2. Manufacturer's catalog cut sheets indicating:
      a. Manufacturer and model numbers.
      b. Ratings of each SPD including but not limited to:
         1) Short circuit current rating.
         2) Nominal discharge current.
         3) Maximum continuous operating voltage.
         4) Voltage protection rating.
         5) System voltage.
         6) System frequency.
         7) Surge current capacity.
   3. Submit independent test data from a nationally recognized testing laboratory verifying the following:
      a. Overcurrent protection.
      b. UL 1449.

C. Shop drawings:
   1. Provide electrical and mechanical drawings by the manufacturer that detail:
      a. Unit dimensions.
      b. Weights.
      c. Components.
      d. Field connection locations.
      e. Mounting provisions.
      f. Connection details.
      g. Wiring diagram.

D. Operation and maintenance manuals:
   1. Provide the manufacturer's manual with installation, start-up, spare parts lists, and operating instructions for the specified system.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

B. Provide SPD units that are designed, manufactured, tested and installed in compliance with the following codes and standards:
   1. Institute of Electrical and Electronics Engineers (IEEE C62.41, C62.45, C62.62).
   2. Federal Information Processing Standards Publication 94 (FIBS PUB 94).
   3. National Electrical Manufacturer Association.
   4. National Fire Protection Association (NFPA 20, 75 and 780).
   5. National Electric Code (NFPA 70).
   6. Underwriters Laboratories (UL 1449 4th Edition and UL 1283).
   7. International Electrotechnical Commission (IEC 801).

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING

A. Coordinate with and provide SPD equipment to the electrical equipment manufacturer before final assembly and factory testing.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00.

B. Extended warranty:
   1. Furnish a manufacturer’s full 5-year parts and labor warranty from date of shipment against any part failure when installed in compliance with manufacturer's written instructions, UL listing requirements, and any applicable national, state, or local electrical codes.
   2. Warranty shall include:
      a. Direct, factory trained employees must be available within 48 hours for assessment of the problem.
      b. A 24-hour toll-free 800-number for warranty support.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Liebert.
   2. Eaton/Cutler-Hammer.
   3. Schneider Electric/Square D.
   4. General Electric.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Provide Type 1 or Type 2 SPD units as required for the locations indicated on the Drawings.

B. Electrical requirements:
   1. SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
   2. MCOV:
      a. For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): Greater than 115 percent of the nominal system operating voltage.
   3. Operating frequency:
      a. 47 to 63 hertz.
   4. SCCR:
      a. 65 kAIC minimum, but not less than the equipment it is connected to as indicated on the Drawings.
      b. The SCCR shall be marked on the SPD in accordance with UL 1449 and the NEC.
   5. Nominal discharge current I_n:
      a. 20 kA.
   6. Maximum VPR:

Modes	240/120	208Y/120	480Y/277
L-N, L-G, N-G	900	900	1,500
L-L	1,200	1,200	2000

   7. Peak surge current:
      a. Service entrance locations:
         1) 240 kA per phase minimum.
         2) 120 kA per mode minimum.
      b. Branch locations:
         1) 120 kA per phase, minimum.
         2) 60 kA per mode minimum.

C. Protection modes:
   1. Provide SPD protection modes as follows:
      a. Line to Neutral (L-N) where applicable.
      b. Line to Ground (L-G).
      c. Neutral to Ground (N-G), where applicable.

D. Environmental requirements:
   1. Storage temperature:
      a. -40 degrees to +50 degrees Celsius.
   2. Operating temperature:
      a. -0 degrees to +60 Celsius.
   3. Relative humidity:
      a. 5 percent to 95 percent.
   4. Audible noise:
      a. Less than 45 dBa at 5 feet (1.5 m).
   5. Operating altitude:
      a. Zero to 12,000 feet above sea level.

E. Provide surge protective devices that are suitable for application in IEEE C62.41 Category A, B and C3 environments, as tested to IEEE C62.45.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Enclosure:
   1. Located in electrical equipment as or in an external NEMA 12 enclosure indicated on the Drawings.
      a. NEMA Type 12 enclosure:
         1) No ventilation openings.
      b. Hinged cover requiring a tool for internal access.
      c. Internal drawing pocket.
      d. All monitoring indications must be visible without opening the door.

B. Internal connections:
   1. Provide low impedance copper plates for intra-unit connections:
      a. Attach surge modules using bolted connections to the plates for low impedance connections.
   2. Size all connections, conductors, and terminals for the specified surge current capacity.

C. Surge diversion modules:
   1. MOV:
      a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer's defects.

D. Overcurrent protection:
   1. Individually fuse all components, including suppression, filtering, and monitoring components:
      a. Rated to allow maximum specified nominal discharge current capacity.
      b. Overcurrent protection that limits specified surge currents is not acceptable.

E. Connections:
   1. Provide terminals to accommodate wire sizes up to #2 AWG.

2.07 ACCESSORIES

A. Unit status indicators:
   1. Provide red and green solid-state indicators, with printed labels, on the front cover to redundantly indicate on-line unit status:
      a. The absence of the green light and the presence of the red light indicate that surge protection is reduced and service is needed to restore full operation.
      b. Indicates the status of protection on each mode or phase.

B. Dry contacts for remote monitoring:
   1. Electrically isolated Form C dry contacts (1 A/125 VAC) for remote monitoring of system integrity, and indication of under voltage, phase and/or power loss.

C. Provide an audible alarm which activates under any fault condition.
   1. Provide an alarm On/Off switch to silence the alarm.
   2. A visible LED will confirm whether alarm is On or Disabled.
   3. Locate both switches and the audible alarm on the unit's front cover.

D. Provide transient counter to count transient voltage surges:
   1. LCD readout located on the unit's front cover.
   2. Counter to utilize batteries with a 10-year nominal life or non-volitile memory to maintain accurate counts in the event of power loss.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Permanently affix surge rating to the SPD.

B. Perform manufacturer's standard factory test.
   1. Perform testing in accordance with UL 1449.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Follow the manufacturer's recommended installation practices and comply with all applicable codes.

C. Special techniques:
   1. Install the SPD with as short and straight conductors including ground conductor as practically possible:
      a. Twist the input conductors together to reduce input conductor inductance.
   2. Do not subject SPD to insulation resistance testing.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_08_50.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_50_10

LIGHTING: LED LUMINAIRES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: LED luminaires, drivers, poles, and accessories.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 26_05_00 - Common Work Results for Electrical.
   4. Section 26_29_05 - Motor Starters.

1.02 REFERENCES

A. As specified in Section 26_05_00.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.

C. Illuminating Engineering Society of North America (IESNA):
   1. LM-79 - IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.
   2. LM-80 - IES Approved Method: Measuring Lumen Maintenance of LED Light Sources.
   3. TM-21 - Projecting Long Term Lumen Maintenance of LED Light Sources.

D. National Electrical Manufacturers Association (NEMA):
   1. 410 - Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts.

E. Underwriters Laboratories (UL):
   1. 1598 - Luminaires.
   2. 8750 - Light Emitting Diode (LED) Equipment For Use In Lighting Products.

1.03 DEFINITIONS

A. As specified in Section 26_05_00.

B. Specific definitions and abbreviations:
   1. CCT: Correlated color temperature - Scientific scale to describe how “warm” or how “cool” the light source is, measured in Kelvin. The lower the Kelvin temperature, the warmer the light feels, or appears.
   2. CRI: Color Rendering Index - A quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source.

3. Driver - Device that manages power and controls the current flow from AC to DC for an LED lighting product.
4. Efficacy - Lumen output of a light source per unit of power supplied to that source (lumens per watt).
5. EMI: Electromagnetic Interference - Electrical interference (noise) generated by electrical and electronic devices.
6. FC: Foot Candles - Measure of light level on a surface being illuminated.
7. L70 - The extrapolated life in hours of the luminaire when the luminous output depreciates 30 percent from initial values.
8. LED: Light emitting diode - A solid-state semiconductor device that produces light when electrical current flows through it.
9. LED light source - See LED luminaire.
10. LED luminaire - A complete lighting unit consisting of LED-based light emitting elements and a matched driver together with parts to distribute light, to position and protect the light emitting elements, and to connect the unit to a branch circuit.
11. Lumen - The international (SI) unit of luminous flux or quantity of light. The amount of light that is spread over a square foot of surface by one candle power when all parts of the surface are exactly one foot from the light source.
12. Lumen ambient temperature multiplier - LED light source relative lumen output when compared to a standard ambient temperature.
13. Lumen maintenance factor - How well an LED light source is able to retain its intensity when compared to new.
14. Luminaire - Lighting unit.
15. THD: Total harmonic distortion - The combined effect of harmonic Distortion on the AC waveform produced by a driver or other device.

1.04 SYSTEM DESCRIPTION

A. Provide luminaires, and accessories for all lighting systems, complete and operable, in accordance with the requirements of the Contract Documents.

B. Individual luminaire types are indicated on the Drawings and on the Luminaire Schedule.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

B. Product data:
   1. LED Luminaires:
      a. Catalog literature for each luminaire specified, cross-referenced to the luminaire type on the Luminaire Schedule in the Drawings.
      b. Provide for each luminaire type:
         1) Materials.
         2) Type of diffuser.
         3) Hardware.
         4) Gasketing.
         5) Reflector.
         6) Chassis.
         7) Finish and color.
         8) Driver type and protection.

9) LED luminaire:
   a) Initial lumen output at 40 degrees Celsius ambient.
   b) Correlated color temperature.
   c) Lumen maintenance factors.
   d) Lumen ambient temperature multipliers.
   e) Drive current.
   f) Efficacy.
10) Picture of luminaire.
11) Dimensioned drawings:
    a) Effective projected area rating for pole mounted luminaires.
12) Weight.
13) Photometric data:
    a) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
    b) Luminaire dirt depreciation factor.
    c) Candlepower distribution curves.
    d) Average luminaire brightness.
    e) Lumen output charts.
14) Furnish support method for interior luminaires weighing more than 30 pounds and all wall-mounted luminaires:
    a) Support methods shall be based on seismic requirements at the project site as specified in Section 26_05_00.

c. Luminaire substitutions:
   1) Provide complete literature for each luminaire substitution:
   2) Submittals for substituted luminaires shall be sufficient for competent comparison of the proposed luminaire to the originally specified luminaire:
      a) Photometric data:
         (1) IES file in standard IES format.
         (2) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
         (3) Candlepower distribution curves.
         (4) Average luminaire brightness.
         (5) Lumen output charts.
         (6) Power requirements in watts and volt-amperes.
      b) Calculations:
         (1) Provide software generated calculations showing illuminance levels in footcandles and power usage in watts per square foot for each of the areas in which substitutions are proposed:
             (a) Use surface reflectance values and luminaire light loss factors approved by the Engineer to perform all calculations.
      c) Specification sheets:
         (1) If lacking sufficient detail to indicate compliance with contract documents, standard specification sheets will not be accepted. This includes, but is not limited to, luminaire type designation, manufacturer's complete catalog number, voltage, LED type, CCT, CRI, specific driver information, system efficacy, L70 life rating, and any modifications necessary to meet the requirements of the contract documents

3) Substitutions for specified luminaires will be evaluated upon quality of construction, light distribution, energy use, appearance, and maintenance.
4) Substitutions shall comply with all applicable building and energy codes.

2. Driver: Provide for each driver type:
   a. Catalog number.
   b. Type of driver.
   c. Output wattage.
   d. Input voltage.
   e. Operating voltage range.
   f. Maximum input power.
   g. Efficiency.
   h. Operating line current.
   i. Power factor.
   j. Operating temperature range.
   k. Current output range in ambient temperatures of 30 degrees Celsius – 55 degrees Celsius.
   l. Surge suppression data.
3. Photocell:
   a. Provide for each photocell type:
      1) Switching capacity.
      2) Life expectancy when used on LED sources.
      3) The means of adjusting the lighting pickup level.
      4) Enclosure type.
      5) Mounting method.
4. Luminaire poles:
   a. Submit complete data for each pole type including but not limited to:
      1) Material.
      2) Finish and color.
      3) Handholes.
      4) Anchoring.
      5) Luminaire attachment methods and fittings.
      6) Pole height.
      7) Pole dimensions.
      8) Bolt hole circle layout and hardware.
      9) Accessories.
      10) Provide the EPA wind load rating.

C. Calculations:
1. Provide complete design calculations and installation documents for pole mounting piers and poles mounted from structures:
   a. Include in the calculations the wind and seismic requirements at the project site.
   b. Calculations and design shall be performed by and signed by a Professional Engineer registered in the state where the project is being constructed:
      1) Because this design is being provided by a Professional Engineer, the submittal will be reviewed for form and content but not reviewed for technical completeness, methods, or calculations.

D. Record documents:
   1. Update the Luminaire Schedule in the Drawings to reflect the acceptable substitutions, after the substitution has been reviewed and accepted by the Engineer.

1.06 QUALITY ASSURANCE

A. As specified in Section 26_05_00.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. Exterior and outdoor lighting system operation shall be demonstrated during the hours of darkness.

B. Lighting demonstration shall occur within 2 weeks before substantial completion.

1.11 WARRANTY

A. As specified in Section 26_05_00.

B. LED luminaire:
   1. 5 year warranty from the date of installation including material, workmanship, photometrics, driver, and LED modules.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Furnish 1 complete spare LED luminaire, with driver, of each type used.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Luminaires: One of the following or equal:
   1. As noted on the Luminaire Schedule.

B. Drivers: One of the following or equal:
   1. Philips Advance.
   2. Thomas Research.
   3. eldoLED.

C. Photo-electric cells: One of the following or equal:
   1. Cooper.
   2. Tork.
   3. Intermatic.

D. Substitutions:
   1. The lighting design and luminaire selection has been based upon the photometric data of the identified luminaire. It is the Contractor's responsibility to ensure and prove to the Engineer at time of submittal the substitutions meet the quality and photometric requirements of the original design.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. LED Luminaires:
   1. General:
      a. Pre-wired with leads of 18-AWG, minimum, for connection to building circuits.
      b. Provide the luminaires furnished per the Luminaire Schedule in the Drawings:
         1) The Specifications noted herein are an addition or supplement to the Luminaire Schedule.
      c. Individual LEDs connected such that a catastrophic loss or the failure of 1 LED will not result in the loss of the entire luminaire.
   2. Minimum ambient temperature range of 0 degrees Celsius to 40 degrees Celsius.
   3. Minimum rated life:
      a. Office Areas: 70,000 hours when operated at 25 degrees Celsius.
      b. Process Areas: 60,000 hours when operated at 40 degrees Celsius.
   4. Minimum efficacy of 70 lumens/watt.
   5. Minimum Color Rendering Index of 70.
   6. Tested according to IESNA LM-79 and LM-80.
   7. Lumen maintenance projection in accordance with IESNA TM-21.
   8. RoHS compliant.
   9. Integral driver.
   10. Suitable for dry, damp, or wet locations as indicated on the Drawings or on the Luminaire Schedule.
       a. Wet or damp locations: UL 1598 listed.
   11. Designed as a complete LED assembly. Retrofit LED lamps in luminaires not designed specifically for LED light sources shall not be used.

12. Exterior/outdoor luminaires:
    a. Luminaires in combination with their mounting pole and bracket shall be capable of withstanding:
        1) Wind levels at the project site without damage.
        2) Seismic levels at the project site.
    b. Corrosion-resistant hardware and hinged doors or lens retainer.
    c. Luminaires furnished with integral photoelectrical control shall be of the luminaire manufacturer's standard design.
    d. California Energy Code Light Pollution Reduction Compliance:
        1) Provide all exterior luminaires with cutoff photometrics.
            a) Luminaire design shall allow no more than 0.01 horizontal footcandles to escape beyond the site boundary.
        2) Provide exterior luminaires with photocells to automatically control exterior lighting dusk to dawn to turn off or lower the lighting levels during inactive periods. Reference the Drawings for specific luminaires to be controlled.

B. Photo-electric cells:
1. Photoelectric cells for control of multiple luminaires:
    a. Self-contained.
    b. Weatherproof.
    c. Provided with time-delay features.
    d. Sized to meet switching capacity of the circuit:
        1) Based on luminaire VA as indicated on the Drawings.
2. Photoelectric cell for control of a single luminaire:
    a. Integral to the luminaire.

C. Luminaire control:
1. Lighting control relays or contactors as specified in Section 26_29_05.

D. Drivers:
1. Dimmable, with dimming signal protocol of 0-10 VDC or DALI.
2. Input power source:
    a. As indicated on the Drawings.
3. Drive current:
    a. As indicated in the Luminaire Schedule.
4. Power factor: greater than 0.90.
5. Efficiency: greater than 80 percent.
6. Total harmonic distortion (THD) of the input current less than 20 percent.
7. Rated life of 60,000 hours in an LED luminaire operated at an ambient temperature of 40 degrees Celsius.
8. Minimum operating temperature of 0 degrees Celsius.
9. Sound rating: Class A+ or quieter.
10. UL listed Class 2 Outdoor in accordance with UL 8750.
11. In accordance with IEEE C62.41 Category A for transient protection.
12. Driver must limit inrush current:
    a. Meet or exceed NEMA 410 driver inrush standard:
        1) 230 Amps per 10 Amp load with a maximum of 106 Amps squared-seconds at 120V.
        2) 430 Amps per 10 Amp load with a maximum of 370 Amps squared-seconds at 277V.

2.06 COMPONENTS

A. Luminaire poles:
   1. As indicated on the Luminaire Schedule.
   2. Anchor bolts:
      a. Use anchor bolts, bolts, or welded studs for anchors for resisting seismic and wind forces.
         1) Standard hex bolt head.
         2) Do not use anchor bolts fabricated from rod stock with an L or J-shape.
      b. Complete with leveling shims.
   3. Anchor base:
      a. Fabricated from the same type of material as the pole shaft.
      b. Base plate to telescope the pole shaft.
      c. Welded top and bottom along the entire perimeter.
      d. With slotted bolt holes on the bolt circles as submitted.
   4. Pole shaft:
      a. As indicated on the Luminaire Schedule.
   5. Handhole:
      a. Reinforced handhole located approximately 18 inches above the base.
      b. Complete with cover fabricated from the same material as the pole shaft and stainless steel attachment screws.
      c. With an integral ground connection nut, 1/2 inch by 13 inch UNC welded to the pole for connection to the grounding system.
   6. Shroud:
      a. Fabricated from the same type of material as the pole shaft.
      b. 1-piece formed channel section that shall conform to the pole shaft taper.
      c. Secured by a locking device with provisions for a padlock to prevent accidental lowering.
   7. Fastening hardware:
      a. All fasteners shall be stainless steel.
   8. Finish:
      a. As indicated on the Luminaire Schedule.

2.07 ACCESSORIES

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 26_05_00.

B. Install luminaires per the manufacturer's guidelines and submitted installation calculations to meet seismic and wind requirements at the project site.

C. Special techniques:
   1. Support luminaires from structural elements capable of carrying the total weight.
   2. Install luminaires plumb and square with building and wall intersections:
      a. Suspend pendant-mounted luminaries that are mounted from sloping ceilings with ball hangers, unless otherwise indicated on the Drawings.
      b. Install luminaires in machinery rooms after machines have been installed, so as to ensure no conflict with machinery, piping, or ductwork.
   3. In all cases, coordinate luminaire locations with work of other trades to prevent obstruction of light from the fixtures:
      a. Locate bottom of luminaire approximately at the bottom of ductwork, unless otherwise specified or indicated on the Drawings.
   4. Provide ceiling or pendent mounted luminaires with a safety chain connecting the lens, driver, and other components to the building structure.
   5. Provide recessed luminaires with auxiliary safety supports attached directly to the building structure:
      a. The safety supports shall consist of number 12 AWG soft drawn galvanized wires.
   6. Install luminaires in accordance with the architectural reflected ceiling Drawings:
      a. Center luminaires on ceiling tiles unless otherwise indicated.
   7. Support luminaires installed in suspended grid ceilings, independently of the grid:
      a. Provide seismic restraint clips for all luminaires installed in suspended grid ceilings.

D. Luminaire poles:
   1. Set poles on anchor bolts and secured with double nuts on each bolt.
   2. Dry-pack the pole base, after the luminaire and pole has been leveled and plumbed.
   3. Bond metal poles to the plant grounding system, utilizing a ground lug connection within the pole:
      a. Route ground conductor through pier and pole base sleeve using Schedule 40 PVC conduit.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00.

3.09 ADJUSTING

A. Aim and verify all exterior and outdoor luminaires alignment, during dark evening hours, as directed by Owner or the Engineer.

3.10 CLEANING

A. As specified in Section 26_05_00.

B. Clean all lenses, diffusers, and reflectors.

C. Refinish all luminaires’ trim, poles, and support brackets, where finish has been damaged.

D. Clean all LED luminaires (new and old), used during construction for construction lighting, before substantial completion.

E. Clean and re-lamp all existing fluorescent and HID luminaires used during construction for construction lighting, before substantial completion.

3.11 PROTECTION

A. As specified in Section 26_05_00.

3.12 SCHEDULES

A. Refer to the Luminaire Schedule in the Drawings.

END OF SECTION

SECTION 31_00_00

EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loosening, excavating, filling, grading, borrow, hauling, preparing subgrade, compacting in final location, wetting and drying, and operations pertaining to site grading for buildings, basins, reservoirs, boxes, roads, and other facilities.
   2. Backfilling and compacting under and around structures.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01_35_45 - Stormwater Pollution Prevention Construction Activities: Best Management Practices.
      b. Section 03_30_00 - Cast-In-Place Concrete.
      c. Section 31_05_15 - Soils and Aggregates for Earthwork.
      d. Section 31_23_24 - Controlled Low Strength Materials (CLSM).
      e. Section 31_32_18.02 - Filter Fabric.
      f. Section 31_32_18.04 - Stabilization Fabric.
      g. Section 32_12_17 - Asphalt Concrete Paving.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
   2. D 1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN m/m^3)).
   3. D 6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.03 DEFINITIONS

A. Backfill adjacent to structure: Backfill within volume bounded by the exterior surfaces of structure, the surface of undisturbed soil in the excavation around structure, and finish grade around structure.

B. Embankments: Dikes, levees, berms, and similar facilities.

C. Excavation: Consists of loosening, removing, loading, transporting, depositing, and compacting in final location, wet and dry materials, necessary to be removed for purposes of construction of structures, ditches, grading, roads, and such other purposes as are indicated on the Drawings.

1.04 SYSTEM DESCRIPTION

A. Performance requirements:
   1. Where mud or other soft or unstable material is encountered, remove such material, and refill space with stabilization material. Wrap stabilization material with stabilization fabric.
   2. Obtain acceptable import material from other sources if surplus materials obtained within Project site do not conform to specified requirements or are not sufficient in quantity.
   3. No extra compensation will be made for hauling of fill materials nor for water required for compaction.

1.05 SUBMITTALS

A. Copy of Property Owner’s Agreement allowing placement of surplus soil material on their property.

B. Excavation plan.

C. Testing lab: Submit Contractor's proposed testing laboratory capabilities and equipment.

D. Test reports:
   1. Submit certified test reports of all tests specified to be performed by the Contractor.
   2. Sign and seal test reports by a registered Geotechnical or Civil Engineer who practices geotechnical engineering registered in California.

1.06 QUALITY ASSURANCE

A. Initial compaction demonstration:
   1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
      a. 50 cubic yards of backfill adjacent to structures.
      b. 100 cubic yards of embankment work.
      c. 100 cubic yards of fill.
      d. 50 cubic yards of roadway base material.
      e. 100 cubic yards of road fill.
   2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
   3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under "FIELD QUALITY CONTROL."

B. Contractor shall perform all work related to this Section in accordance with the approved Stormwater Pollution Prevention Plan (SWPPP) and as specified in Section 01_35_45.

1.07 SEQUENCING AND SCHEDULING

A. Schedule earthwork operations to meet requirements specified in this Section for excavation and uses of excavated material.

B. If necessary, stockpile excavated material in order to use it at specified locations.

C. Excavation, backfilling, and filling: Perform excavation, backfilling, and filling during construction in manner and sequence that provides drainage at all times.

PART 2 PRODUCTS

2.01 MATERIALS

A. Water for compacting: Use water from source acceptable to Engineer.

B. Soil and rock materials:
1. General:
    a. Provide aggregate base course, Class 2 permeable, controlled low-strength material, drain rock, gravel, native material, sand, select material, and stabilization material where specified or indicated on the Drawings.
    b. If suitable surplus materials are available, obtain native material and select material from cut sections or excavations.
2. Aggregate base course materials: As specified in Section 31_05_15.
3. Drain rock: As specified in Section 31_05_15.
4. Gravel: As specified in Section 31_05_15.
5. Native material: As specified in Section 31_05_15.
6. Sand: As specified in Section 31_05_15.
7. Stabilization material: As specified in Section 31_05_15.

C. Controlled low-strength material: As specified in Section 31_23_24.

D. Geotextile fabrics:
1. Filter fabric: As specified in Section 31_32_18.02.
2. Stabilization fabric: As specified in Section 31_32_18.04.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:
1. Character and quantity of material:
    a. Verify character and quantity of rock, gravel, sand, silt, water, and other inorganic or organic materials to be encountered in work to be performed.
    b. Determine gradation, shrinkage, and swelling of soil, and suitability of material for use intended in work to be performed.

c. Determine quantity of material, and cost thereof, required for construction of backfills, cuts, embankments, excavations, fills, and roadway fills, whether from onsite excavations or imported materials. Include in cost of work to be performed.
d. Include wasting of excess material, if required, in cost of work to be performed.

3.02 PREPARATION

A. Backfills:
1. After clearing and excavation are completed, scarify entire areas that underlie backfills or structures to a depth of 8 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
2. Recompact scarified areas to density specified before placing backfill material or concrete.
3. If foundation areas have soft soils, do not scarify the top 8 inches prior to compaction. Remove all loose material using hand equipment or with a flat-edged backhoe bucket. Do not remold and weaken the remaining soil by operating heavy equipment on final bottom elevation of excavation.
4. If foundation areas have cemented rock, cobbles, or boulders, do not scarify the top 8 inches prior to compaction. Moisten the native soil and compact the coarse fill as specified in this Section.
5. Do not place backfill against walls until:
   a. Walls have been cast full height of structure and concrete has reached the specified strength.
   b. Connecting slabs and beams have been cast, and concrete has reached the specified strength.
6. Prior to backfilling:
   a. Remove all forms.
   b. Clean all trash and debris from the excavation site.
7. After inspection of foundation, walls, and pipes, place backfill symmetrically around structures to prevent eccentric loading of structures.

B. Embankments:
1. After clearing is completed, scarify entire areas that underlie embankments to a depth of 8 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
2. Recompact scarified areas to density specified for embankments before placing of embankment material.

C. Fills:
1. After clearing is completed, scarify entire areas that underlie fill sections or structures to a depth of 8 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
2. Recompact scarified areas to density specified for compacted fills before placing of fill material or concrete.

D. Roadway fills:
   1. After clearing is completed, scarify entire areas that underlie roadway fills to a depth of 8 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
   2. Recompact scarified areas to density specified for roadway fills before placing of roadway fill material.

E. Sloped surfaces for fill or foundations:
   1. Foundations for fill having slopes in excess of 1 vertical to 4 horizontal:
      a. Bench or terrace to adequately key existing ground and fill built thereon.
   2. Slopes of original hillsides and old fills: Bench minimum of 10 feet horizontally as fill is placed.
   3. Provision of new benches:
      a. Start new bench wherever vertical cut of next lower bench intersects existing grade.
      b. Recompact material thus cut out along with new embankment material at no additional cost to the Owner.

3.03 INSTALLATION

A. General:
   1. Dispose of excavated materials that are not required or are unsuitable for fill and backfill in lawful manner.
   2. Dispose of surplus material on private property only when written permission agreement is furnished by owner of property. Submit copies of such agreements.
   3. Rocks, broken concrete, or other solid materials larger than 4 inches in greatest dimension: Remove from project site at no additional cost to the Owner.
   4. Stabilization of subgrade: Provide materials used, or perform work required, to stabilize subgrade so it can withstand loads that may be placed upon it by Contractor's equipment.

B. Borrow area: There is no borrow area on Project site.
   1. Where material is required, import material from source located off Project site selected by the Contractor and subject to acceptance by the Engineer.
   2. There will be no additional cost to the Owner for use of imported material.

C. Compaction:
   1. Provide specified compaction for backfills, cuts, embankments, fills, roadway fills, and other earthwork.
   2. Perform confirmation tests to verify and confirm that work has complied, and is complying at all times, with compaction requirements specified in this Section for initial compaction demonstration and field quality control testing.
   3. In-place density of compacted backfills, cuts, embankments, fills, and roadway fills determined in accordance with ASTM D 1556, or with ASTM D 6938.
   4. Maximum density obtained in laboratory when tested in accordance with ASTM D 1557.
   5. To prevent damage to structures due to backfilling operations, place backfill with equipment that does not exceed H-20 loading, within a distance from the face of the structure of not less than 1/2 the depth of backfill. The depth of backfill is the distance between the level being compacted and the bottom of

the excavation. Outside this distance, heavier compaction equipment may be used.

6. Compact to percentage of maximum density as follows:
   a. Backfill adjacent to structures: 95 percent.
   b. Backfilling voids: 95 percent.
   c. Loose fill:
      1) No compaction other than by hauling vehicles will be required.
      2) Uniformly distribute travel of vehicles over fill area as required to provide uniformly compacted surface.
   d. Other areas: 85 percent.
   e. Under present and future structures: 95 percent.
   f. Under roadways, parking and storage areas, curbs, and sidewalks: 95 percent.
   g. Upper 6 inches of cuts: 95 percent.
   h. Fills: 95 percent.

D. Excavation:
1. Blasting: Not permitted.
2. Excavations for structures:
   a. Provide excavations conforming to dimensions and elevations indicated on the Drawings for each structure, including trenching for piping and all work incidental thereto.
   b. After clearing is complete, excavate for the structure, down to the elevation indicated on the Drawings. Unless directed by Engineer, do not carry excavations below elevation indicated on the Drawings.
   c. Where soil is encountered having unsuitable bearing value, Engineer may direct in writing that excavation be carried to elevations below those indicated on the Drawings.
   d. Where excavations are made below elevations indicated on the Drawings, adjust elevations of excavations in accordance with the following requirements:
      1) Under slabs: Restore to proper elevation in accordance with procedure specified for backfill in this Section.
      2) Under footings: Restore to the proper elevation using one of the following:
         a) Aggregate base course.
         b) Controlled low-strength material.
   e. Excavation width:
      1) Extend excavations at least 2 feet clear from walls and foundations of structures to allow for placing and removal of forms, installation of services, and inspection.
      2) Do not undercut slopes.
   f. Difficulty of excavation: No extra compensation will be made for removal of rock or any other material due to difficulty of excavation.
3. Excavation of lined channels:
   a. Excavations in open cut for lined channels may be made so as to place concrete directly against excavated surfaces providing faces of excavations are:
      1) Firm and unyielding.
      2) Will stand or can be made to stand without sloughing.
   b. Excavations to provide subgrade for lined channel or subdrainage material: Excavate to lines and grades indicated on the Drawings.

4. Excavation of unlined channels and basins:
    a. Excavate to lines and grades indicated on the Drawings.
    b. Perform excavation and grading so that finish surfaces are in uniform planes with no abrupt breaks in surface.
5. Excavation of ditches and gutters:
    a. Cut ditches and gutters accurately to cross sections and grades indicated on the Drawings.
    b. Take care not to excavate ditches and gutters below grades indicated on the Drawings.
    c. Backfill excessive ditch and gutter excavations to grade with suitable material acceptable to the Engineer.
    d. Do not deposit any material within 3 feet of edge of ditch unless otherwise indicated on the Drawings.
6. Necessary over excavation:
    a. Where it becomes necessary to excavate beyond normal lines of excavation in order to remove boulders or other interfering objects, backfill voids remaining after removal as specified in backfilling of voids below, or as acceptable to the Engineer.
    b. Backfill voids with material acceptable to the Engineer:
        1) With acceptance of the Engineer, backfill with one of the following:
            a) Aggregate base course.
            b) Controlled low-strength material.

E. Materials for backfills, embankments, fills, and roadway fills:
1. General:
    a. Obtain import material from other sources if surplus materials from cuts and excavations obtained from within Project site do not conform to specified requirements or are not sufficient in quantity for construction of Project.
2. Backfills:
    a. Backfill adjacent to structures, slabs, or walls: Native material or imported material meeting the requirements of native material, unless otherwise specified or indicated on the Drawings.
    b. Backfill material under concrete structures: Aggregate base course material, except in areas where controlled low-strength material or concrete encasement are indicated on the Drawings.
    c. Extend backfill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
3. Fills:
    a. Native material or imported material meeting the requirements of native material, unless otherwise specified or indicated on the Drawings.
    b. Extend fill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
4. Roadway fills: One of the following, unless otherwise specified or indicated on the Drawings:
    a. Aggregate base course material.
    b. Native material or imported material meeting the requirements of native material.

F. Placement:
1. General:
a. Lines and grades:
1) Construct backfills, embankments, fills, and road fills, at locations and to lines and grades indicated on the Drawings.
2) Overbuild all permanent fill slopes by at least 1 foot and then cut to final grade to provide adequate compaction of the remaining fill.
2. Backfills:
a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
b. Bring each layer to a moisture content between optimum moisture content and 2 percent above optimum moisture content before compacting.
c. Defective compacted backfills: Remove and recompact.
3. Fills:
a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
b. Bring each layer to a moisture content between optimum moisture content and 2 percent above optimum moisture content before compacting.
c. Defective compacted fills: Remove and recompact.
4. Roadway fills:
a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
b. Bring each layer to a moisture content between optimum moisture content and 2 percent above optimum moisture content before compacting.
c. Defective compacted roadway fills: Remove and recompact.
5. Loose fill:
a. In disposal areas: In disposal areas, bring fill up in an essentially level layer over entire spoil area indicated:
1) Continue filling spoil area until disposal of surplus excavated material is completed.
2) Slope edges of fill area at between 1 and 2 horizontal to 1 vertical to the intersection with existing grade.
3) Provide slopes that are smooth and uniform.
4) Slope finished surface of disposal area to prevent ponding water.
b. Clods or hard lumps of earth of 6 inches in greatest dimension: Break up before compacting material in embankments, except as provided as follows:
1) When fill material includes large rocky material or hard lumps, such as hardpan or cemented gravel which cannot be broken readily, distribute such material throughout fill.
2) Place sufficient earth or other fine material around larger material as it is deposited so as to fill interstices and produce dense, compact fill. Do not place such material within 2 feet of finish grade of fill.

3.04 FIELD QUALITY CONTROL

A. Tests:
1. Confirmation tests:
a. Contractor's responsibilities:
1) Accomplish specified compaction for backfills, fills, and other earthwork.

2) Control operations by confirmation tests to verify that compaction work complies, and is complying at all times, with requirements specified in this Section concerning compaction, control, and testing.
3) Cost of confirmation tests: Paid for by the Contractor.
4) Qualifications of Contractor's testing laboratory: Perform confirmation testing by soils testing laboratory acceptable to the Engineer.
5) Copies of confirmation test reports: Submit promptly to the Engineer.

b. Frequency of confirmation testing:
1) Perform testing not less than the following:
a) In-place density:
(1) Backfill: One (1) every 50 cubic yards or 1 foot of depth, whichever is less.
(2) Cuts: One (1) every 200 cubic yards or 1 foot of depth, whichever is less.
(3) Fills: One (1) every 50 cubic yards or 1 foot of depth, whichever is less.
(4) Roadway fills: One (1) every 50 cubic yards or 1 foot of depth, whichever is less.
b) Maximum dry density versus moisture:
(1) Backfill: Each change in material type.
(2) Cuts: Each change in material type.
(3) Fills: Each change in material type.
(4) Roadway fills: Each change in material type.

2. Compliance tests:
a. Periodic compliance tests will be made by the Engineer to verify that compaction is meeting requirements previously specified.
b. Remove overburden above level at which the Engineer wishes to test. Backfill and recompact excavation after testing is completed.
c. If compaction fails to meet specified requirements, perform remedial work by one of the following methods:
1) Remove and replace materials at proper density.
2) Bring density up to specified level by other means acceptable to the Engineer.
d. Retesting:
1) Contractor bears the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
2) Contractor's confirmation tests during performance of remedial work: Double the normal rate specified.

B. Tolerances:
1. Finish grading of backfills, cuts, embankments, fills, and roadway fills:
a. Perform fine grading under concrete structures such that finish surfaces are never above the grade or cross section indicated on the Drawings and are never more than 0.10 feet below.
b. Provide finish surface for areas outside of structures that are within 0.10 feet of grade or cross section indicated on the Drawings.
2. Unlined channels and basins:
a. In both cut and fill, and levee and access road side slopes in cut: Vertical tolerance of none above and 3 inches below grade indicated on the Drawings on bottom and side slopes.

b. On top surface of levee and access road in both cut and fill, and levee and access road side slopes in fill: Vertical tolerance of none below and 3 inches above grade indicated on the Drawings.

3. Areas which are not under structures, concrete, asphalt, roads, pavements, sidewalks, dikes, and similar facilities:
   a. Provide finish graded surfaces of either undisturbed soil, or cohesive material not less than 6 inches deep.
   b. Intent of proceeding is to avoid sandy or gravelly areas.
4. Finish grading of surfaces:
   a. Reasonably smooth, compacted, and free from irregular surface changes.
   b. Provide degree of finish that is ordinarily obtainable from blade grader operations, except as otherwise specified.
   c. Uniformly grade areas that are not under concrete.
   d. Finish ditches and gutters so that they drain readily.

3.05 ADJUSTING

A. Finish grades of excavations, backfills, and fills:
   1. Repair and reestablish grades to required elevations and slopes due to any settlement or erosion that may occur from action of the elements or any other cause prior to final acceptance.

3.06 PROTECTION

A. Finish grades of backfills, cuts, excavations, and fills:
   1. Protect newly graded areas from erosion and deterioration by action of the elements.

B. Ditches and gutters:
   1. Maintain ditches and gutters free from detrimental quantities of debris that might inhibit drainage until final acceptance.

END OF SECTION

SECTION 31_05_15

SOILS AND AGGREGATES FOR EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Aggregate base course.
   2. Drain rock.
   3. Gravel.
   4. Imported fill.
   5. Native material.
   6. Sand.
   7. Stabilization material.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C117 - Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
   2. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   3. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   4. C535 - Standard Test Method for Resistance to Degradation of Larger-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   5. D422 - Standard Test Method for Particle-Size Analysis of Soils.
   6. D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
   7. D2844 - Standard Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils.
   8. D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   9. D4829 - Standard Test Method for Expansion Index of Soils.
   10. D5821 - Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.

B. California Department of Transportation:
   1. Standard Specifications.
   2. California Test 205.
   3. California Test 211.
   4. California Test 217.
   5. California Test 229.
   6. California Test 301.

C. California Department of Toxic Substance Control (DTSC)
   1. "The Information Advisory Clean Imported Fill Material," dated October 2001 (Advisory).

1.03 SUBMITTALS

A. Product data:
  1. Material source.
  2. Gradation.
  3. Testing data.

B. Quality control for aggregate base course:
  1. Test reports: Reports for tests required by Sections of Standard Specifications.
  2. Certificates of Compliance: Certificates as required by Sections of Standard Specifications.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection: Protect from segregation and excessive moisture during delivery, storage, and handling.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
  1. Provide material having maximum particle size not exceeding 4 inches and that is free of trash, lumber, debris, leaves, grass, roots, stumps, and other organic matter.
  2. Materials derived from processing demolished or removed asphalt concrete are not acceptable.

B. Aggregate base course:
  1. Class 2, 3/4-inch maximum aggregate size, free from organic matter and other deleterious substances, and of such nature that aggregate can be compacted readily under watering and rolling to form a firm, stable base.
  2. Aggregate base course for structures:
     a. Consist of crushed or fragmented particles.
     b. Coarse aggregate material retained in Number 4 sieve shall consist of material of which at least 25 percent by weight shall be crushed particles when tested in accordance with California Test 205.
  3. Aggregate shall not be treated with lime, cement, or other chemical material.
  4. Durability index: Not less than 35 when tested in accordance with California Test 229.
  5. Aggregate grading and sand equivalent tests shall be performed to represent not more than 500 cubic yards or 1 day's production of material, whichever is smaller.
  6. Sand equivalent: Not less than 25 when tested in accordance with California Test 217.
  7. Resistance (R-value): Not less than 78 when tested in accordance with California Test 301.

8. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and ASTM C136:

Sieve Sizes (Square Openings)	**Percent by Weight Passing Sieve**
1 inch	100
3/4 inch	90 - 100
Number 4	35 - 60
Number 30	10 - 30
Number 200	2 - 9

C. Drain rock:
1. Durability index: Not less than 40 when tested in accordance with California Test 229.
2. Consists of hard, durable particles of stone or gravel; screened or crushed to specified size and gradation; and free from organic matter, lumps or balls of clay, or other deleterious matter.
3. Crush or waste coarse material and waste fine material as required to meet gradation requirements.
4. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and C136:

Sieve Size (Square Openings)	**Percent By Weight Passing Sieve**
2 inch	100
1-1/2 inch	95 - 100
3/4 inch	50 - 100
3/8 inch	15 - 55
Number 200	0 - 2

D. Gravel:
1. Consists of hard, durable particles of stone or gravel; or crushed to the specified sizes and gradations; and free from organic matter, lumps or balls of clay, and other deleterious matter.
2. Crush or waste coarse material and add or waste fine material in order to meet the specified gradations.
3. Fraction of material passing Number 40 sieve: Material having plasticity index not greater than 5 when tested in accordance with ASTM D4318.
4. Durability percentage of wear not greater than 40 percent when tested in accordance with California Test 211.

5. Conform to sizes and grade within the following limits when tested in accordance with ASTM C117 and C136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve		
	Type A	**Type B**	**Type C**
2 inch	100	--	--
1-1/2 inch	95 - 100	100	--
3/4 inch	35 - 60	55 - 85	100
3/8 inch	15 - 40	35 - 65	50 - 100
Number 4	0 - 25	20 - 35	30 - 45
Number 30	--	5 - 15	10 - 20
Number 200	0 - 5	2 - 9	2 - 9

E. Imported material:
1. Import material shall be non-hazardous and derived from a single, consistent soil type source in conformance with the following requirements:
   a. Percent Organic Content: Less than 3.
   b. Maximum Particle Size: 3 inches.
   c. Percent Passing #4 Sieve: 65 - 100.
   d. Percent Passing #200 Sieve: 20 - 40.
   e. Expansion Index: Less than 20.
   f. Minimum R-value (in paved areas): 40.
   g. Corrosion Potential:
      1) Soluble Sulfates: < 1,500 mg/Kg
      2) Soluble Chlorides: < 300 mg/Kg
      3) Soil Resistivity: > 3,000 ohm-cm

F. Native material:
1. Sound, earthen material passing 3-inch sieve.
2. Percent of material by weight passing Number 200 sieve shall not exceed 30 when tested in accordance with ASTM D422.
3. Expansion index less than 35 when tested in accordance with ASTM D4829.

G. Sand:
1. Clean, coarse, natural sand.
2. Non-plastic when tested in accordance with ASTM D4318.
3. 100 percent shall pass a 1/2-inch screen.
4. No more than 20 percent shall pass a Number 200 sieve.

H. Stabilization material:
1. Durability percentage of wear not greater than 40 percent when tested in accordance with California Test 211.
2. Consists of clean, hard, durable particles of crushed rock or gravel; screened or crushed to the specified sizes and gradations; and free of any detrimental quantity of soft, friable, thin, elongated, or laminated pieces, disintegrated material, organic matter, oil, alkali, or other deleterious substance.
3. Shall be free of slaking or decomposition under the action of alternate wetting and drying.

4. The portion of material retained on the 3/8-inch sieve shall contain at least 50 percent of particles having 3 or more fractured faces. Not over 5 percent shall be pieces that show no such faces resulting from crushing. Of that portion which passes the 3/8-inch sieve but is retained on the Number 4 sieve, not more than 10 percent shall be pieces that show no faces resulting from crushing.
5. Conforms to size and grade when tested in accordance with ASTM C117 and ASTM C136.

Sieve Size (Square Openings)	**Percent by Weight Passing Sieve**
1 inch	100
3/4 inch	90 - 100
Number 4	0 - 10
Number 200	0 - 2

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 31_10_00

SITE CLEARING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Clearing, grubbing, and stripping project site.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01_35_44 - Hazardous Material Procedures.
      b. Section 31_05_15 - Soils and Aggregates for Earthwork.

1.02 REFERENCES (NOT USED)

1.03 DEFINITIONS

A. Clearing: Consists of removal of natural obstructions and existing foundations, buildings, fences, lumber, walls, stumps, brush, weeds, rubbish, trees, boulders, utility lines, and any other items which interferes with construction operations or are designated for removal.

B. Grubbing: Consists of the removal and disposal of wood or root matter below the ground surface remaining after clearing and includes stumps, trunks, roots, or root systems greater than 1 inch in diameter or thickness to a depth of 6 inches below the ground surface.

C. Stripping: Includes the removal and disposal of all organic sod, topsoil, grass and grass roots, and other objectionable material remaining after clearing and grubbing from the areas designated to be stripped. The depth of stripping is estimated to be 8 inches, but the required depth of stripping will be determined by the Engineer.

1.04 QUALITY ASSURANCE

A. Regulatory requirements: Verify and comply with applicable regulations regarding those governing noise, dust, nuisance, drainage and runoff, fire protection, and disposal.

B. Pre-construction conference: Meet with Engineer to discuss order and method of work.

1.05 PROJECT CONDITIONS

A. Environmental requirements:
   1. For suspected hazardous materials found: As specified in Section 01_35_44.

1.06 SEQUENCING AND SCHEDULING

A. Clearing and grubbing: Perform clearing and grubbing in advance of grading operations.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Examine site and verify existing conditions for beginning work.

3.02 PREPARATION

A. Protect existing improvements from damage by site preparation work.

3.03 INSTALLATION

A. Clearing:
   1. Clear areas where construction is to be performed and other areas as indicated on the Drawings, or specified in this Section, of fences, lumber, walls, stumps, brush, roots, weeds, trees, shrubs, rubbish, and other objectionable material of any kind which, if left in place, would interfere with proper performance or completion of the work, would impair its subsequent use, or form obstructions.
   2. Do not incorporate organic material from clearing and grubbing operations in fills and backfills.
   3. Contractor's temporary construction facilities: Fill or remove pits, fill, and other earthwork required for erection of facilities, upon completion of the work, and level to meet existing contours of adjacent ground.

B. Grubbing:
   1. From excavated areas: Grub stumps, roots, and other obstructions 3 inches or over in diameter to depth of not less than 18 inches below finish grade.
   2. In embankment areas or other areas to be cleared outside construction area: Do not leave stumps, roots, and other obstructions higher than the following requirements:

Height of Embankment over Stump	Depth of Clearing and Grubbing
0 feet to 2 feet	Grub stumps or roots 3 inches or over in diameter to 18 inches below original grade. Cut others flush with ground.
2 feet to 3 feet	Grub stumps 1 foot and over in diameter to 18 inches below original grade. Cut others flush with ground.
Over 3 feet	Leave no stumps higher than stump top diameter, and in no case more than 18 inches.

3. Backfill and compact cavities left below subgrade elevation by removal of stumps or roots to density of adjacent undisturbed soil.

C. Stripping:
1. Remove soil material containing sod, grass, or other vegetation to depth of 8 inches from areas to receive fill or pavement and from area within 5 feet outside foundation walls.
2. Deposit stripped material in accordance with following requirements:
   a. At locations acceptable to Engineer.
   b. Use accepted material in top 8 inches of areas to be used for future planting.
3. Replace topsoil where indicated on the Drawings.

D. Material reuse and recycling:
1. 100 percent of trees, stumps, rocks and associated vegetation and soils resulting primarily from land clearing shall be reused or recycled. For a phased project, such material may be stockpiled on site until project completion.
2. Contractor shall provide Engineer with list of local markets and salvage sites for reuse of clearing debris.

E. Special techniques: Not used.

END OF SECTION

SECTION 31_23_17

TRENCHING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Trench excavation, fine grading, pipe bedding, backfilling, and compaction for the following, including requirements for ditch crossings:
   1. Pipes.
   2. Direct buried electrical and control conduits.
   3. Electrical and control duct banks.
   4. Manholes, valves, or other accessories.
   5. Potable water pipe appurtenances.

B. Related sections:
   1. Section 31_00_00 - Earthwork.
   2. Section 31_05_15 - Soils and Aggregates for Earthwork.
   3. Section 31_23_24 - Controlled Low Strength Material (CLSM).
   4. Section 31_50_00 - Excavation Support and Protection.
   5. Section 40_05_00.09 - Piping Systems Testing.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
   2. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
   3. D6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.03 SUBMITTALS

A. Lab certification.

B. Confirmation test reports.

1.04 QUALITY ASSURANCE

A. Initial compaction demonstration:
   1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
      a. 200 linear feet of trench backfill.
   2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.

3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under "FIELD QUALITY CONTROL".

PART 2 PRODUCTS

2.01 MATERIALS

A. Soil and rock materials:
   1. Aggregate base course material: As specified in Section 31_05_15.
   2. Gravel: As specified in Section 31_05_15.
   3. Native material: As specified in Section 31_05_15.
   4. Sand: As specified in Section 31_05_15.
   5. Select material: As specified in Section 31_05_15.

B. Controlled low-strength material: As specified in Section 31_23_24.

PART 3 EXECUTION

3.01 PREPARATION

A. General:
   1. Embankment condition:
      a. Exists where width of trench exceeds limits specified in this Section.
      b. Before laying pipes in fill, place fill and compact it to not less than 2 feet above top of pipe.
      c. After placing and compacting fill, excavate pipe trench through fill.

B. Protection: Stabilize trench excavations as specified in Section 31_50_00.

3.02 INSTALLATION

A. Trench excavation:
   1. General requirements:
      a. If, because of soil conditions, safety requirements, or other reasons, trench width at top of pipe is increased beyond width specified in this Section, upgrade laying conditions or install stronger pipe designed in conformance with Specifications for increased trench width, without additional cost to Owner.
      b. Excavate bottom of trench to depth indicated on the Drawings. The bottom of the trench excavation shall be firm and dry.
   2. The trench may be excavated by machinery to the grade indicated on the Drawings provided that the soil material remaining in the bottom of the trench is no more than slightly disturbed.
   3. Rock:
      a. Pipe: If bottom of trench excavation is found to consist of rock or any material that by reason of its hardness cannot be excavated to provide uniform bearing surface, remove such rock or other material to a depth of not less than 4 inches below bottom of fine grading material. Backfill overcut with aggregate base course material compacted to 95 percent of maximum density up to bottom of fine grading material.

b. Direct buried electrical and control conduits: If bottom of trench excavation is found to consist of rock or any material that by reason of its hardness cannot be excavated to provide uniform bearing surface, remove such rock or other material to a depth of not less than 4 inches below bottom of conduit bedding material. Backfill overcut with aggregate base course material up to bottom of conduit bedding material.
c. Electrical and control duct banks: If bottom of trench excavation is found to consist of rock or any material that by reason of its hardness cannot be excavated to provide uniform bearing surface, remove such rock or other material to a depth of not less than 4 inches below bottom of concrete duct bank. Backfill overcut with aggregate base course material up to bottom of concrete duct bank.

4. Overcut of trench bottom: Where the bottom of the trench is excavated below the depth indicated on the Drawings, restore trench bottom to proper grade by back filling with aggregate base course material compacted to 95 percent of maximum density, at no additional cost to Owner.
5. Soft or unstable material:
   a. If bottom of excavation is found to consist of soft or unstable material which is incapable of providing proper support, remove such material to a depth and for the length required, as determined by the Engineer. Backfill trench to bottom of fine grading material with aggregate base course material compacted to 90 percent of maximum density.
6. Trench widths:
   a. Minimum clear width of trench for pipe (measured at top of pipe):
      1) For pipe sizes 4 inches to and including 24 inches: Not less than outside diameter of pipe plus 18 inches.
      2) For pipe sizes larger than 24 inches: Not less than outside diameter of pipe plus 24 inches.
   b. Maximum clear width of trench for pipe (measured at top of pipe):
      1) For pipe sizes 4 inches to and including 24 inches: Not to exceed outside diameter of pipe plus 24 inches.
      2) For pipe sizes larger than 24 inches: Not to exceed outside diameter of pipe plus 36 inches.
7. For manholes, valves, or other accessories:
   a. Provide excavations sufficient to leave at least 12 inches clear between their outer surfaces and sides of trench or shoring.
   b. Backfilling of manhole excavation: Conform to backfilling requirements as specified for trenches in this Section.
   c. Backfill under manholes, vaults, tanks, or valves with aggregate base course material. Do not backfill with soil.
   d. Fill any unauthorized excess excavation below elevation indicated on the Drawings for foundation of any structure with aggregate base course material at no additional cost to Owner.
8. Potable water pipe appurtenances:
   a. Lay in trenches separate from those used for sewers.
   b. Unless otherwise specified or indicated on the Drawings, lay in trenches having cover of not less than 3 feet below surface of ground and located at distance of not less than 10 feet from any parallel sewer trench.
9. At road crossings or existing driveways:
   a. Make provision for trench crossings at these points, either by means of backfills, tunnels, or temporary bridges.

B. Pipe fine grading:
   1. Schedule fine grading material as specified in this Section.
   2. For pipes 16 inches in nominal diameter and under.
      a. Place 4 inches of fine grading material below bottom of pipe.
      b. Place fine grading material at uniform density, with minimum possible compaction.
   3. For pipe over 16 inches in diameter.
      a. Place 4 inches, or 1/12 the outside diameter of pipe, whichever is greater, of fine grading material below bottom of pipe.
      b. Place fine grading material at uniform density, with minimum possible compaction.
   4. Bell or coupling holes:
      a. Dig holes after trench bottom has been graded.
      b. Provide holes of sufficient width to provide ample room for grouting, banding, or welding.
      c. Excavate holes only as necessary for making joints and to ensure that pipe rests upon prepared trench bottom and not supported by any portion of the joint.
   5. Depressions for joints, other than bell-and-spigot:
      a. Make in accordance with recommendations of joint manufacturer for particular joint used.

C. Pipe bedding:
   1. Schedule bedding material as specified in this Section.
   2. After pipe laid:
      a. Place bedding material under and around pipe in 6 inch maximum lifts of bedding material, to level 12 inches above top of pipe. Compact to 90 percent of maximum density.
   3. Pipe displacement:
      a. Take necessary precautions in placement and compaction of bedding material to prevent displacement of piping.
      b. In event there is movement or floating of the piping, re-excavate, re-lay, and backfill the pipe.

D. Trench backfill above pipe bedding, electrical and control conduit bedding, and electrical and control duct banks:
   1. Under structures:
      a. Backfill trench up to underside of structure with aggregate base course material as specified in Section 31_05_15 compacted to 95 percent of maximum density or controlled low-strength material as specified in Section 31_23_24.
   2. Cuts across roadways and paved streets:
      a. Backfill trench to underside of pavement with aggregate base course material as specified in Section 31_05_15 compacted to 95 percent of maximum density or controlled low-strength material as specified in Section 31_23_24.
   3. Under and parallel to roadways, paved areas, or storage areas:
      a. Backfill trench up to within 2 feet of finish grade with native material as specified in Section 31_05_15 or controlled low-strength material (CLSM) compacted to 95 percent of maximum density.
      b. Then backfill from 2 feet below finish grade to finish grade, or underside of aggregate base course or pavement as indicated on the Drawings with

aggregate base course material as specified in Section 31_05_15, compacted to 95 percent of maximum density or controlled low-strength material as specified in Section 31_23_24.

4. In areas outside the improved section of roadways or in open country:
   a. Backfill to finish grade with native material as specified in Section 31_05_15 compacted to 90 percent of maximum density.
5. Through earth slopes adjacent to, or supporting structures:
   a. Backfill to finish grade with aggregate base course material or select material compacted to 95 percent of maximum density.

E. Under existing intersecting pipes or conduits larger than 3 inches in diameter:
   1. Backfill from bottom of new pipe trench to spring line of intersecting pipe or conduit with aggregate base course material, as specified in Section 31_05_15, compacted to 90 percent of maximum density or controlled low-strength material as specified in Section 31_23_24.
   2. Extend aggregate base course material as specified in Section 31_05_15 or controlled low-strength material as specified in Section 31_23_24 two feet on either side of intersecting pipe or conduit to ensure that material remains in place while other backfill is being placed.
   3. Backfill remainder of trench as specified in “Trench backfill above pipe bedding, electrical and control conduit bedding, and electrical and control duct banks” above.

F. Compaction:
   1. In-place density of compacted trench backfill, and bedding determined in accordance with ASTM D1556, or with ASTM D6938.
   2. Maximum density obtained in laboratory when tested in accordance with ASTM D1557.
   3. Consolidation:
      a. Do not use water settling methods such as flooding, poling, or jetting.

G. Excess material:
   1. Remove excess excavated material from the Project site as specified in Section 31_00_00 and dispose of legally off site.

3.03 FIELD QUALITY CONTROL

A. Tests:
   1. Confirmation tests:
      a. Contractor's responsibilities:
         1) Accomplish specified compaction of trench backfill.
         2) Control operations by confirmation tests to verify and confirm that compaction work complies, and is complying at all times, with requirements specified in this Section concerning compaction, control, and testing.
         3) Cost of confirmation tests: Paid for by the Contractor.
         4) Qualifications of Contractor's testing laboratory: Acceptable to Engineer. Provide lab certification.
         5) Copies of confirmation test reports: Submit promptly to the Engineer.

b. Frequency of confirmation testing:
    1) Perform testing not less than as follows:
        a) For trenches: At each test location include tests for each type or class of backfill from bedding to finish grade.
        b) In open fields: 2 every 1,000 linear feet.
        c) Along dirt or gravel road or off traveled right-of-way: 2 every 500 linear feet.
        d) Crossing paved roads: 2 locations along each crossing.
        e) Under pavement cuts or within 2 feet of pavement edges: 1 location every 400 linear feet.

2. Compliance tests:
    a. Frequency of testing: Periodic compliance tests will be made by the Engineer to verify that compaction is meeting requirements previously specified.
    b. If compaction fails to meet specified requirements: Perform remedial work by one of the following methods:
        1) Remove and replace backfill at proper density.
        2) Bring density up to specified level by other means acceptable to the Engineer.
3. Retesting:
    a. Costs of retesting: Contractor is responsible for the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
    b. Contractor's confirmation tests during performance of remedial work:
        1) Performance: Perform tests in manner acceptable to the Engineer.
        2) Frequency: Double amount specified for initial confirmation tests.

B. Piping system testing:
    1. As specified in Section 40_05_00.09.

3.04 SCHEDULES

A. Pipe fine grading materials:
    1. Fine grading material shall be the same as bedding material.

B. Bedding materials:
    1. Pipes:
        a. For pipe less than 16-inch nominal size: Except as otherwise specified, use sand or aggregate base course material.
        b. For pipe from 16- inch to 48-inch nominal size: Except as otherwise specified, use sand or aggregate base course material.
        c. For pipe over 48 inches: Aggregate base course material.
        d. For polyvinyl chloride or other plastic pipe less than 2 inches in diameter: Sand.
    2. Direct buried electrical and control conduits: Sand.

END OF SECTION

SECTION 31_23_24

CONTROLLED LOW STRENGTH MATERIAL (CLSM)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Controlled low strength material (CLSM), also known as “flowable fill”.

B. Related sections:
   1. Section 01_45_00 - Quality Control.
   2. Section 01_45_17 - Contractor Quality Control Plan.
   3. Section 01_45_24 - Special Tests and Inspections.

1.02 REFERENCES

A. American Concrete Institute (ACI)
   1. 229R - Report on Controlled Low-Strength Materials.
   2. 301 - Specifications for Structural Concrete.

B. ASTM International (ASTM):
   1. C 33 - Standard Specification for Concrete Aggregates.
   2. C 94 - Standard Specification for Ready Mix Concrete.
   3. C 143 - Standard Test Method for Slump of Hydraulic Cement Concrete.
   4. C 150 - Standard Specification for Portland Cement.
   5. C 260 - Standard Specification for Air-Entraining Admixtures for Concrete.
   6. C 403 - Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance
   7. C 494 - Standard Specification for Chemical Admixtures for Concrete.
   8. C 618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   9. D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3(600 kN-m/m3).
   10. D 1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3(2,700 kN-m/m3)).
   11. D 4832 - Standard Test Method of Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
   12. D 5971 - Standard Practice for Sampling Freshly Mixed Controlled Low Strength Material.
   13. D 6023 - Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material.

1.03 SYSTEM DESCRIPTION

A. Mixture of portland cement, water, pozzolan, fine aggregate and admixtures, proportioned in accordance with the recommendations of ACI 229 to produce a homogeneous mixture that is flowable, that will readily work into corners and angles; that will not segregate in the plastic state; and that is self-compacting at the time of placement without the use of mechanical vibration.

B. Performance requirements:
   1. Air content, total calculated in accordance with ASTM D 6023: Not less than 8.0 percent, nor greater than 12.0 percent.
   2. Compressive strength, measured in accordance with ASTM D 4832 at 28 days: Not less than 50 pounds per square inch, nor greater than 150 pounds per square inch.
   3. Wet density: Not greater than 132 pounds per cubic foot.
   4. Slump, measured in accordance with ASTM C 143 at the point of placement: Greater than 9 inches and that allows CLSM to flow freely and to be self-compacting during placement.

1.04 SUBMITTALS

A. Product data: Submit data completely describing materials in the mix and demonstrating compliance with the requirements of this Section.
   1. Cement: Mill tests. Indicate alkali content representative of each shipment.
   2. Fly ash: Identify source and type of fly ash.
   3. Water: Identify source and quality if not from a municipal treatment source.
   4. Admixtures: Manufacturer’s product data indicating suitability for use in CLSM mixes and recommended dosage rates.
   5. Aggregate:
      a. Submit source, type, and sieve analyses. Include testing to demonstrate that materials in accordance with ASTM C 33 requirements.
      b. Resubmit at any time there is a significant change in grading of materials.

B. Mix design:
   1. Submit full details, including mix design calculations for mix proposed for use.
   2. Trial batch test data:
      a. Submit data for each test cylinder.
      b. Submit data that identifies mix and slump for each test cylinder.

1.05 DELIVERY, STORAGE AND HANDLING

A. Store or stockpile cement, fly ash, and aggregate in accordance with ACI 301.

B. Store admixtures in accordance with the manufacturer’s recommendations.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cement:
   1. Portland cement in accordance with ASTM C 150, Type II.
   2. Having total alkali content not more than 0.60 percent.

B. Fly ash: Class C or Class F fly ash in accordance with ASTM C 618.

C. Water:
   1. Potable water. Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.

D. Admixtures: Products of a single manufacturer, specifically manufactured or recommended by that manufacturer for use in CLSM.
    1. Air entraining admixture: In accordance with ASTM C 260.
    2. Water reducing admixture: In accordance with ASTM C 494, Type A.

E. Aggregate:
    1. Non-expansive, non-reactive, inert natural sand conforming to the following requirements:
        a. Not more than 12 percent passing a No. 200 sieve.
        b. No plastic fines present.
        c. Including pea gravel no larger than 3/8 inch.
    2. Non-expansive, non-reactive, inert natural sand in accordance with ASTM C 33 for fine aggregate.

2.02 MIXES

A. See System Description for performance requirements of the plastic and hardened mix.

2.03 SOURCE QUALITY CONTROL

A. Trial batch:
    1. After mix design has been accepted by Engineer, have trial batch of the accepted mix design prepared by testing laboratory acceptable to Engineer.
    2. Prepare trial batches using the specific cement, fly ash, admixtures, aggregates, and water proposed for the Work.
    3. Prepare trial batch with quantity sufficient to determine slump, workability, and consistency; and to provide test cylinders as indicated in the following paragraphs.

B. Trial batch testing:
    1. Determine slump in accordance with ASTM C 143, with the following modifications:
        a. Do not rod the concrete material.
        b. Place material in slump cone in one semi-continuous filling operation, slightly overfill, tap lightly, strike off, and then measure and record slump.
    2. Prepare and test trial batch specimens in accordance with ASTM D 4832, with the following modifications:
        a. Provide cylindrical test specimens, each 6-inches in diameter by 12-inch high.
        b. Provide a minimum of 8 cylinders for testing of each trial batch.
        c. Fill the molds to overflowing and tap sides lightly to settle the mix.
        d. Do not rod the mix for consolidation in the cylinder.
        e. Strike off the excess material.
    3. Place test cylinders in a moist curing room. Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
    4. Do not remove the test cylinder from mold until that cylinder is to be capped and tested.
        a. Perform the capping carefully to prevent premature fractures.
        b. Do not perform initial compression test until the cylinders reach a minimum age of 3 days.

5. Provide compressive strength tests.
    a. Test 4 test cylinders at 7 days after casting, and another 4 cylinders at 28 days after casting.
    b. The compression strength of the 4 test cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength.

C. If the trial batch tests do not meet the Specifications for strength or density, revise and re-submit the mix design, prepare additional trial batch(es), and complete additional trial batch tests. Repeat until an acceptable trial batch is that conforms to the Specifications is produced.
    1. All the trial batches and acceptability of materials shall be paid by the Contractor.
    2. After acceptance, do not change the mix design without submitting a new mix design, trail batches, and test information.

PART 3 EXECUTION

3.01 PREPARATION

A. Do not place CLSM until preparation and condition of surfaces receiving the fill have been observed and accepted by the Engineer.

B. Remove debris foreign matter, and standing or running water from excavations and areas receiving CLSM before placement.

C. Pipes and trenches.
    1. Where CLSM is placed around and over pipes, secure pipes in place, or place CLSM in lifts to prevent pipe flotation.
    2. Where CLSM is placed in long, open trenches, confine material using bulkheads of sandbags, earth dams, or stiffer concrete at open ends of placement.

D. Soil preparation:
    1. Prior to placement of CLSM, prepare underlying soils as follows:
        a. Scarify surface to a depth of 8 inches.
        b. Adjust moisture content to or slightly above the optimum in accordance with ASTM D 1557.
        c. Re-compact scarified surface to a minimum of 95 percent relative density in accordance with ASTM D 1557.

3.02 MEASURING, BATCHING, MIXING AND TRANSPORTING

A. Measure, batch, mix and transport CLSM in accordance with the requirements of ASTM C 94 and this Section.

B. Mix until there is uniform distribution of materials.

C. Discharge mixer completely prior to recharging.

D. After trial batch testing and mix acceptance, maintain slump during construction within plus or minus 1 inch of the design slump.

3.03 PLACING

A. Place controlled low strength material by method that preserves the quality of the material in terms of compressive strength and density.

B. Maintain fluid properties of the mix during placement.
   1. At point of placement, provide material that flows easily around, beneath, or through walls, pipes, conduits, or other structures.
   2. Do not place CLSM that has partially hardened or that has been contaminated by foreign materials.
   3. Handle and place CLSM using methods that minimize segregation of the mix.
   4. Deposit mix as near its final position as possible to avoid segregation due to rehandling or flowing.
   5. Contain and confine mix while it is fluid. Design containment structures and bracing at walls and forms to withstand lateral pressures of wet mix.

C. Lifts:
   1. Limit lift heights of CLSM placed against structures and other facilities that could be damaged due to the pressure from the CLSM, to the lesser of 3 feet or the lift height indicated on the Drawings.
   2. Do not place another lift of CLSM until the last lift of CLSM has set and gained sufficient strength to prevent additional lateral load against the forms or structure due to the weight of the next lift of CLSM.

D. Water conditions:
   1. Do not place CLSM in standing or flowing water.
   2. Do not permit water to flow over the surface of freshly placed or un-hardened CLSM.
   3. Do not submerge CLSM in water within 24 hours after placement.

E. Manage CLSM bleed water.
   1. Grade top surface of CLSM to drain away from the fill.
   2. Provide side containment that permits bleed water to drain to a contained management area away from the fill.

3.04 CURING AND PROTECTION

A. Curing;
   1. Prior to and during curing, install barriers to prevent equipment or personnel from falling into or becoming entrapped in CLSM.

B. Protect CLSM from:
   1. Damage from the elements.
   2. Damage of any nature during surrounding construction operations.

3.05 FIELD QUALITY CONTROL

A. Provide quality control over the Work of this Section as specified in Sections 01_45_00 and 01_45_17 and as specified in this Section.

B. General:
   1. Engineer inspection and acceptance required prior to placement.

2. Make provisions for and furnish all material for the test specimens, and provide manual assistance to assist the Owner's Testing Laboratory in preparing said specimens.

3.06 FIELD QUALITY ASSURANCE

A. Provide quality control over the work of this Section as specified in Sections 01_45_00 and 01_45_17.

B. Field inspections:
   1. Engineer shall provide on-site inspection for the Work of this Section.
   2. Advise Engineer of readiness to proceed at least 24 hours prior to each placement of CLSM.
   3. Required inspections:
      a. Engineer will observe the prepared areas. Do not place CLSM until Engineer has observed and accepted preparations.
   4. Record of inspections.

C. Special tests and inspections:
   1. As specified in Section 01_45_24.

D. Field sampling and testing:
   1. During construction, Contractor shall provide sampling and testing to determine whether the CLSM, as produced and placed, complies with the requirements specified.
      a. Make provisions for and furnish material for test specimens. Cooperate by allowing free access for Owner's independent testing firm to sample and test materials. Provide assistance in obtaining and preparing said specimens.
   2. Sample CLSM for testing in accordance with ASTM D 5971.
   3. Required tests:
      a. Air content: Prepare sample and test in accordance with ASTM D 6023
      b. Compressive strength: Prepare and test cylinder specimens in accordance with ASTM D 4832.
         1) Prepare 6-inch diameter by 12-inch high specimens for testing.
            a) Provide one set of specimens for each 150 cubic yards of CLSM placed, but not less than 1 set for each half day's placement.
            b) Prepare and test not less than 3 cylinders for each set.
            c) Place CLSM in the molds in accordance with ASTM D 4832. Do not rod or otherwise consolidate the material in the mold.
            d) In accordance with ASTM D 4832 recommendations for displacing bleed water at the top of the molds and refilling the molds before covering with a lid. Do not use air-tight lids.
         2) Place the cylinders in a safe location away from construction activities.
            a) Protect cylinders from bumping and impact.
            b) Maintain temperature surrounding cylinders between 60 and 80 degrees Fahrenheit until delivery to the laboratory for testing.
            c) After the first day, surround molds with a high humidity environment by covering with wet burlap, or equivalent highly absorptive material. Maintain saturation of the cover. Do not sprinkle water directly on the cylinders.

3) After 4 days, place the cylinders in a protective container for transport to the laboratory for testing.
    a) Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
    b) Transport container may be a box with a Styrofoam or similar lining that will limit jarring and bumping of the cylinders.
4) Upon receipt at the testing laboratory, place test cylinders in a moist curing room until dates for testing.
5) Do not remove test cylinders from molds until the day that cylinders is to be capped and tested.
6) Cap and test for compressive strength in accordance with ASTM D 4832.
    a) Do not perform initial compression test until the cylinders reach an age of at least 4 days.
    b) Test 1 cylinder at 7 days and 2 at 28 days.
7) Compressive strength of the cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength specified.

3.07 NON-CONFORMING WORK

A. When testing or observation indicates CLSM with properties outside the specified and accepted range, Engineer will issue instructions regarding disposition of nonconforming materials.

B. Engineer may:
    1. Reject CLSM represented by those test specimens and require its removal and replacement.
    2. Require modification of the mix design to provide CLSM with the properties specified.

C. Make such modifications at no additional expense to the Owner and with no adjustment to the schedule.

END OF SECTION

SECTION 31_32_18.02

FILTER FABRIC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Nonwoven filter fabric.

1.02 REFERENCES

A. ASTM International (ASTM):
1. D 4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
2. D 4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
3. D 4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
4. D 4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
5. D 4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
6. D 5261 - Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
7. D 6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.

1.03 DEFINITIONS

A. Filter fabric: Nonwoven geotextile fabric manufactured from polypropylene fibers.

1.04 SUBMITTALS

A. Product data.

B. Samples.

C. Quality control submittals:
1. Certificates of Compliance.
2. Manufacturer's Instructions.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection:
1. Furnish filter fabric in protective covers capable of protecting the fabric from ultraviolet rays, abrasion, and water.

1.06 PROJECT CONDITIONS

A. Take field measurements to determine the lengths and dimensions of the surfaces to receive the fabric.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
  1. Propex, Geotex 401.
  2. Ten Cate Geosynthetics, Mirafi 140N.

2.02 MATERIAL REQUIREMENTS

A. Physical properties: Meet the following minimum requirements:

Property (1)	Test Method	Unit	Requirements (1)
Minimum Weight	ASTM D 5261	oz	4.0
Grab Tensile Strength	ASTM D 4632	lbs	100
Grab Elongation	ASTM D 4632	%	50
Trapezoid Tear Strength	ASTM D 4533	lbs	50
CBR Puncture Resistance	ASTM D 6241	lbs	300
UV Resistance (strength retained at 500 hrs)	ASTM D 4355	%	70
Apparent Opening Size (AOS)	ASTM D 4751	US sieve	70
Permittivity	ASTM D 4491	sec^{-1}	1.7
Flow Rate	ASTM D 4491	gpm/ft^2	130
(1) Minimum average roll values.			

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Verify that conditions are satisfactory for the installation of filter fabric.

3.02 PREPARATION

A. Surface preparation:
  1. During grading operations, take care not to disturb the subgrade.
  2. This may require use of lightweight dozers for low strength soils such as saturated, cohesionless, or low cohesion soils.

B. Prior to placement of fabric: Prepare surface to smooth condition free of debris, depressions, or obstructions that may damage the fabric.

3.03 INSTALLATION

A. Follow manufacturer's installation instructions and as complimented herein.

B. Place the filter fabric smoothly without folds or wrinkles.

C. Use special care when placing the filter in contact with the soil so that no void spaces occur between the filter and the prepared surface.

D. Overlap the parallel rolls and ends of rolls a minimum of 24 inches and not less than manufacturer's instructions.

E. Do not drag filter fabric across subgrade.

F. Make overlaps at ends of rolls in the direction of the aggregate placement with the previous roll on top.

G. Use lightweight dozers if necessary. Do not allow equipment directly on filter fabric.

3.04 FIELD QUALITY CONTROL

A. Inspection:
  1. Before covering, the condition of the fabric will be observed by the Engineer to determine that no holes or rips exist in the fabric.
  2. Repair all holes and rips by placing a new layer of fabric extending beyond the defect in all directions a distance equal to the minimum overlap required for adjacent rolls.

END OF SECTION

SECTION 31_32_18.04

STABILIZATION FABRIC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Woven stabilization fabric used for subgrade enhancement.

1.02 REFERENCES

A. ASTM International (ASTM):
1. D4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon Arc Type Apparatus.
2. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
3. D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
4. D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
5. D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
6. D6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.

1.03 DEFINITIONS

A. Stabilization fabric: Woven geotextile fabric manufactured from polypropylene yarns.

1.04 SUBMITTALS

A. Product data.

B. Samples.

C. Quality control submittals:
1. Certificates of Compliance.
2. Manufacturer's Installation Instructions.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection:
1. Furnish stabilization fabric in protective covers capable of protecting the fabric from ultraviolet rays, abrasion, and water.

1.06 PROJECT CONDITIONS

A. Field measurements:
1. Take field measurements to determine the exact lengths and dimensions of the surfaces to receive the fabric.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Propex, Geotex 200ST.
   2. Ten Cate Geosynthetics, Mirafi 500X.

2.02 MATERIAL REQUIREMENTS

A. Physical properties: Meet the following minimum requirements:

Property [(1)]	Test Method	Unit	Requirements [(1)]
Grab Tensile Strength	ASTM D 4632	lbs	200
Grab Elongation	ASTM D 4632	%	15
Trapezoid Tear Strength	ASTM D 4533	lbs	75
CBR Puncture Resistance	ASTM D 6241	lbs	700
UV Resistance (strength retained at 500 hrs)	ASTM D 4355	%	70
Apparent Opening Size (AOS)	ASTM D 4751	US sieve	40
Permittivity	ASTM D 4491	sec^{-1}	0.05
Flow Rate	ASTM D 4491	gpm/ft^2	4
(1) Minimum average roll values.			

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Verify that conditions are satisfactory for the installation of stabilization fabric.

3.02 PREPARATION

A. Surface preparation: During grading operations, take care not to disturb the subgrade. This may require use of lightweight dozers for low strength soils such as saturated, cohesionless, or low cohesion soils.

B. Prior to placement of fabric: Prepare surface to smooth condition free of debris, depressions, or obstructions that may damage the fabric.

3.03 INSTALLATION

A. Follow manufacturer's installation instructions and as complimented herein.

B. Place the stabilization fabric smoothly without folds or wrinkles.

C. Use special care when placing the stabilization fabric in contact with the soil so that no void spaces occur between the stabilization fabric and the prepared surface.

D. Overlap the parallel rolls and ends of rolls a minimum of 24 inches and not less than recommended by manufacturer.

E. Do not drag stabilization fabric across subgrade.

F. Make overlaps at ends of rolls in the direction of the aggregate placement with the previous roll on top.

G. Use lightweight dozers, if necessary. Do not allow equipment directly on stabilization fabric.

3.04 FIELD QUALITY CONTROL

A. Inspection: Before covering, the condition of the fabric will be observed by the Engineer to determine that no holes or rips exist in the fabric. Repair all holes or rips by placing a new layer of fabric extending beyond the defect in all directions, a distance equal to the minimum overlap required for adjacent rolls.

END OF SECTION

SECTION 31_50_00

EXCAVATION SUPPORT AND PROTECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for designing, providing, maintaining, and removing excavation support and protection.

B. Related sections:
   1. Section 01_41_00 - Regulatory Requirements.
   2. Section 31_23_24 - Controlled Low Strength Material (CLSM).

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. Guidelines of Engineering Practice for Braced and Tied-Back Excavations.

B. California Code of Regulations (CCR):
   1. Title 8 - Industrial Relations:
      a. Division 1. Department of Industrial Relations.
         1) Chapter 4. Division of Industrial Safety.
            a) Subchapter 4. Construction Safety Orders.
               (1) Article 6. Excavations.

C. Department of the Navy Naval Facilities Engineering Command (NAVFAC):
   1. Design Manual 7.2 - Foundations and Earth Structures.
   2. Design Manual 7.3 - Soil Dynamics and Special Design Aspects.

D. State of California Department of Transportation (Caltrans):
   1. Caltrans California Trenching and Shoring Manual.

E. United States Steel Corporation (USS):
   1. Steel Sheet Piling Design Manual.

1.03 DEFINITIONS

A. General Engineering Design Practice: General engineering design practice in area of the Project, performed in accordance with recent engineering literature on subject of shoring and stability of excavations.

B. Shoring: A temporary structural system designed to support vertical faces, or nearly vertical faces, of soil or rock for purposes of excavation. Shoring includes cantilevered sheet piling, internally braced sheet piling, slurry walls, soldier piles and lagging, and other similar shoring systems. Sloping of the soil is not shoring.

C. Support levels: Level of tiebacks, wales, rackers, bottom of excavation, and other types of support.

1.04 SYSTEM DESCRIPTION

A. Where General Engineering Design Practice is specified, provide drawings and calculations that are performed and signed by civil or structural engineer registered in State where Project is located:
   1. Clearly disclose assumptions made, criteria followed, and stress values used for materials being used in design calculations.
   2. Submit list of references acceptable to Engineer that substantiating appropriateness of design assumptions, criteria, and stress values.

B. Design requirements:
   1. General:
      a. In accordance with requirements in CCR, Title 8, Chapter 4, Subchapter 4, Article 6 for trench excavations 5 feet or more in depth and for trenches less than 5 feet in depth when there is potential for cave-in.
         1) Where such designs vary from excavation support standards set forth in CCR, Title 8, Chapter 4, Subchapter 4, Article 6, submit design calculations pursuant to general engineering design practice.
         2) Provide means for safe and stable excavations that are not less effective than required in CCR, Title 8, Chapter 4, Subchapter 4, Article 6.
         3) The preceding requirements do not apply to trench excavation support conforming to standards set forth CCR, Title 8, Chapter 4, Subchapter 4, Article 6.
      b. When electing to design with material stresses for temporary construction higher than allowable stresses prescribed in building code as specified in Section 01_41_00, increase in such stresses shall not exceed 10 percent of value of prescribed stresses.
      c. Minimum safety factor used for design shall not be less than 1.5.
      d. The calculated minimum depth of penetration of shoring below bottom of excavation shall be increased not less than 30 percent if full value of allowable passive pressure is used in design.
      e. Maximum height of cantilever shoring above bottom of excavation shall not exceed 15 feet. Use braced shoring when height of shoring above bottom of excavation exceeds 15 feet.
      f. The location of point of fixity for shoring shall not be less than half calculated minimum embedment depth below bottom of excavation.
      g. Generally acceptable references for design of shoring and excavations are as follows:
         1) ASCE Guidelines of Engineering Practice for Braced and Tied-Back Excavations.
         2) Caltrans California Trenching and Shoring Manual.
         3) NAVFAC Design Manual 7.2.
         4) NAVFAC Design Manual 7.3.
         5) USS Steel Sheet Piling Design Manual.
      h. Maximum total deflection of shoring at any point on shoring shall not be more than 1/2inch.
   2. Soldier piles and lagging:
      a. Provide lagging over full face of excavation. Joints between pieces of lagging shall be tight to prevent loss of soil.
      b. Provide full face lagging all around penetrations through lagging.

c. If the soldier piles are installed in predrilled holes and are not concrete encased, fill predrilled holes with controlled low strength material as specified in Section 31_23_24 after soldiers piles are installed.

d. Assumed effective width for passive soil resistance:
   1) Effective width of driven soldier piles shall not exceed 2 times width of pile.
   2) Effective width of CLSM encased soldier piles in drilled holes shall not exceed 2 times width of pile.
   3) Effective width of concrete encased soldier piles shall not exceed 2 times width of concrete encasement.

e. Fill voids behind lagging with gravel or other material acceptable to Engineer.

f. Apply loads from tie back soil, rock, or deadman anchors concentrically to soldier piles or wales spanning between soldier piles:
   1) Wales shall be back-to-back double channels or other members acceptable to Engineer.
   2) Do not eccentrically load structural section of soldier piles or wales.

g. Design soldier piles for downward loads including vertical loads from tieback anchors.

3. Soil anchors, rock anchors, and deadman anchors:
   a. Design tieback anchors for a safety factor of not less than 2 times calculated load from shoring.
   b. Proof load all production anchors to 150 percent of calculated load from shoring.
   c. Lock off production anchors at calculated load from shoring.
   d. Length of soil anchors used to calculate resistance to load from shoring shall not include any length within potential active pressure soil failure zone behind face of shoring.
   e. Design tie rods for tieback anchors for 130 percent of calculated load from shoring.
   f. Design tie rods for tieback anchors for 150 percent of the calculated load from shoring when tie rod couplers are used and for other conditions where stress concentrations can develop.

4. Set inside face of shoring back from structure not less than greater of following:
   a. 5 feet from face of wall.
   b. 2 foot 6 inches from edge of foundation.
   c. Depth of excavation below bottom of foundation.

C. Performance requirements:

1. General:
   a. Support faces of excavations and protect structures and improvements in vicinity of excavations from damage and loss of function due to settlement or movement of soils, alterations in ground water level caused by such excavations, and related operations.
   b. Specified provisions:
      1) Complement, but do not substitute or diminish, obligations of Contractor for furnishing of safe place of work pursuant to provisions of the Occupational Safety and Health Act of 1970 and its subsequent amendments and regulations and for protection of Work, structures, and other improvements.

2) Represent minimum requirement for:
   a) Number and types of means needed to maintain soil stability.
   b) Strength of such required means.
   c) Methods and frequency of maintenance and observation of means used for maintaining soil stability.

2. Provide safe and stable excavations by means of sheeting, shoring, bracing, sloping, and other means and procedures, such as draining and recharging groundwater and routing and disposing of surface runoff, required to maintain stability of soils and rock.
3. Provide support for trench excavations for protection of workers from hazard of caving ground.
4. Provide shoring:
   a. Where, as result of excavation work and analysis performed pursuant to general engineering design practice, as defined in this Section:
      1) Excavated face or surrounding soil mass may be subject to slides, caving, or other types of failures.
      2) Stability and integrity of structures and other improvements may be compromised by settlement or movement of soils, or changes in soil load on structures and other improvements.
   b. For trenches 5 feet and deeper.
   c. For trenches less than 5 feet in depth, when there is potential for cave-in.
   d. Where indicated on the Drawings.
5. For safe and stable excavations, use appropriate design, construction, and maintenance procedures to minimize settlement of supported ground and to prevent damage to structures and other improvements, including:
   a. Using stiff shoring systems.
   b. Following appropriate construction sequence.
   c. Using shoring system that is tight enough to prevent soil loss through the shoring.
   d. Using shoring system that extends far enough below bottom of excavation to prevent piping, heave, or flow of soil under shoring.
   e. Design for safety factor of not less than 1.50.
   f. Providing surface runoff routing and discharge away from excavations.
   g. Where dewatering inside shoring is necessary, recharge groundwater outside shoring as necessary to prevent settlement in area surrounding shored excavation.
   h. Where sheet piling is used, use interlocking type sheets:
      1) Sheet piles shall be continuous and driven in interlock.
      2) If bottom of the excavation is located below the water table, use “ball and socket” or "thumb and finger" type interlock.
   i. Not applying shoring loads to existing structures and other improvements.
   j. Not changing existing soil loading on existing structures and other improvements.
   k. Provide welded steel packing between soil retaining members such as sheet piles and wales and similar members when gap exceeds 1/2 inch before wales are loaded.

1.05 SUBMITTALS

A. Shop drawings and calculations:
   1. Calculations for different load, support, and other conditions that occur during the sequence of installation of shoring, construction of facilities protected by shoring, and sequence of removal of shoring.
   2. Sketches showing the condition at various stages of installation and removal of shoring.
   3. Show on plan shoring, structures, pipelines, and other improvements located near shoring.
   4. When utilities penetrate shoring, show location of penetrations on elevation of all sides of shoring.
   5. Show details for ground support and sealing around utility penetrations.
   6. Indicate method used for installing driven shoring.

B. Written geotechnical report with soil characteristics and design recommendations.

C. Control points and schedule of measurements:
   1. Submit location and details of control points and method and schedule of measurements.
   2. Survey data.

D. Detailed sequence of installation and removal of shoring:
   1. Consider effects of ground settlement in sequence of installation and removal of shoring.
   2. Provide sketches showing conditions at various stages in sequence of installation and removal of shoring.

E. Submit submittals for excavation support and protection as complete package and include all items required in this Section:
   1. Incomplete submittals will not be reviewed and will be returned for resubmittal as complete package.

1.06 SEQUENCING

A. Do not begin construction of any shoring or excavation operations until:
   1. Submittals for shoring and dewatering have been accepted.
   2. Control points as specified in this Section and on existing structures and other improvements as indicated on the Drawings have been established and surveyed to document initial elevations and locations.
   3. Materials necessary for installation are on site.

B. Submit submittals minimum of 60 days prior to scheduled date to begin excavation work.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 CONSTRUCTION

A. Installation of shoring:
   1. Install means for providing safe and stable excavations as indicated in submittals.

B. Removal of shoring:
   1. Except for concrete encased soldier piles, slurry walls, and similar shoring systems, remove shoring by completion of Work.
   2. Select shoring system and method of removal, which will minimize soil that sticks to shoring from creating voids and causing settlement.
   3. To prevent settlement caused by pulling shoring, fill voids with pressure injected grout:
      a. Inject grout starting at bottom of void and progressively fill void to grade.
      b. Minimize length of shoring removed ahead of grouting operation and limit time void is left ungrouted to prevent void from closing up before being grouted.
   4. Pressure preservative treated wood lagging may be left in place if acceptable to Engineer.

C. Control points:
   1. Establish control points on shoring and on structures and other improvements in vicinity of excavation for measurement of horizontal and vertical movement:
      a. Set control points on shoring support system:
         1) Set points at distances not exceeding 25 feet at each support level.
   2. Promptly upon completion of construction of control points survey control points. Submit copy of field notes with measurement.
   3. Perform horizontal and vertical survey and measurement of control points at least once every week.
      a. Field notes shall show current measurement and change in measurement from first measurement taken.
   4. Set control points on corners of existing structures and on curbs, manholes, and other improvements at the locations indicated on the Drawings.
   5. Provide plumb bobs with horizontal targets indicating original position of plumb bobs in relation to shoring at control points.

D. Maintenance:
   1. Where loss of soil occurs, plug gap in shoring and replace lost soil with fill material acceptable to Engineer.
   2. Where measurements and observations indicate possibility of failure or excessive movement of excavation support, determined in accordance with general engineering design practice, take appropriate action immediately.

END OF SECTION

SECTION 32_01_15

PAVEMENT RESTORATION AND REHABILITATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Resurfacing roads and paved surfaces in which surface is removed or damaged by installation of new work.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor’s Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 03_30_00 - Cast-in-Place Concrete.
      b. Section 31_05_15 - Soils and Aggregates for Earthwork
      c. Section 32_12_17 - Asphaltic Concrete Paving.

1.02 SYSTEM DESCRIPTION

A. Performance requirements:
   1. Limiting dimensions:
      a. Determine the exact lengths and dimensions of such roads, pavements, parking areas, and walks that will require removal and replacement for new work.
      b. Join existing surfaces to terminals of new surfacing in smooth juncture.

1.03 SUBMITTALS

A. Mix designs:
   1. Prior to placement of asphalt concrete, submit full details, including design and calculations for the asphalt concrete mix proposed.
   2. Submit gradation of aggregate base.
   3. Submit proposed mix design of portland cement concrete.

PART 2 PRODUCTS

2.01 MATERIALS

A. Aggregate base course: As specified in Section 31_05_15.

B. Asphalt pavement: As specified in Section 32_12_17.

C. Portland cement concrete replacement material: Class A concrete as specified in Section 03_30_00.

2.02 EQUIPMENT

A. Roads, pavements, parking areas, and walks:
   1. Equipment requirements: Good condition, capable of performing work intended in satisfactory manner.

2.03 ACCESSORIES

A. Material for painting asphalt concrete pavement: Tack coat as specified in Section 32_12_17.

PART 3 EXECUTION

3.01 INSTALLATION

A. Aggregate surface removal replacement:
   1. When trench cut is in aggregate surfaced areas, replace aggregate base course material with material matching existing material compacted to 95 percent of its maximum density.

B. Pavement removal and temporary asphalt replacement:
   1. Install temporary asphalt pavement or first course of permanent pavement replacement immediately following backfilling and compaction of trenches that have been cut through existing pavement.
   2. Except as otherwise provided, maintain this temporary pavement in safe and reasonably smooth condition until required permanent pavement is installed.
   3. Remove and dispose of temporary paving from project site.
   4. Where longitudinal trench is partly in pavement, replace pavement to original pavement edge, on a straight line, parallel to centerline of roadway.
   5. Where no part of longitudinal trench is in pavement, surfacing replacement shall only be required where existing surfacing materials have been removed.

C. Asphalt pavement replacement:
   1. Replace asphalt pavement to same thickness as adjacent pavement and match as nearly as possible adjacent pavement in texture, unless otherwise indicated on the Drawings.
   2. Cut existing asphalt pavements to be removed for trenches or other underground construction by wheel cutter, clay spade, or other device capable of making neat, reasonably straight, and smooth cut without damaging adjacent pavement. Cutting device operation shall be subject to acceptance of Engineer.
   3. Cut and trim existing pavement after placement of required aggregate base course and just prior to placement of asphalt concrete for pavement replacement, and paint trimmed edges with material for painting asphalt concrete pavement immediately prior to constructing new abutting asphalt pavements. No extra payment will be made for these items, and all costs incurred in performing this work shall be incidental to pipe laying or pavement replacement.
   4. Conform replacement of asphalt pavement to contour of original pavement.

D. Portland cement concrete pavement replacement:
  1. Where trenches lie within portland cement concrete section of streets, alleys, sidewalks, and similar concrete construction, saw cut such concrete (to a depth of not less than 1-1/2 inches) to neat, vertical, true lines in such manner adjoining surfaces are not damaged.
  2. Place portland cement concrete replacement material to dimension as indicated on the Drawings.
  3. Provide expansion joints that match existing.
  4. Before placing replacement concrete, thoroughly clean edges of existing pavement and wash with neat cement and water.
  5. Surface finish: Wood float finish.

E. Curb, gutter, and sidewalk replacement:
  1. Where any concrete curb, gutter, or sidewalk has been removed or displaced, replace to nearest construction joints with new Class A curb, gutter, or sidewalk to same dimensions and finish as original construction that was removed:
     a. Provide expansion joints of same spacing and thickness as original construction.

F. Asphalt pavements:
  1. Trim existing asphalt pavements which are to be matched by pavement widening or pavement extension to neat true line with straight vertical edges free from irregularities with saw specifically designed for this purpose. Minimum allowable depth of cut shall be 1-1/2 inches.
  2. Cut and trim existing pavement after placement of required aggregate base course and just prior to placement of asphalt concrete for pavement widening or extension, and paint trimmed edges with material for painting asphalt concrete pavement immediately prior to constructing new abutting asphalt concrete pavements.
  3. No extra payment will be made for these items and all costs incurred in performing this work shall be incidental to widening or pavement extension.

3.02 FIELD QUALITY CONTROL

A. Tests:
  1. Asphalt concrete as specified in Section 32_17_15.
  2. Concrete as specified in Section 03_30_00.

B. Inspection:
  1. Asphalt concrete:
     a. Lay 10-foot straightedge parallel to centerline of trench when the trenches run parallel to street, and across pavement replacement when trench crosses street at angle.
     b. Remove and correct any deviation in cut pavement replacement greater than 1/4 inch in 10 feet.
  2. Portland cement concrete replacement pavement:
     a. Lay 10-foot straightedge either across pavement replacement or longitudinal with centerline of gutter or ditch.

b. Remove and correct any deviation in cut pavement replacement greater than 1/4 inch in 10 feet.

END OF SECTION

SECTION 32_12_17

ASPHALTIC CONCRETE PAVING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Asphalt pavement on prepared subgrade or aggregate base course to lines, grades, and compacted thickness as indicated on the Drawings.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 31_05_15 - Soils and Aggregates for Earthwork.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D 1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft. lbf/f_4^3)(2,700 kN-m/m^3).
   2. D 1561 - Standard Practice for Preparation of Bituminous Mixture Test Specimens by Means of California Kneading Compactor.

B. Caltrans Standard Test Methods:
   1. Calif Test 202 - Sieve Analysis of Fine and Coarse Aggregates.
   2. Calif Test 304 - Preparation of Bituminous Mixtures for Testing.
   3. Calif Test 362 - Determining Asphalt Content in Bituminous Mixtures by Vacuum Extraction.
   4. Calif Test 375 - Determining the In-Place Density and Relative Compaction of AC Pavement.
   5. Calif Test 379 - Determining Asphalt Content in Bituminous Mixtures (Troxler Nuclear Gauge Model 3241).

C. State of California Department of Transportation Standard Specifications, latest edition (Caltrans Standard Specifications):
   1. Section 37 - Bituminous Seals.
   2. Section 39 - Hot Mix Asphalt.
   3. Section 88 - Geosynthetics.
   4. Section 92 - Asphalts.
   5. Section 93 - Liquid Asphalts.
   6. Section 94 - Asphaltic Emulsions.

1.03 SYSTEM DESCRIPTION

A. This Work shall consist of furnishing and mixing aggregate and asphalt binder at a central mixing plant, spreading and compaction of the mixture as specified and as indicated on the Drawings.

B. In general, asphalt concrete and asphalt concrete base shall conform to Section 39 “Hot Mix Asphalt,” and all applicable referenced sections of the Caltrans Standard Specifications:
   1. Where conflicts exist, this specification shall govern.

1.04 DEFINITIONS

A. “Asphalt Concrete” as used by Caltrans shall be considered the “Surface Course”, or the final lift of the pavement section.

B. “Asphalt Concrete Base” as used by Caltrans shall be the remaining portion of the asphalt pavement section excluding the final lift.

C. “Asphalt Pavement” shall be the total pavement section of asphalt including Asphalt Concrete and Asphalt Concrete Base.

1.05 SUBMITTALS

A. Mix design.

B. Shop drawings.

C. Product Data:
   1. Asphalt.
   2. Asphalt aggregate.
   3. Pavement reinforcing fabric.

D. Quality control submittals:
   1. Test results.
   2. Certificate of Compliance.
   3. Certificate of Competence.

E. Equipment list.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Asphalt pavement delivery:
   1. Transport the mixture from the mixing plant to the point of use in vehicles having tight bodies previously cleaned of all foreign materials.
   2. Treat bodies as necessary to prevent material from sticking to the bodies.
   3. Cover each load with canvas or other suitable material of sufficient size and thickness to protect the asphalt mixture from the weather.

1.07 PROJECT CONDITIONS

A. Environmental requirements:
   1. Asphalt concrete:
      a. Place asphalt concrete only when surface is dry, and when atmospheric temperature in the shade is 40 degrees Fahrenheit and rising, or above 50 degrees Fahrenheit if falling.
      b. Do not place asphalt concrete when weather is foggy or rainy, when base on which material is to be placed is in wet or frozen conditions, or when, in the opinion of the Engineer, weather conditions will prevent proper handling, finishing, or compaction of the mixtures.

PART 2 PRODUCTS

2.01 ASPHALT PAVEMENT MATERIALS

A. Asphalts:
   1. Asphalt binder: Steam-refined paving asphalt, PG 64-10, conforming to Section 92-1.02C “Grades” of the Caltrans Standard Specifications.
   2. Tack coat: Grade SC-70, conforming to Section 93 of the Caltrans Standard Specifications.

B. Asphalt aggregate:
   1. Aggregate for asphalt concrete shall conform to Section 39-2.02 of the Caltrans Standard Specifications for Type A grading, 3/4-inch maximum, medium.
   2. Aggregate for asphalt concrete base shall conform to Section 39-2.02 of the Caltrans Standard Specifications for Type A grading.
   3. The use of reclaimed asphalt pavement (RAP) in asphalt concrete and asphalt concrete base is prohibited.

C. Asphalt pavement shall be produced in a batch mixing plant, a continuous pugmill mixing plant, or dryer-drum mixing plant:
   1. Proportioning shall conform to Section 39-3.03 of the Caltrans Standard Specifications.
   2. Mixing shall conform to Section 39-3.04 of the Caltrans Standard Specifications.

2.02 AGGREGATE BASE COURSE

A. Aggregate base course: As specified in Section 31_05_15.

B. Aggregate base course shall be placed at the following locations:
   1. At all locations indicated on the Drawings.

C. Compacted thickness of aggregate base course shall be as indicated on the Drawings.

2.03 EQUIPMENT

A. Spreading and compacting equipment:
   1. Spreading equipment shall conform to Section 39-1.10 and all applicable referenced sections of the Caltrans Standard Specifications:
      a. Only in areas inaccessible to the machine, by approval of the Engineer, will hand spreading be permitted.
   2. Compaction equipment shall conform to Section 39-1.10 and all applicable referenced sections of the Caltrans Standard Specifications.

2.04 SOURCE QUALITY CONTROL

A. The Engineer will perform sampling and tests of materials in accordance with California Test Method Number 304 and California Test Method Number 362 or 379, as applicable. Samples will be taken from materials as delivered to the site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Verify surfaces and site conditions are ready to receive work. If unsatisfactory conditions exist, do not commence installation until such conditions have been corrected. Beginning application means acceptance of existing conditions.

3.02 PREPARATION

A. Protection:
   1. Protect concrete pavements and walks, curbs and bases, and other improvements adjacent to the operations with suitable materials.
   2. Building and other surfaces shall be covered with paper or other protection, when required.
   3. Contractor shall be responsible for any damage caused by Contractor's employees. All damage caused by the Contractor's operations shall be repaired to the satisfaction of the Engineer at no additional cost to Owner.

B. Subgrade preparation:
   1. Immediately prior to applying tack coat, or immediately prior to placing the asphalt pavement when tack coat is not required, the subgrade to receive asphalt pavement shall conform to the compaction requirement and elevation tolerances specified for the material involved and shall be cleaned to remove any loose or extraneous material.
   2. If the asphalt pavement is to be placed on an existing base or pavement that was not constructed as part of the contract, the Contractor shall clean the surface by sweeping, flushing, or other means to remove all loose particles of paving, all dirt, and all other extraneous material immediately before applying the tack coat.

3.03 TACK COAT

A. Tack coat:
   1. A tack coat of asphaltic emulsion shall be applied to all vertical surfaces of existing pavement, curbs, gutters, and construction joints in the surfacing against which additional material is to be placed, or as otherwise specified in this Section.
   2. Tack coat shall be applied in one application at a rate of 0.1 gallons per square yard of surface covered.

3.04 ASPHALT PAVEMENT

A. Placing materials in a windrow, then picking it up and placing it in the asphalt paver with loading equipment, will be permitted provided that:
   1. The asphalt paver is of such design that the material will fall into a hopper that has a movable bottom conveyor to feed and screed.
   2. The loader is constructed and operated so that substantially all of the material deposited into windrows is picked up and deposited into the paving machine.
   3. The windrow is deposited only so far in advance of the paver to provide for continuous operation of the paver and not so far as to allow the temperature of the asphalt pavement in the windrow to fall below 260 degrees Fahrenheit.

B. Unless lower temperatures are directed by the Engineer, asphalt concrete shall be spread, and the first coverage of initial or breakdown compaction shall be performed when the temperature of the mixture is not less than 250 degrees Fahrenheit, and all breakdown compaction shall be completed before the temperature of the mixture drops below 205 degrees Fahrenheit.

C. Asphalt pavement shall be spread and compacted in the number of layers and of the thicknesses indicated in the following table:
   1. A thickness tolerance of within 0.1 inches is allowed for asphalt concrete.
   2. A total thickness tolerance of within 0.2 inches is allowed for asphalt concrete base.

Total Thickness Indicated on Drawings[a]	Number of Lifts	Top Layer Thickness		Next Lower Layer Thickness		All Other Lower Layer Thicknesses	
		Min	Max	Min	Max	Min	Max
>=5”	[b]	1-3/4”	2-1/4”	1-3/4”	3”	1-3/4”	4-3/4”

Notes:

a When pavement-reinforcing fabric is shown to be placed between layers of asphalt pavement, the thickness of asphalt pavement above the pavement-reinforcing fabric shall be considered to be the “Total Thickness Indicated on the Drawings” for the purpose of spreading and compacting the asphalt pavement above the pavement-reinforcing fabric.

b At least 2 layers shall be placed if the total thickness is less than 5 inches. At least 3 layers shall be placed if the total thickness is more than 5 inches, and less than 10-1/2 inches. At least 4 layers shall be placed if the total thickness is greater than 10-1/2 inches.

D. A layer shall not be placed over another layer which exceeds 3 inches in compacted thickness until the temperature of the layer which exceeds 3 inches in compacted thickness is less than 160 degrees Fahrenheit at mid depth:
   1. If the temperature of any layer drops below 140 degrees Fahrenheit, or if directed by the Engineer, apply tack coat before placing next layer.

E. Unless otherwise indicated on the Drawings, asphalt mixtures shall not be handled, spread, or windrowed in a manner that will stain the finished surface of any pavement or other improvements.

F. The completed mixture shall be deposited on the prepared subgrade at a uniform quantity per linear foot, as necessary to provide the required compacted thickness without resorting to spotting, picking up, or otherwise shifting the mixture.

G. Spreading:
   1. All layers of asphalt pavement shall be spread with an asphalt paver and shall conform to Section 39-1.11 and all applicable referenced sections of the Caltrans Standard Specifications.
   2. At locations where the asphalt pavement is to be placed over areas inaccessible to spreading and rolling equipment, all layers of asphalt pavement shall be distributed directly out of the back of the dump truck and spread by hand:
      a. Asphalt pavement spread by hand shall be compacted thoroughly to the required lines, grades, and cross-sections by means of pneumatic tampers, or by other methods that will produce the same degree of compaction as pneumatic tampers.

H. Compaction:
   1. Compaction of asphalt pavement shall conform to Sections 39-1.11, 39-3.03, 39-3.04, and all applicable referenced sections of the Caltrans Standard Specifications.
   2. Minimum required density for each layer of asphalt pavement shall be 95 percent of that obtained in the laboratory in accordance with ASTM Test Method D 1561.

I. Segregation shall be avoided, and the surfacing shall be free of pockets of coarse or fine material. Asphalt pavement containing hardened lumps shall not be used:
   1. In areas inaccessible to paving and compacting equipment where spreading is done by hand, minimize the amount of segregation.

J. Location of longitudinal joints in the top layer will be determined by the Engineer and shall not adversely affect the quality of the finished product.

K. At all locations, or as directed by the Engineer, the asphalt concrete shall be square and at least 1-inch thick when conforming to existing surfacing. Tapering or feathering is not allowed.

3.05 FIELD QUALITY CONTROL

A. The Contractor shall control the quality of Work and shall provide adequate testing to ensure compliance with these Specifications:
   1. The type and size of the samples shall be suitable to determine conformance with stability, density, thickness, and other specified requirements. Use an

approved power saw or core drill for cutting samples. Furnish all tools, labor, and materials for cutting samples, testing, and replacing the pavement where samples were removed. Take a minimum of 1 sample for every 4,000 square feet of asphalt pavement placed.

B. All asphalt pavement shall match the grades indicated on the Drawings and shall be completely free from unintended hollows and high spots:
   1. After completion of paving work, all paving shall be flooded with water. Any ponding that results in standing water greater than 3/4 inch in depth shall be ringed with chalk. Such hollows shall be corrected by removing and replacing the asphalt concrete. The asphalt concrete patch shall be square and at least 1-inch thick when conforming to existing surfacing. Tapering or feathering is not allowed.

C. Contractor shall perform in-place density and compaction tests of the completed pavement in accordance with California Test Method Number 375, to determine compliance with the specified requirements. Submit test results to Engineer for approval.

D. Cracks, settling of surface, improper drainage, improper compaction, and sloppy connection to previously laid surfaces will be construed as improper workmanship and will not be accepted.

3.06 MAINTENANCE OF PAVEMENT

A. Upon completion of final rolling, traffic shall not be permitted on the finished pavement for at least 6 hours, or until the asphalt pavement has cooled sufficiently to withstand traffic without being deformed.

3.07 WORKMANSHIP AND WARRANTY

A. Contractor shall provide written warranty against defects in materials or workmanship for a period of not less than 1 year upon completion of Work.

END OF SECTION

SECTION 32_16_14

CONCRETE CURBS, GUTTERS, AND SIDEWALKS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Concrete curbs, gutters, sidewalks, driveways, access ramps, and alley intersections.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 03_15_00 - Concrete Accessories.
      b. Section 03_30_00 - Cast-In-Place Concrete.
      c. Section 03_35_29 - Tooled Concrete Finishing.
      d. Section 31_05_15 - Soils and Aggregates for Earthwork.

1.02 SYSTEM DESCRIPTION

A. Performance requirements: Construct various types of concrete curb, gutter, sidewalk, driveways, and alley intersections to dimensions and details indicated on the Drawings.

B. See City of Tulare Technical Specification No. 14 Concrete Curbs, Drive Approaches, Sidewalks, and Cross Gutters for additional requirements.

1.03 SUBMITTALS

A. Product data: Submit data completely describing products.

B. Samples: Submit samples when requested.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete: Class B, as specified in Section 03_30_00.

B. Curb finishing mortar: 1 part portland cement to 2 parts sand.

C. Form release material: Light oil or other releasing agent of type which does not discolor concrete or interfere with the application of finishing mortar to curb tops and faces.

D. Joint materials:
  1. Expansion: As specified in Section 03_15_00.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of Conditions:
  1. Verify field conditions, including subgrade condition and interferences, before beginning construction.

3.02 PREPARATION

A. Surface preparation:
  1. Subgrade:
    a. Construct and compact true to grades and lines indicated on the Drawings and requirements as specified Section 31_05_15.
    b. Remove soft or unsuitable material to depth of not less than 6 inches below subgrade elevation and replace with satisfactory material.
  2. Forms and subgrade: Water immediately in advance of placing concrete.

3.03 INSTALLATION

A. Special techniques:
  1. Contractor's option:
    a. Construct concrete curbs and gutters by conventional use of forms, or by means of curb and gutter machine when acceptable to the Engineer.
    b. When use of machines designed specifically for work of this Section are accepted by the Engineer, results must be equal to or better than those produced by use of forms.
    c. Applicable requirements of construction that apply to use of forms also apply to use of machines.
    d. Discontinue use of machines when results are not satisfactory to the Engineer.

B. Forms:
  1. Carefully set to line and grade and securely stake in position forms conforming to dimensions of items to be constructed.
  2. Thoroughly clean prior to each use and coat with form releasing material.

C. Expansion and weakened-plane joints:
  1. Expansion joints:
    a. Construct vertically, and at right angles to centerline of street and match joints in adjacent pavement or sidewalks.
    b. Constructed at radius points, driveways, alley entrances, and at adjoining structures.
    c. Fill joints with expansion joint filler material.

2. Weakened-plane joints:
    a. Construct as indicated on the Drawings.
    b. Match joint locations and details in adjacent curbs, gutters, and sidewalks.

D. Concrete:
1. Placing:
    a. Thoroughly spade concrete away from forms so that no rock pockets exist next to forms and so that no coarse aggregate will show when forms are removed.
2. Compacting:
    a. Compact by mechanical vibrators accepted by the Engineer.
    b. Continue tamping or vibrating until mortar flushes to surface and coarse aggregate is below concrete surface.
3. Form removal:
    a. Front form faces: Do not remove before concrete has taken initial set and has sufficient strength to carry its own weight.
    b. Gutter and rear forms: Do not remove until concrete has hardened sufficiently to prevent damage to edges. Take special care to prevent damage.
4. Finishing and curing: Comply with requirements as specified in Section 03_35_29 except as modified here:
    a. As soon as curb face forms are stripped, apply finishing mortar to the top and face of curb and trowel to a smooth, even finish. Finish with fine haired broom in direction of work.
    b. Where curb is installed without integral gutter, extend finish 2 inches below grade.
    c. Edge concrete at expansion joints to 1/4 inch radius.
    d. Flow lines of gutters shall be troweled smooth 4 inches out from curb face for integral curb and gutter and 4 inches on both sides of flowline for gutters without curbs.
    e. Sidewalks and ramps: Broom finish.

E. Backfilling:
1. Unless otherwise specified, backfill behind curbs, gutters, or sidewalks with soil native to area and to lines and grades indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

A. Tests:
1. Curbs and gutters:
    a. Test face, top, back, and flow line with 10 foot straightedge or curve template longitudinally along surface.
    b. Correct deviations in excess of 1/4 inch.
2. Gutters:
    a. Frequency of testing: When required by the Engineer, where gutters have slope of 0.8 foot per 100 feet or less, or where unusual or special conditions cast doubt on capability of gutters to drain.
    b. Test method: Establish flow in length of gutter to be tested by supplying water from hydrant, tank truck, or other source.
    c. Required results:
        1) 1 hour after supply of water is shut off, inspect gutter for evidence of ponding or improper shape.

2) In event water is found ponded in gutter to depth greater than 1/2 inch, or on adjacent asphalt pavement, correct defect or defects in manner acceptable to the Engineer without additional cost to the Contract.

3.05 ADJUSTING

A. Repair portions of concrete damaged while stripping forms or, when damage is severe, replace such work at no additional cost to the Contract. Evidence of repairs shall not be noticeable in the finished product.

B. Remove and replace sections of work deficient in depth or not conforming to requirements indicated on the Drawings and specified in the Specifications at no additional cost to the Contract. Removal and replacement shall be the complete section between 2 joints.

END OF SECTION

SECTION 32_16_15

PRECAST CONCRETE CURBS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Precast concrete curbs or parking bumpers.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 03_30_00 - Cast-in-Place Concrete.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A 615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   2. C 150 - Standard Specification for Portland Cement.

1.03 SUBMITTALS

A. Shop drawings.

B. Product data.

C. Field sample: Include configuration and dimensions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete: As specified in Section 03_30_00 with minimum 4,000 pounds per square inch compressive strength at 28 days containing portland cement in accordance with ASTM C 150, low alkali.

B. Reinforcing: In accordance with ASTM A 615, Grade 60 steel, Number 3 bars.

C. Bonding agent: Approved epoxy resin cement.

D. Hold-down pins: In accordance with ASTM A 615, Grade 60 steel, plain Number 4 bar by 24 inches long.

2.02 FABRICATION

A. Precast concrete curbs: In accordance with local highway standards; approximately 8-inch base width; 6-inch top width; 72-inch base length; 70-inch top length; 3/4- to 1-inch radius top/side edges; 2 reinforcing bars at 3 inches on center, 2 inches from base, 1-1/2-inch concrete cover at ends; holes to accommodate pins at 4 inches from curb ends.

PART 3 EXECUTION

3.01 INSTALLATION

A. Set back of curbs at property line, unless otherwise indicated on the Drawings.

B. Drill holes for hold-down pin in portland cement paving.

C. Embed precast concrete curbs in continuous bead of bonding agent on pavement.

D. Anchor precast concrete curbs with at least 2 steel hold-down pins through holes cast in curbs. Drive hold-down pins until pins are flush with top of curb.

E. When installing curbs on natural earth or gravel surfaces, place minimum 24-inch diameter by 24-inch deep concrete foundation around each hold-down pin.

END OF SECTION

SECTION 32_31_00

FENCES AND GATES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
1. Fence, framework, fabric, and accessories.
2. Excavation for post bases and concrete foundation for posts.
3. Manual gates and related hardware.
4. Gate operators.

B. Related sections:
1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 03_30_00 - Cast-in-Place Concrete.
   b. Section 31_00_00 - Earthwork.

1.02 REFERENCES

A. ASTM International (ASTM):
1. A 121 - Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.
2. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
3. A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
4. A 385 - Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
5. A 392 - Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
6. A 702 - Standard Specification for Steel Fence Posts and Assemblies, Hot-Wrought.
7. F 626 - Standard Specification for Fence Fittings.
8. F 668 - Standard Specification for Polyvinyl Chloride (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric.
9. F 1043 - Standard Specification for Strength and Protective Coatings on Steel Industrial Chain Link Fence Framework.
10. F 1184 - Standard Specification for Industrial and Commercial Horizontal Slide Gates.
11. City of Tulare Technical Specification No. 34 6' Chain Link Fence.

1.03 SUBMITTALS

A. Product data: Submit data completely describing products.

B. Shop drawings:
   1. The contractor shall submit the manufacturer's certification that the chain-link fence materials to be furnished under these specifications meet the Specifications requirements. The certification shall include the manufacturers' names, catalog numbers and names, Federal Specification references, and weights and gauges of materials.

C. Samples: Provide for polyvinyl chloride coated fabric and accessories.

D. Quality control submittals:
   1. Certificates of compliance: Provide certification that materials conform to referenced specifications.
   2. Qualifications: Provide installer's references and list of local references.
   3. Manufacturer's instructions: Provide for gate operator equipment.

1.04 QUALITY ASSURANCE

A. Pre-installation conference: Participate in conference, if required.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Storage and handling: Unload, store, and protect materials such that they are not damaged.

1.06 PROJECT CONDITIONS

A. Field measurements:
   1. Verify actual field distances so that post spacing can be made uniform.
   2. Verify and coordinate gate opening and column distances for driveway.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Chain link fence and gates: One of the following or equal:
   1. Allied Tube and Conduit.
   2. Master-Halco.

2.02 MATERIALS

A. Chain link fence:
   1. Fabric:
      a. Height:
         1) 6 feet 0 inch or as otherwise indicated on the Drawings.
      b. Mesh for privacy slats: 3-1/2 inches by 5 inches.
      c. Size wire: 9 gauge
         1) Coating: Zinc coating, ASTM A 392, Class 1.
         2) Tensile strength: 80,000 pounds per square inch minimum.

2. Framework: In accordance with ASTM F 1043 Group 1A or 1C. Pipe shall be straight and conform to the following weights:

Pipe Size Outside Diameter (Inches)	Group IA Weight (Lbs/ft)	Group IC Weight (Lbs/ft)
1-5/8	2.27	1.84
1-7/8	2.72	2.28
2-3/8	3.65	3.12
2-7/8	5.79	4.64
3-1/2	7.58	5.71
4	9.11	6.56
6-5/8	18.97	-
8/5/8	24.70	-

a. Top rail:
1) Size: 1-5/8 inches outside diameter.
2) Tension wire: 7-gauge galvanized coil spring wire.

b. Line posts:
1) Size: 2-3/8-inch outside diameter.

c. Terminal, corner, and pull posts:
1) Size: 2-7/8-inch outside diameter.

d. Coatings:
1) Group IA: External coatings in accordance with ASTM F 1043 Type A; internal coatings in accordance with ASTM F 1043 Type A.
2) Group IC: External coatings in accordance with ASTM F 1043 Type B; internal coatings in accordance with ASTM F 1043 Type D.

3. Accessories:

a. Fence fittings: In accordance with ASTM F 626.
1) Post top fittings:
a) Provide post caps that fit snugly over posts to exclude moisture. Provide dome style caps for terminal posts and loop style caps for line posts.
b) Extension arms, 45-degree angle type, capable of receiving 3 strands of barbed wire.
2) Rail and brace ends: Provide pressed steel or malleable castings that are cup shaped to receive rail and brace ends.

b. Fabric accessories:
1) Wire clips: Minimum 6 gauge hot-dip galvanized.
2) Tension bars: 1/4 inch by 3/4 inch, galvanized.
3) Steel bands: 11 gauge, 1 inch wide, hot-dip galvanized.
4) Bolts and nuts: 3/8-inch diameter.
5) Hog rings: 11 gauge.

c. Privacy slats:
1) Vinyl strips, sized to fit fabric weave, brown color.

B. Barbed wire fence:

1. Fence:

a. Total number strands: 3.
b. Line posts: In accordance with ASTM A 702, Class B, "T-Section," 7 feet long and weighing not less than 9.3 pounds including anchor plate.
c. Gate and corner posts: Unpunched angle posts, 2-1/2 inches by 2-1/2 inches by 1/4 inch with 2 inches by 2 inches by 1/4 inch angle braces.

d. Barbed wire strands:
   1) Not less than 12-1/2 gauge galvanized wires with 14 gauge, 4 point galvanized barbs (at not more than 5 inches on center spacing).
   2) Wires per strand: 2.
e. Coatings:
   1) Galvanize: In accordance with ASTM A 121, Class 2.
   2) PVC: In accordance with ASTM F 668, color selected by Engineer.
f. Stays: Minimum 9-1/2 gauge galvanized twisted wire.

C. Chain link and barbed wire gates:

1. Gate posts and concrete foundations for gate posts: Except where differently indicated on the Drawings, determine gate posts and concrete foundations for gate posts in accordance with following schedule:

Gate Leaf Widths (Feet)	**Gate Posts**	**Foundations**	
	Post O.D. ASTM F 1043 Group IA or IC (Inches)	**Diameter (Inches)**	**Depth (Feet)**
0 TO 6	2-7/8	12	4
Over 6 to 13	4	18	3
Over 13 to 18	6-5/8 (Group IA)	18	4
Over 18 to 25	8-5/8 (Group IA)	18	4.5

2. Chain link gates:
   a. Frames and center supports: 1-7/8-inch outside diameter galvanized steel pipe that in accordance with ASTM F 1043 Group IA or IC.
   b. Gate accessories:
      1) Post top fittings:
         a) Provide post caps that fit snugly over posts to exclude moisture.
         b) Provide dome style caps for terminal posts and loop style caps for line posts.
         c) Post top fittings: Extension arms, 45-degree angle type, capable of receiving three strands of barbed wire.
      2) Corner fittings: Heavy pressed steel or malleable castings.
      3) Gate tensioning:
         a) Cross tensioning rods: 3/8 inch, galvanized.
         b) Turnbuckles: Heavy duty.
      4) Tension rods for 4-foot gates: 3/8 inch, easily adjustable, galvanized.
      5) Gate frame corner fittings: Fitting designed for purpose, Manufacturer's standard.
      6) Horizontal gate stiffeners: 1-5/8-inch outside diameter galvanized steel pipe that in accordance with ASTM F 1043 Group IA or IC.
      7) Gate hardware:
         a) Catch and locking attachment: Combination steel or malleable iron catch and locking attachment of acceptable design.
         b) Stops:
            (1) Type 1: Capable of holding gates open.
            (2) Type 2: Center rest with catch.
         c) Color: Match color of fabric.

D. Barbed wire gates:
  1. Frame: 1-3/8-inch outside diameter tubular steel, galvanized.
  2. Center support: 7/8 inch outside diameter tubular steel, galvanized.
  3. Filler wire: 11 gauge.
  4. Wire clamps: Wire T-clamps, galvanized.
  5. Hardware: Suitable hinges and latches.
  6. Padlocks: 1-1/2-inch minimum galvanized. Key padlocks alike.
  7. Chain:
     a. Links: Hardened steel, minimum 1-3/8 inches long, minimum 3/16-inch diameter links.
     b. Length: Sufficient to padlock 2 gates together.

2.03 MANUFACTURED UNITS

A. Special gates:
  1. Roller gates:
     a. Consist of 2 movable sections, each operated independently of each other.
     b. Provide each section with front roller wheels and 2 sets of rear rollers on channel tracks.
     c. Fence sections.
     d. Shop welded by arc-gas shield method.
     e. Provide welds that are smooth and clean. No weld residue will be allowed.
  2. Swing gates:
     a. Corners of gate frames:
        1) Fasten together and reinforce with fitting designed for purpose or by welding.
        2) Grind weld smooth.
     b. Gate stiffeners: Provided as follows:
        1) On gates 12 feet and wider: Vertically on gates at 6 feet on center.
        2) On gates over 7 feet in height: Horizontally.
     c. Gates with fabric 7 feet or more in height:
        1) Install vertical stiffeners at maximum of 8-foot centers.
        2) Install adjustable tension rod on gates over 4 feet in width.
        3) Chain link fence fabric: Attach to gate frame by use of tension bars and tie wires as specified for fence construction, and suitable tension connectors spaced at approximately 16-inch intervals.
     d. Gate tensioning: Provide gates with cross tensioning rods and turnbuckles rigidly attached to gate frame.
     e. Gate hardware: Provide each pair gates with following:
        1) Catch and locking attachment.
        2) 2 Type 1 stops and 1 Type 2 stop as indicated on the Drawings.
  3. Swing gates:
     a. Hinges: Provide swing gates with minimum 2 hinges designed as to securely clamp to gatepost and permit gate to be swung open 180 degrees.

b. Controls:
    1) Provide control for pair of motor operators for each gate by either of 2 manually operated switches located where indicated on the Drawings:
        a) Also provide controls for pair of motor operators for each gate controlled by either of 2 key-operated switch stations located at each gate.
        b) Provide gooseneck stands for mounting of switch stations.
        c) Gate keying: Key gates alike.

4. Rolling gates:
    a. Provide controls for each gate motor operator such that operator can be controlled by either of 2 manually operated switches located where indicated on the Drawings:
        1) Also provide control for motor operator such that gate can be controlled by either of 2 key-operated switch stations.
        2) Provide gooseneck-mounting stands for switch station and key such stations alike.
    b. Provide 1 key-operated switch station located inside gate.

B. Outside gate operator stands for plant entry gates.

2.04 FABRICATION

A. Shop finishing:
1. Galvanizing: For items not fabricated of galvanized materials hot-dip galvanize products after fabrication in accordance with following as applicable:
    a. ASTM A 123.
    b. ASTM A 153.
    c. ASTM A 385.
2. Mark galvanized products with name of galvanize, applicable ASTM designation, and weight of zinc coating.
3. Galvanize fabricated items complete, or in largest practicable sections.
4. Provide galvanizing at rate of 2.0 ounces per square foot, minimum.
5. Hardware:
    a. Padlocks: Cadmium plated.
    b. Chain: Galvanized.

B. Finish schedule:
1. Ferrous metal:
    a. Typical: Clean, then hot-dip galvanize in accordance with galvanizing standards.

C. Field finish touch-up painting:
1. Galvanized repair paint: Apply paint having minimum dry film thickness of 2.0 to 3.5 mils.

2.05 CANTILEVER GATE

A. Material:
   1. Fabricated from 6063-T5 aluminum alloy extrusions:
      a. The primary members (top and bottom) shall be "P" shaped in cross section weighing not less than 1.6 pounds per linear foot.
         1) This member shall be "keyed" to interlock with the "keyed" track member.
         2) The vertical members at the ends of the frame shall be square in cross section with nominal base dimensions of no less than 2 inches by 2 inches weighing not less than 1.1 pounds per linear foot.
      b. Intermediate vertical members shall alternate between 1 inch by 2 inches and 1 inch by 1 inch in cross section weighing not less than .82 pounds per linear foot and .52 pounds per linear foot respectively. Intermediates shall be spaced at a maximum of 3-foot centers.

B. Gate frame:
   1. Fabricate in modular sections or in single units depending on size constraints then shop or field assembled for the specified opening.
   2. The gate frame shall have a separate semi-enclosed "keyed" track:
      a. Track: extruded from 6105-T5-aluminum alloy, weighing not less than 2.9 pounds per linear foot.
      b. When interlocked with the top member, and welded to it, it forms a composite structure with the top of the gate frame.
      c. Welds to be placed alternately along the top and side of the track at 9-inch centers with welds being a minimum of 2 inches long.
   3. The gate frame is to be supported from the track by 2-swivel type, self-aligning, 4-wheeled, sealed lubricant, and ball bearing truck assemblies.
      a. The bottom of the support posts shall be equipped with 2 pairs of 3-inch rubber guide wheels.
   4. Diagonal "X" bracing of 3/16 inch minimum diameter stainless steel aircraft cable shall be installed to brace the gate panels.

C. The gate shall be completed by installation of an approved filler as specified. It shall extend the entire length of the gate, which includes the opening and counterbalance, secured at the ends with standard fence industry tension bars and tied with standard fence industry ties at each 2-inch by 2-inch vertical member.

D. Support posts shall be 4-inch OD galvanized steel with concrete footings as specified by the Engineer.

E. Gate and installation: In accordance with ASTM F 1184 standards for aluminum cantilever slide gates, Type II, Class 2.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Verify field conditions prior to construction.

3.02 PREPARATION

A. Surface preparation:
   1. Before locating fence posts grade ground to permit grade of fence to remain constant over any local elevations or depressions in ground line.

3.03 INSTALLATION

A. Chain link fences and gates:
   1. General:
      a. Install chain link fence and gates as indicated on the Drawings and specified in this Section.
      b. Provide fence systems that are plumb, taut, true to line and grade, and complete in all details.
      c. Install fencing to generally follow finish grade of ground and provide pull posts at points where required to conform to change in grade.
      d. Install fencing such that space between bottom of fence and finish ground line does not exceed 3 inches.
   2. Concrete foundation for fence posts:
      a. Set fence posts in concrete foundations, that extend at least 3 feet into ground, and space posts not over 10 feet apart.
      b. Provide concrete foundations having minimum of 10 inches in diameter for line posts and 12 inches in diameter for corners and gates.
      c. Provide foundations that extend minimum of 1 inch above finish grade and have tops that are shaped to slope to drain away from posts.
      d. Trowel finish tops of footings, and slope or dome to direct water away from posts.
      e. Set keepers, stops, sleeves, tracks, eye bolts, and other accessories into concrete as required.
      f. Wheel rolling area for sliding gates shall be steel-trowel smooth finish concrete.
   3. Post bracing:
      a. End corner, pull, and gate posts: Brace with same material as top rail and trussed to line posts with 3/8-inch rods and tighteners.
      b. Bracing end, corner, slope, and gate posts:
         1) Brace to midpoint of nearest line post or posts with horizontal braces used as compression members.
         2) Then from such line posts truss from brace back to bottom of end, corner, slope, or gate post with 3/8-inch steel truss rods with turnbuckles or other suitable tightening devices used as tension members.
   4. Top rail:
      a. Unless otherwise specified or indicated on the Drawings, install fencing with top rail and bottom tension wire.
   5. Fabric:
      a. Place fabric on outward facing side of the posts and install so that top edge projects over top rail of fence.
      b. Stretch fabric taut and securely fasten to posts, top rail, and bottom tension wire.
      c. Install tension wire parallel to line of fabric.
      d. Fabric: Connect fabric to:
         1) Line posts with wire clips minimum every 14 inches.

2) Terminal, corner, and gate posts with tension bars tied to posts minimum 14 inches on center and with steel bands and bolts and nuts.
3) Tension wires with hog rings minimum 24 inches on center.

6. Post top fittings: Provide post tops with extension arms.
7. Swing gates:
   a. Provide chain link fencing with swing gates, unless otherwise indicated on the Drawings or specified in this Section.
   b. Provide swing chain link gates where indicated on the Drawings.

B. Swing gates:
   1. Provide gates with 2 leafs at each gate location.
   2. Hang gates by at least 2 hinges.

3.04 FIELD QUALITY CONTROL

A. Manufacturer's field service: Manufacturer shall check and test all powered gates and accessories before acceptance.

3.05 ADJUSTING

A. Adjust gate travel, stops, and operator position to meet field conditions.

3.06 CLEANING

A. Clean up surplus dirt, concrete, and other waste material and dress grade up upon completion of the work.

3.07 PROTECTION

A. Protect installed fences and gates against damage and, if damaged, repair prior to final acceptance.

END OF SECTION

SECTION 33_05_01

SUBSURFACE UTILITY ENGINEERING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Requirements for subsurface utility engineering (SUE) as part of the Work for new pipelines.

B. Related section:
   1. Document 00_73_00 - Supplementary Conditions.
   2. Section 01_14_00 - Work Restrictions.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. 38-02 Standard Guideline for the Collection and Depiction of Existing and Subsurface Utility Data.

1.03 DEFINITIONS

A. General: Definitions used in this Section are in accordance with ASCE 38-02.

1.04 REQUIREMENTS

A. Existing utilities indicated on the Drawings are approximately only and are provided based on the best information available by use of reports listed in Document 00_73_00.

B. Existing utilities are shown for the convenience of Contractor only.
   1. It is the Contractor’s responsibility to field verify the vertical and horizontal location of all utilities including those not indicated or incorrectly indicated on the Drawings.

C. Contractor is responsible to review all geotechnical reports, record drawings, and Contract Documents.

D. Coordinate with utility locator, such as CALL BEFORE YOU DIG, and other affected entities.

E. Contractor is responsible for protecting all utilities encountered.
   1. Before any excavation, follow requirements of Section 01_14_00.
   2. If a conflict exists between what is indicated on the Drawings and what exists in the field, Contractor shall notify Engineer immediately.

F. Where scheduled, provide subsurface utility engineering services by a Civil Engineer registered in California in accordance with ASCE 38-02.

G. Requirements: The SUE shall entail the following at a minimum:
   1. Review of existing record drawings.
   2. Geophysical methods such as ground penetrating radar.
   3. Soft excavation to locate known utilities along the proposed pipeline alignment.
   4. Open trench excavation to locate unknown utilities along the proposed pipeline alignment.
   5. Utilization of field survey by a Professional Land Survey licensed in California in for determination of vertical and horizontal locations.

1.05 QUALIFICATIONS

A. General: Contractor shall utilize the services of a qualified subconsultant for SUE services with minimum qualifications that include but are not limited to:
   1. Minimum of 5 years of SUE experience in California where providing vertical and horizontal locations of utilities in accordance with ASCE 38-02 utility quality level A was required.
   2. Completion of 5 SUE projects of equal or greater magnitude within the past 5 years.

1.06 SUBMITTALS

A. Shop Drawings:
   1. Contractor shall submit all SUE information as follows:
      a. Plan drawings that clearly illustrates vertical and horizontal location of known and unknown utilities.
         1) Horizontal location shall include northing and easting coordinates.
      b. Identifies size and material and service for known utilities.
      c. Identify size and material for unknown utilities.
   2. Review of shop drawings and calculations by Engineer and Owner are for record only.
   3. Drawings shall be performed, stamped, and endorsed by a Civil Engineer registered in California.
   4. Field survey information shall be performed, stamped, and endorsed by a Surveyor registered in California in.

B. Detailed sequence of SUE:
   1. Submit a schedule for all SUE events that shows start, end, and intermediate milestones.
   2. Provide sketches showing the conditions at various stages in the sequence of SUE.

C. Submit submittals for stability of excavations as a complete package and include all items required in this Section.
   1. Incomplete submittals will not be reviewed and will be returned for resubmittal as a complete package.

1.07 SEQUENCING AND SCHEDULING

A. Coordinate all Work with restrictions provided in Section 01_14_00.

B. Do not begin Work until submittals have been accepted by Engineer and until equipment and materials necessary for installation are on site.

C. Submit submittals a minimum of 30 days prior to the scheduled date to begin excavation work.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 SUE SCHEDULE

A. Provide SUE services for all utility crossings.

END OF SECTION

SECTION 33_05_16

PRECAST DRAINAGE STRUCTURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Onsite utility structures:
   1. Precast concrete manholes.
   2. Precast drainage inlets.
   3. Standpipes for irrigation or drainage pipes.

B. Related sections:
   1. Section 03_30_00 - Cast-in-Place Concrete.
   2. Section 05_50_00 - Metal Fabrications.
   3. Section 07_90_00 - Joint Sealants.
   4. Section 31_23_17 - Trenching.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C 361 - Standard Specification for Reinforced Concrete Low-Head Pressure Pipe.
   2. C 478 - Standard Specification for Precast Reinforced Concrete Manhole Sections.
   3. C 857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   4. C 858 - Standard Specification for Underground Precast Concrete Utility Structures.

1.03 SYSTEM DESCRIPTION

A. Performance requirements:
   1. Manholes and appurtenances: Manholes and appurtenances shall be watertight and free from infiltration or exfiltration.

1.04 SUBMITTALS

A. Shop drawings: Submit shop drawings for precast utility structures.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Precast concrete manholes:
   1. Construct precast concrete manholes in accordance with design, size, shape, form, details, and at locations indicated on the Drawings and specified.
   2. Construct manholes of precast eccentric or concentric manhole units in accordance with the requirements indicated on the Drawings and specified.

3. Provide precast, cylinder units, taper sections, and eccentric flat top sections meeting strength requirements in accordance with ASTM C 478.
4. Base design and manufacture to A-16 (HS 20-44) loading in accordance with ASTM C 857.
5. Construct precast manhole sections of Class D concrete as specified in Section 03_30_00 to form and dimensions indicated on the Drawings.

B. Precast drainage inlets:
1. Construct precast concrete drainage inlets in accordance with the size, shape, form, details, and at locations indicated on the Drawings and specified.
2. Base design and manufacture to A-16 (HS 20-44) loading in accordance with ASTM C 857.
3. In accordance with ASTM C 858.
4. Construct precast drainage inlets of Class D concrete as specified in Section 03_30_00 to form and dimensions indicated on the Drawings.

C. Standpipes for irrigation or drainage pipes:
1. Pipe may be used in lieu of cast-in-place structures, as indicated on the Drawings.
2. Use concrete pipe in accordance with ASTM C 361.
3. Construct precast pipe of Class D concrete as specified in Section 03_30_00 to form and dimensions indicated on the Drawings.

2.02 ACCESSORIES

A. Standpipes for irrigation or drainage pipes:
1. Covers: As indicated on the Drawings.

B. Precast concrete manholes:
1. Joint sealant: Use precast concrete joint sealant as specified in Section 07_90_00.
2. Manhole frames and cover sets: Type, size, and quality as specified in Section 05_50_00 or as indicated on the Drawings.
3. Drop manhole fittings:
   a. Drop tee and other fittings: Vitrified clay pipe or as otherwise specified or indicated on the Drawings.
4. Piping penetrations through cylinder units:
   a. Install Kor-N-Seal, or equivalent, rubber gasket boots with steel clamps.
   b. Piping connections to the manhole bases shall be as indicated on the Drawings.

C. Precast drainage inlets:
1. Covers: As indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Standpipes for irrigation or drainage pipes:
1. Excavation and backfill: As specified in Section 31_23_17.

B. Concrete manholes:
1. Excavation and backfill: As specified in Section 31_23_17.
2. Precast concrete manholes:
   a. Manhole bases:
      1) Form and place concrete on undisturbed soil and/or on aggregate base course compacted to 95 percent of maximum density.
      2) Form that portion of base above invert elevation of sewer pipe to provide smooth channel section as indicated on the Drawings.
      3) Check forms for accuracy of dimensions and relative smoothness prior to placing concrete for base. Channels shall vary uniformly in size and shape from inlet to outlet if required.
      4) Construct of Class A concrete as specified in Section 03_30_00 to form and dimensions indicated on the Drawings.
      5) Place base concrete as monolith.
   b. Manhole sections:
      1) Set each manhole section plumb.
      2) Use sections of various heights and adjustment rings to bring top of manhole ring and cover to required elevation.
   c. Joints:
      1) Seal joints with precast concrete joint sealant as specified in Section 07_90_00 unless otherwise indicated on the Drawings.
      2) Clean joints with brush and prime.
      3) Apply precast concrete joint sealant as follows, except where instructions differ from manufacturer's printed instructions. Where these instructions differ from manufacturer's instructions, install precast concrete joint sealant in accordance with manufacturer's written instructions:
         a) Remove silicon treated protective paper from one side of preformed rope and lay preformed rope, paper side up, on cleaned joint surface. Press surface firmly end-to-end around entire joint, making minimum 1-inch laps where necessary.
         b) Remove protective paper from preformed rope and lower next section into place.
      4) Seal joints watertight.
   d. Manhole frame and cover sets:
      1) Install manhole frames and cover sets at locations indicated on the Drawings.
      2) Setting:
         a) Set manhole frames and covers at elevations and requirements indicated on the Drawings.
            (1) Set manhole covers flush with paving.
            (2) Where no paving exists, set manhole cover 6 inches above surrounding grade.
         b) Where structure is outside limits of traveled shoulder but not in roadside ditch, place structure 1/10 foot or more above existing ground surface.
         c) Where cover is in existing pavement or in traveled way of existing road shoulder, place cover flush with existing surface.
         d) Where manhole cover falls in existing roadside ditch or right of way, place manhole cover approximately 1-1/2 feet above existing ground surface.

e) Set manhole frames at required grade and securely attach to top of precast manhole shaft unit or on adjustment rings, using cement mortar.

f) Setting covers:

(1) After frames are securely set in place in accordance with requirements specified, install covers and perform necessary cleaning and scraping of foreign materials from frames and covers as required to accomplish and to assure proper fit.

(2) Any frame and cover which creates noise when passed over by traffic shall be replaced.

3. Drop manholes:
    a. Construct drop manholes at locations and in accordance with details indicated on the Drawings.
    b. Provide inside diameter of drop inlet pipe the same as intercepted sewer unless otherwise indicated on the Drawings or specified in this Section.
    c. Furnish and set fittings as indicated on the Drawings.
4. Pipe stubs:
    a. Provide pipe stubs at manhole locations and in conformance with details indicated on the Drawings and as specified.
    b. Plugging stubs:
        1) Plug stubs with vitrified clay stopper or brick plug as indicated on the Drawings.
        2) Unless otherwise indicated on the Drawings, comply with following:
            a) Stubs up to and including 21 inches: Vitrified clay stoppers.
            b) Stubs greater than 21 inches: Brick plugs.

C. Precast drainage inlets:
    1. Excavation and backfill: As specified in Section 31_23_17.

3.02 FIELD QUALITY CONTROL

A. Tests:
    1. Sanitary sewer manholes: Vacuum test all sanitary sewer manholes. Use following vacuum test procedures and requirements:
        a. After completion of the manhole barrels but prior to backfilling and grade ring installation, seal all openings in the manhole with plugs and a rubber ring "donut" type plug inserted inside the opening of the cone.
        b. Attach a small vacuum pump to a hose connected to the plug and apply 4 pounds per square inch of vacuum.
            1) Allow vacuum to stabilize at 3.5 pounds per square inch for 1 minute, then begin the test.
            2) The manhole must maintain vacuum such that no greater than 0.5 pounds per square inch of vacuum is lost during the specified test period.

c. The specified test period is as follows:

Manhole Depth (Feet)	Minimum Test Period (Minutes)
0-5	4.5
5-10	5.5
10-15	6.0
Greater than 15	6.5

d. Patch as required and retest manholes that fail the test.

e. Provide a vacuum regulator on the vacuum pump such that no greater than 4 pounds per square inch can be applied to the manhole during the test.

f. Repair all manholes that do not meet the leakage test, or are unsatisfactory from visual inspection.

   1) Retest after repair is completed.

END OF SECTION

SECTION 33_05_18

PRECAST CONCRETE VAULTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Precast concrete vaults.

B. Related section:
1. Section 01_33_00 - Submittal Procedures.
2. Section 01_81_02 - Seismic Design Criteria.
3. Section 07_90_00 - Joint Sealants.
4. Section 08_31_14 - Floor Access Doors.
5. Section 09_96_01 - High-Performance Coatings.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO).
1. LRFD Bridge Design Specifications.

B. American Concrete Institute (ACI):
1. 318 - Building Code Requirements for Structural Concrete and Commentary.

C. ASTM International (ASTM):
1. C 150 - Standard Specification for Portland Cement.
2. C 857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete utility Structures.
3. C 858 - Standard Specification for Underground Precast Concrete utility Structures.

D. Occupational Safety and Health Administration (OSHA).

1.03 SUBMITTALS

A. General:
1. Furnish submittals as specified in Section 01_33_00.

B. Shop drawings:
1. Show dimensions, locations, lifting inserts, reinforcement, and joints.
2. Structural design calculations for vaults, signed by a licensed registered Civil or Structural Engineer licensed in the State where project is located.

C. Manufacturer's Certification for Vaults: Written certification that the vault complies with the requirements of this Section.

1.04 QUALITY ASSURANCE

A. Inspection:
   1. After installation, the Contractor shall demonstrate that vaults have been properly installed, level, with tight joints, at the correct elevations and orientations, and that the backfilling has been carried out in accordance with the Contract Documents.

PART 2 PRODUCTS

2.01 VAULTS

A. Manufacturers: One of the following or equal:
   1. Utility Vault Company.
   2. Oldcastle Precast.

B. Provide precast vaults for the size indicated on the Drawings.

C. The minimum structural member thickness for vaults shall be 5 inches.
   1. Cement shall be Type V portland cement in accordance with ASTM C 150.
   2. The minimum 28-day concrete compressive strength shall be 4,000 pounds per square inch.
   3. All reinforcing steel shall be embedded in the concrete with a minimum clear cover as recommended by ACI 318.

D. Design requirements: Loads on structures:
   1. In accordance with ASTM C 857, except as modified in this Section.
   2. Loads at the ground surface:
      a. ”Roadway”: Load from heavy, frequently repeated vehicle traffic:
         1) ASTM C 857, Table 1, Designation A-16 (AASHTO HS20-44).
   3. Loads against walls. Include effects of groundwater and seismic accelerations on earth pressures.
      a. Equivalent lateral pressure:
         1) Triangular distribution: 70 pounds per square foot per foot of depth (triangular distribution).
      b. Surface surcharge load: In accordance with ASTM C 857 A-16 wheel load if such surcharge exceeds backfill loads described in the preceding paragraph.
      c. Groundwater effects: Include groundwater effects on lateral earth pressure loads using design elevation at grade.
         1) Use equivalent lateral pressure of 90 pounds per square foot per foot of depth (triangular distribution) for soil below the design groundwater elevation.
   4. Soil bearing pressure at base:
      a. Maximum 1,500 pounds per square foot total pressure on prepared subgrade soils.
   5. Lifting and handling loads:
      a. Make provision in the design for the effects of loads or stresses that may be imposed on structures during fabrication, transportation, or erection.
   6. Load combinations:
      a. Design structures to sustain the specified loads individually or in combination.

E. Design requirements: Structural analysis, design and detailing:
   1. Analyze and design structures including the effects of 2-way action (“plate action”) and of load transfer around current and future openings.
   2. Where structures include panels designed for future removal (“knockout panels”), design structures for loads and stresses with any combination of any or all such panels in place or removed.
   3. Design structures in accordance with the requirements of ACI 318 and this Section.
   4. Provide reinforcement at all areas subject to tensile stress when loaded with the specified loads and combinations thereof.
   5. Provide temperature and shrinkage reinforcement to equal or exceed ACI 318 requirements in all concrete sections.
   6. Provide minimum clear concrete cover over reinforcement at both interior and exterior faces of all members in accordance with the following:
      a. Vaults: 2 inches.
   7. Reinforcement details:
      a. Walls: For structures with wall thickness of 8 inches or less, locate a single mat of reinforcement at the center of the wall.
      b. Slabs: For structures with slab thickness of 7 inches or less, locate a single mat of reinforcement at the center of the slab.
      c. Structures with wall or slab thicknesses exceeding these limits shall have a reinforcement at each face of the member.
   8. Joints:
      a. Provide structures with watertight joints between sections, and detailed to minimize water infiltration at duct bank and conduit penetrations.
      b. Provide structures with non-skid, shiplap, or tongue and groove joints between sections.

F. Design requirements: Materials:
   1. Portland cement concrete vaults:
      a. In accordance with ASTM C 858, except as modified in this Section.
      b. Proportion concrete mixes to resist damage from freezing and thawing in a moist environment, and for exposure to deicing chemicals. In accordance with ACI 318 requirements for minimum specified compressive strength and air entrainment.
   2. Seal joints watertight with precast concrete joint sealant as specified in Section 07_90_00.

G. Where joints are designed in pre-cast concrete vaults, such joints shall be interlocking to secure proper alignment between members and prevent migration of soil through the joint. Structural sections at joints shall be sized sufficiently to reinforce the section against localized distress during transportation and handling and against excess contact bearing pressures through the joint.

H. Vault shall be solid walled construction.
   1. Where penetration of the pre-cast concrete vault is required for piping, conduit, or ducts, such penetrations shall be accommodated through pre-cast openings or core-drilled sections.
   2. Openings for penetrations shall be smooth and free of surface irregularities and without exposed steel reinforcing.
   3. Vaults need not be designed to resist thrust from piping passing through the vault.

4. Coordinate pipe penetration locations with piping arrangement as indicated on the Drawings.

I. Slope bottom of vault to Drainage Sump as indicated on the Drawings.

J. Drainage Sump: Dimensions as indicated on the Drawings.
   1. Drainage Sump shall consist of an open knockout in the bottom of the vault. Provide additional reinforcing as required to accommodate knockout.
   2. Provide FRP grating with rebate as indicated on the Drawings.
      a. Grating shall be designed for 300 pounds per square foot load with L/200 maximum deflection.
      b. Provide removable grating sections to facilitate grating removal without disconnecting Automatic Sump Drain Ejector Assembly indicated on the Drawings.

K. Ladders:
   1. General:
      a. Type:
         1) Safety type conforming to local, State, and OSHA standards as minimum.
         2) Furnish guards for ladder wells.
      b. Size: 18 inches wide between side rails of length, size, shape, detail, and location indicated on the Drawings.
   2. Aluminum ladders:
      a. Materials: 6063-T5 aluminum alloy.
      b. Rungs:
         1) 1-inch minimum solid square bar with 1/8-inch grooves in top and deeply serrated on all sides.
         2) Capable of withstanding 1,000 pound load without failure.
      c. Side rails: Minimum 4-inch by 1/2-inch flat bars.
      d. Fabrication:
         1) Welded construction, of size, shape, location, and details indicated on the Drawings.

2.02 ACCESS HATCH

A. Where openings for access to the vault are required, the full clear space opening indicated shall be provided, without obstructions from brackets or supports. For large openings where brackets or supports are designed to protrude into the opening for support of required covers, such brackets or supports shall be designed to be easily removed and replaced with a minimum of effort and without cutting or welding.

B. Access hatch as specified in Section 08_31_14 for access floor requirements.

2.03 COATINGS

A. Coat interior and exterior of valve vault in accordance with Section 09_96_01 or as indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Pre-cast concrete sections shall be transported and handled with care in accordance with the manufacturer's written recommendations.
   1. Where lifting devices are provided in pre-cast sections, such lifting devices shall be used as intended.
   2. Where no lifting devices are provided, the Contractor shall follow the manufacturer's recommendations for lifting procedures to provide proper support during lifting.

B. Buried pre-cast concrete vaults shall be assembled and placed in excavations on properly compacted soil foundations as indicated. Pre-cast concrete vaults shall be set to grade and oriented to provide the required dimensions and clearances from pipes and other structures.

C. Apply coatings in accordance with manufacturer's instructions.

D. Ladders:
   1. Secure to supporting surface with bent plate clips providing minimum 8 inches between supporting surface and center of rungs.
   2. Anchorage by manufacturer.
   3. Where exit from ladder is forward over top rung, extend side rails 3 feet 3 inches minimum above landing, and return the rails with a radius bend to the landing.
   4. Where exit from ladder is to side, extend ladder 5 feet 6 inches minimum above landing and rigidly secure at top.
   5. Erect rail straight, level, plumb, and true to position indicated on the Drawings. Correct deviations from true line or grade which are visible to the eye.

END OF SECTION

SECTION 33_05_23.13

HORIZONTAL DIRECTIONAL DRILLING

PART 1 GENERAL

1.01 SUMMARY

A. The Contractor shall furnish all labor, equipment, and materials necessary to install 12-inch and 18-inch HDPE storm drainage pipeline using horizontal directional drilling (HDD) at the locations shown on the plans.

B. Related Sections:
1. Section 01_35_61 - Work Within Public Right-of-Way.
2. Section 40_05_00.01 - Common Work Results for General Piping
3. Section 40_05_33.03 - High Density Polyethylene Plastic (HDPE) Pipe: AWWA C906

C. Measurement and Payment Procedures:
1. Payment shall be based on a lump sum value. No additional payment will be made for Contractor failure to maintain alignment and having to pull back and realign pilot hole.
2. No additional payment will be made to the Contractor if the pipe binds and has to be removed during pull back (see exceptions noted).

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):
1. Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings, Designation F 1962-99, American Society for Testing and Materials, 1999

1.03 DEFINITIONS

A. Borehole Annular Space: The space between the excavated HDD reamed bore diameter and the product pipe or cable.

B. Horizontal Directional Drilling: Horizontal directional drilling (HDD) is a surface-launched, guided, steerable drilling system used for the trenchless installation of pipes, conduits, and cables. A pilot bore path is excavated in a shallow arc from a surface-launched drill rig. Excavation takes place with fluid assisted cutting from a drilling tool on the drill string. The pilot bore is directed by the positioning of a bent sub or inclined face drill bit. Tracking of the drill string is achieved using a walkover receiver and downhole transmitter or using a downhole wireline survey tool which may be augmented by using an energized wire grid at the surface. The bore is filled with drilling mud/fluid to stabilize the bore, to cool the cutting tools, and to mix the cuttings into slurry, which is circulated to the entry point where solids are removed before the drilling fluids are returned to the bore. The bore path is enlarged with subsequent reaming passes until the desired diameter is achieved. The product pipe, conduit, or cable is then pulled into the fluid-stabilized bore hole.

C. Drilling Fluid/Mud: A mixture of water, bentonite, and/or polymers continuously pumped to the drilling tools to facilitate the removal of soil cuttings, and stabilization of the bore. These fluids also cool the cutting tools and lubricate the drill pipe and product pipe string.

D. Pilot Bore: The action of creating the first guided pass of the HDD process which is then reamed in one or more passes to the size required to allow pullback of the pipe or casing.

E. Drilling Tool/Bit: Any tool or system of tools which excavates at the face of a bore.

F. Pullback: The part of a HDD process in which the drill pipe, swivel, and product pipe or cable are pulled back through the bore to the entry.

G. Pullback Loads: The loads (forces) applied to a drill string and product pipe during the pullback process. In addition to the tensile pullback loads, bending, buckling and combination loads must be considered in design.

H. Obstruction: Any hard object lying completely or partially within the design pathway of the bore and pipeline that prevents further advancement of the drill pipe, pre-reamer, reamer, and/or pipe, after all reasonable Contractor attempts to advance past the object or re-drill around the object have failed.

I. Settlement Point: A point with elevation and spatial location established by survey prior to construction. The point is re-surveyed periodically to monitor ground movements. The point may be a nail, pin, subsurface settlement rod, borehole extensometer, or other device that can be readily located and surveyed.

J. Geotechnical Engineering Investigation Report, Proposed Water Storage Tanks, Tulare, California, prepared by BSK Associates, December 15, 2016.

K. Horizontal Directional Drilling (HDD) Work Plan: Written descriptions, together with sketches, drawings, schedules, and other documents defining Contractor’s plans and procedures for horizontal directional drilling.

1.04 SYSTEM DESCRIPTION

A. Performance Requirements: The installed pipeline shall be with six (6) inches horizontal and six (6) inches vertical of the alignment indicated in the Contract Documents at all locations, and the average slope of the installed pipeline shall not be less than the slope indicated on the drawings.

1.05 DESIGN CRITERIA

A. Equipment: The Contractor shall provide all equipment, materials, and personnel necessary for completing the installation as shown on the Plans and specified herein. The equipment and materials shall include but are not limited to:

1. Directional drilling rig with all ancillary equipment, including drill pipe, drilling fluid, cutting tools, reaming bits, swivels, expanders, motors, pumps, hoses, mixing equipment, drilling fluid processing equipment (cuttings separation equipment), downhole transmitter or survey equipment receiver, energized surface grid tracking system if used, fluid pressure and flow rate monitoring

equipment, spare parts, pipe handling equipment, crane, backhoe, rollers, side boom tractors, control cabin, control equipment, and office equipment.
2. Drilling fluids, water, fuel, lubricant, polymers, or other additives.
3. Any other expendable or reusable materials, supplies, and equipment needed for the installation.
4. Pipe ramming rig with all ancillary equipment.

B. The drilling equipment shall be capable of advancing through the geologic conditions to be encountered at the site, as described in the Geotechnical Report, and as anticipated by the Contractor.

C. The drilling fluid shall be designed for the geologic conditions to be encountered at the site, as described in the Geotechnical Report, and as anticipated by the Contractor.

D. The drilling system shall include a fluid pump and separation plant that can achieve the rates of drilling fluid pumping, spoil separation, and slurry cleaning required by the Contractor to achieve planned production rates for the clay rich, fine grained soils described in the Geotechnical Report, and as anticipated by the Contractor. Shaker screens and hydrocyclones may be required for efficient separation of spoils. The Contractor is advised that the separation plant must fit within the allowable work areas shown on the Plans.

E. All spoil and slurry must be contained in trucks, tanks, approved recirculation pits, or other containers at all times. Dumping of spoil or slurry on the ground, discharge into sewers, or discharge into water bodies will not be permitted. All spoils will be transported and disposed of off-site at an approved disposal facility that meets all State of California and permit requirements.

F. Perform all work within work areas shown on the Plans.

G. The pipeline shall be installed as shown on the Plans, unless deviations are approved in writing by the Engineer.

H. Surface settlement or heave of utilities and other features above the HDD centerlines and within the zone influenced by the HDD construction shall be limited to values that avoid damage. The Contractor shall repair any damage resulting from settlement or heave caused by HDD activities at no additional cost to the Owner. The Contractor shall grout any voids caused by or encountered during drilling.

I. Safety: It shall be the Contractor's sole responsibility that all work is done in conformance with all applicable Federal, State, and local safety requirements. Required safety equipment and procedures shall be employed by the Contractor at all times. All materials and methods of construction shall meet the applicable requirements of the General Conditions, and the applicable requirements of the Construction Safety Orders of the State of California Department of Industrial Relations and Division of Occupational Safety and Health. Particular attention is called to Subpart S of the Standards (29 CFR 1926/1920, published as U.S. Department of Labor Publication 207, revised October 1, 1979, and August 1, 1989. See Federal Register dated June 2, 1989, for the revised standard and commentary), and the Division 1, California Department of Industrial Relations, Chapter 4, Division of Industrial Safety, Subchapter 20, Tunnel Safety Orders.

These Special Provisions shall supersede any conflicting requirements of the General Conditions.

J. Pipe: The pipe will be certified by the Contractor as meeting all requirements of the pipe specification Section 40_05_33.03, High-Density Polyethylene Plastic (HDPE) Pipe: AWWA C906.

K. The Contractor shall allow access to the Engineer and shall furnish necessary assistance and cooperation to aid the Engineer in observations and data and sample collection, including, but not limited to the following:
   1. The Owner and/or Engineer shall have full access to the operator control panel or container prior to, during, and following all HDD operations. This shall include, but not be limited to, providing visual access to real-time operator control screens, gauges, and indicators.
   2. The Owner and/or Engineer shall have full access to the slurry separation plant prior to, during, and following all HDD operations. This shall include, but not be limited to, full access to shaker screens, hydrocyclones, conveyor belts, and slurry and spoil holding tanks. The Engineer shall be allowed to collect soil samples from the shaker screens and/or spoil holding tanks on the slurry separation plant a minimum of once per installed pipe section, and whenever changes in conditions are observed or suspected.

1.06 SUBMITTALS

A. Submit the following in accordance with the requirements of Section 01_33_00, Submittal Procedures, providing sufficient detail to allow the Engineer to judge whether the proposed equipment, materials, and procedures will meet the Contract requirements. All drawings shall be legible with dimensions accurately shown and clearly marked in English. Drawings and photographs transmitted by a facsimile will not be accepted. The Engineer's review of submitted details and data will be based on consideration of requirements for the completed work, protection of existing utilities and surface features, and the possibility of unnecessary delays in the execution of the work to be constructed under this Contract.

B. Horizontal Directional Drilling Work Plan: Submit an HDD Work Plan complete with drawings and written description identifying details of the proposed method of construction and the sequence of operations to be performed during construction. The HDD Work Plan shall satisfy all permit requirements.

C. Qualifications: Submit written documentation of HDD superintendent and key personnel experience in accordance with Sections 1.7.A and B. Submit evidence of CalOSHA certification for the Site Safety Representative.

D. Daily Logs: The Contractor shall submit daily logs and records in accordance with Section 1.7.C. Daily logs and records shall be provided to the Engineer by noon on the day following the shift for which the data or records were taken.

E. The Contractor shall provide written notice at least 72 hours prior to the inception of drilling activities as described in Section 1.7.D.

F. Shop Drawings:
   1. The Contractor shall submit all shop drawings to the Engineer. All shop drawings shall have been reviewed and accepted by the Engineer prior to

Contractor's mobilization. All drawings shall be legible with dimensions accurately shown and clearly marked in English.

2. Drawings and photographs transmitted by a facsimile will not be accepted. The drawings shall include the planned equipment, equipment setup and work areas, pipe layout areas, any excavations or mud recirculation pits and traffic control.
3. Indicate the outside diameter, dimension ratio, wall thickness, and inside diameter for each pipe.

G. Schedule: At least fifteen (15) days prior to mobilization, the Contractor shall submit a detailed schedule for each HDD installation showing all major construction activities and durations, with beginning and completion dates shown. The schedule shall be updated at least every two weeks or more frequently, as directed by the Engineer, and shall include:

1. “One call” utility locate requests and visual confirmation of all crossing utilities and all parallel utilities within ten (10) feet laterally of the bore centerline.
2. Rig mobilization and setup.
3. Pilot bore drilling.
4. Pre-reaming and reaming.
5. Layout and fusing of HDPE pipe.
6. Final reaming and pullback of HDPE pipe.
7. Tie-ins and/or connections.
8. Cleanup, surface restoration, and demobilization.

H. Description of Methods, Equipment, and Materials: The Contractor shall submit detailed descriptions of methods, equipment, and materials to be used for the storm drain installations. Descriptions of drilling fluid additives shall be accompanied by Materials Safety Data Sheets (MSDS) and manufacturers' descriptions and warranties. Descriptions of equipment shall include manufacturer's specifications, calibrations, appropriate drawings, photographs, and descriptions of any modifications since manufacture.

I. Surveying, Equipment and Procedures: The Contractor shall submit records of equipment calibrations and certifications for all equipment used for surveying and tracking of the drill head. Procedures for operating the survey tools shall be described, including measures to verify the accuracy of the equipment readings.

J. Equipment Layout: The Contractor shall submit sketches depicting the layout and locations of equipment within the rig side work area and pipe side work area, including any proposed drilling fluid containment and recirculation pits. The Contractor shall confirm that all operations shall be completely contained within the temporary staging area shown on the Plans.

K. Surface Spill and Frac-Out Contingency Plan: The Contractor shall submit a Frac-Out and Surface Spill Contingency Plan describing procedures for preventing drilling fluid losses or spills into waterways or fluid returns to the surface as required by the Special Provisions. The plan shall address observations to be made and plans for containment and cleanup, if spills or hydrofracture occur. The plan shall also address changes that may be required to the Contractor's operations to avoid recurrences.

L. Rig Capacity: The Contractor shall submit details on the capacity of the drill rig verifying that the pullback and torque capacity are greater than the required pullback and torque determined by the Contractor.

M. Soil Separation Plant: The Contractor shall submit details on the pump and cleaning plant. Include dimensions, manufacturer's specifications, pump capacity, noise rating, and soundproofing details on the system.
   1. Pump capacity should be specified for water at sea level elevation, and adjusted for actual elevation and anticipated fluid viscosity.
   2. Provide details on the generator, including dimensions, noise ratings at 25 feet, and soundproofing. Confirm that the generator and other on-site equipment can be operated without exceeding the maximum allowable noise tolerances.

N. Radius of Curvature: The Contractor shall confirm that the bore can be completed as shown on the plans and that installation stresses shall not exceed allowable pipe stresses.

O. Plans for Disposal of Spoils and Drilling Fluids: The Contractor shall submit plans for disposal of waste materials resulting from the pipeline construction, including drilling fluids, cuttings, waste oil, fuel, discharge water, etc. The Contractor shall identify the disposal site and submit a letter indicating willingness and legal authority to accept the described and anticipated waste products.

P. Contact Grouting: The Contractor shall submit descriptions of methods, equipment, and materials to be used for contact grouting any areas where over-excavation, aborted bores, voids, or cavities are created or encountered.

Q. Contingency Plans for Potential Problems: The Contractor shall submit contingency plans for remediation of potential problems that may be encountered during the drilling operations. The contingency plans shall address the observations that would lead to the discovery of the problem and the methods that would be used to mitigate the problem. Potential problems that shall be addressed include:
   1. Obstructions encountered.
   2. Utility strike.
      a. Electrical.
      b. Fiber Optic.
      c. Gas.
      d. Water.
      e. Sewer.
   3. Inadvertent drilling fluid returns or spills to ground surface or water body.
   4. Loss of circulation.
   5. Deviation from planned bore path exceeds design tolerances.
   6. Inability to advance drill pipe.
   7. Drill pipe twisted off or broken off in borehole.
   8. Pipe collapses or pipe deformations exceed maximum allowable tolerances.
   9. Excessive ground settlement or heave.
   10. Damage to the existing Calabazas Creek concrete lined channel.

R. Protection of Adjacent Structures and Facilities: Provide details on measures to be taken to monitor and protect adjacent utilities, structures, and roadways, and provide details on monitoring equipment and provisions, including the layout of all settlement points and other monitoring points.

S. Provide pre-construction survey of adjacent structures and photographs with captions to document conditions prior to beginning HDD construction.

T. Safety Plan: The Contractor shall submit a Safety Plan, including the name of the Contractor's Site Safety Representative, emergency telephone numbers for medical facilities, and precautions for handling and disposal of any hazardous or flammable materials. The Safety Plan shall include a code of safe practices and an emergency plan in accordance with OSHA and CalOSHA requirements.

U. The following shall be submitted as construction progresses and at the completion of construction.
   1. Daily Logs and Records: The Contractor shall submit complete, legible, written daily logs and records as called for in Section 1.7.C of this specification and as directed by the Engineer, by noon of the following day to which the records correspond.
   2. Variations in Plan and Profile: The Contractor shall document any variations between the actual plan and profile of the bore path and the location shown on the plans. The Contractor shall notify the Engineer immediately upon discovery of any deviations.
   3. Mud Weights: The Contractor shall submit measured mud and/or drilling fluid weights used during pilot boring and reaming of the bore measured at a minimum of twice per shift or at least once per 300 feet of drilled or reamed length, whichever is more frequent.
   4. Submit maximum drilling and reaming rates for pilot bore and each reaming pass and confirm that pump capacity is adequate for these anticipated drilling rates for the soils anticipated, drilling fluid weights and viscosities anticipated.
   5. Pilot Bore As-Built Profile: The Contractor shall submit an as-built profile of the pilot bore within 24 hours of completion of the pilot bore.

1.07 QUALITY ASSURANCE

A. Contractor Qualifications and Experience: The Contractor shall have at least three (3) years of successful experience installing pipelines using the horizontal directional drilling process on at least five (5) projects with similar diameters, installation lengths, and ground and groundwater conditions. At least three (3) of the projects must include 16-inch outer diameter or larger pipeline installations. These projects shall include individual bore lengths of at least 300 feet under similar soil conditions. The Contractor shall demonstrate successful completion of at least three (3) projects where multiple HDPE pipes were installed in the same bore hole with horizontal directional drilling techniques. The Contractor shall furnish evidence of successful experience, including project owner, project name, location, diameter, length, depth, ground conditions, any problems encountered and how they were resolved, and any claims and how they were resolved. The Owner's representative with address and telephone number shall be provided.

B. Qualifications and Experience of Contractor Personnel: The Contractor shall employ skilled, experienced superintendent(s) and key personnel. The superintendent(s) and drill rig operator(s) shall have at least three (3) years of successful experience using the HDD process, on at least five (5) projects with similar diameters, pullback lengths, and ground conditions. The projects should include individual bores of at least 300 feet in length. The Contractor shall furnish resumes of the superintendent(s) and drill rig operator(s). Personnel experience records should include project names, locations, pullback lengths, ground conditions, pipe materials, project description, project owner, Engineer, and references with names, addresses, and telephone numbers. The superintendent and drill rig operator listed in the approved submittal shall be on site during all construction related activities required for the HDD installation.

C. Daily Logs and Records: Daily logs and records shall be maintained by the Contractor and shall include drilling lengths, location of drill head, drilling fluid pressures and flow rates, drilling fluid losses, inadvertent returns, drilling times required for each pipe joint, any instances of retraction and re-drilling of the pilot bore or segments thereof, and any other relevant observations, including any observed settlement, heave, frac-outs, or surface spills. The drilling fluid pressures shall be measured at the entry point and recorded at least once per drill pipe length. These records shall be maintained and provided daily to the Engineer. The position of the drill head shall be continuously tracked and recorded by a walkover or downhole wireline tracking locator system. A plot of actual locations of the bore path shall be maintained and updated daily, or more frequently, as directed by the Engineer.

D. Advance Notice and Inspections: The Contractor shall provide at least 72 hours advance written notice to the Engineer of the planned inception of major drilling activities, including pilot bore launch, pre-reaming, reaming, and pipe pullback. The Contractor shall immediately notify the Engineer, in writing, when any significant problems are encountered or if ground conditions are considered by the Contractor to be materially and significantly different than those represented within the Contract Documents. All work by the Contractor shall be performed in the presence of the Engineer, unless the Engineer grants prior written approval to perform such work in the Engineer's absence.

E. Surveying Equipment and Procedures: All surveying equipment used for downhole surveying and tracking of the bore path and drill head shall be inspected and calibrated by the equipment manufacturer prior to use. Proof of this inspection and calibration shall be provided to the Engineer prior to the commencement of drilling operations.

1.08 SEQUENCING AND SCHEDULING

A. Schedule horizontal directional drilling to avoid conflicts with tank construction, landscaping, final grading, and other construction activities.

PART 2 PRODUCTS

2.01 HDPE PIPE

A. As specified in Section 40_05_33.03.

B. The pipe thickness and dimension ratio (DR) must conform to the most conservative design with respect to design calculations for the critical combination of internal and external pressure, pullback, and bending.

1. The pipe wall thickness shall be the greater of what is required by the design calculations or as specified in the Pipe Schedule in Section 15052. Submit the actual internal diameter of the pipes to the Engineer for review with conformance to the hydraulic calculations.

2.02 WATER

A. The Contractor shall secure a suitable source of water, and shall be responsible for transporting, storing, and disposing of any water required.

2.03 DRILLING FLUIDS

A. The Contractor will provide Material Safety Data Sheets (MSDS) for all drilling fluids planned for use or on site. Drilling fluids shall be a mixture of water and bentonite, with mixture proportions selected by the Contractor to ensure borehole stability, reduce drag on the pipe, and completely fill the annular space between the bore and the pipe to control settlement. Management and disposal of drilling fluids shall be the Contractor’s responsibility.

2.04 DRILL RODS/DRILL STEM

A. The Contractor will provide high quality drill rods that the Contractor has inspected and determined are adequate for the project requirements. Bent, cracked, or fatigued drill stem will not be used. Threads must be in good condition. The lengths of drill rods should be measured and recorded.

2.05 DIRECTIONAL DRILLING EQUIPMENT

A. Drill Unit: The drill unit shall be a remote-steerable tunneling system that is designed specifically for use in the installation of gravity drainage pipelines and is capable of accurately drilling (true to line and grade) through the soils identified in the geotechnical report and in bedrock and in mixed bedrock and soil face conditions. The drilling system shall utilize a high-pressure, low-volume, liquid-assisted, mechanical excavation technology that is capable of installing pipelines of the diameter and length required in ground conditions as identified in the geotechnical report.

B. Electronic Detection System: The Contractor shall provide and use an electronic detection system that is capable of locating the position of the drilling head to an accuracy of one (1) inch, both horizontal and vertical, at a depth of up to ten (10) feet.

C. All drilling equipment shall have a permanent, inherent alarm system capable of detecting an electrical current. The equipment shall be grounded and shall be equipped with an audible alarm to warn the operator when the drill head nears electrified cable.

D. All crews shall be provided with grounded safety mats, heavy gauge ground cables with connectors, and hot boots and gloves.

PART 3 EXECUTION

3.01 GENERAL

A. The Contractor shall provide adequate control of surface water and drilling fluids drainage and runoff, and provide silt fences, hay bales, and wattles to prevent surface water or drilling fluids from entering storm drains, sewers, paved and landscaped areas, or waterways.

B. The Contractor shall not initiate HDD operations until all submittals are received, reviewed, and accepted by the Engineer.

C. The Contractor shall not initiate HDD operations until all required permits are obtained.

3.02 PROTECTION OF UNDERGROUND UTILITIES

A. The Contractor shall mark planned excavation bore path with white paint in accordance with California Law Government Code (section 4216.2).

B. At least 48 hours prior to excavation, but not more than 14 days prior to excavation, the Contractor shall notify Underground Service Alert (811) to request marking of utilities by utility owners/operators that subscribe to One Call, and shall individually notify all other known or suspected utilities to request marking of their utilities.

C. The Contractor shall confirm that all requested locates are made prior to commencing drilling operations.

D. Contractor shall make all diligent efforts to locate any unmarked or abandoned utilities using all available information, maps, and drawings. The Contractor shall visually confirm and stake all existing lines, cables, or other underground facilities including exposing all crossing utilities and utilities within ten (10) feet laterally of the designed drilled path.

E. The Contractor shall obtain and review "as-built" drawings of all crossing utilities and utilities within 10 feet laterally to avoid striking or damaging existing utilities.

F. The Contractor shall control drilling practices to prevent damage to existing utilities.

G. The Contractor shall be responsible for all losses and repairs occasioned by damage to underground utilities resulting from drilling operations that do not comply with the requirements established in the California One-Call Law and generally accepted good practices.

3.03 WORK STAGING AREA

A. Work Staging: The Contractor shall limit staging and Work operations to the areas shown on the Plans, or as otherwise accepted in writing by the Engineer, for storage of equipment and materials, parking, pipe layout, drilling, and other work.

B. Construction Impacts: The Contractor shall maintain the work area in a manner that shall minimize adverse impacts on other public use activities. The Contractor shall proceed with work in a safe, orderly manner, while maintaining the work site free of debris and unnecessary equipment and materials.

C. Control of Drilling Fluids: The Contractor shall follow all requirements of the Frac-Out and Surface Spill Contingency Plan and shall control operational pressures, drilling mud weights, drilling speeds, and any other operational factors required to avoid hydrofracture, fluid losses to formations, and control drilling fluid spillage. This includes any spillages or returns at entry and exit locations or at any intermediate point. All inadvertent returns or spills shall be promptly contained and cleaned up. The Contractor shall maintain on-site mobile spoil containment and removal equipment during all drilling, pre-reaming, reaming, and pullback operations and shall be capable of quickly removing spoils. The Contractor shall immediately notify the Engineer of any inadvertent returns or spills and immediately contain and clean up the return or spill.

D. Materials: Combustible materials (fuel, oil, lubricants, etc.) shall be stored off-site or in a well-ventilated storage facility removed from the immediate vicinity of the drilling area by at least twenty (20) feet.

E. Temporary Lighting: The Contractor shall procure and maintain all temporary lighting needed for Contractor's operations, safety, testing, and inspection. Temporary lighting shall be removed after completion of construction.

F. Barricades, Warning Signs, and Lights: The Contractor shall, in accordance with approved Traffic and Safety Plans, erect appropriate barriers, warning lights, and signs, painted with approved colors, warnings, and graphics to ensure adequate warning to personnel and the public.

G. Removal of Temporary Facilities: At the completion of construction, the Contractor shall remove all temporary facilities installed by the Contractor. Unused soil, aggregate, and other materials shall be removed and disposed of at approved sites in accordance with all Federal, State, and Local regulations. Any damage to streets, lawns, common areas, and sidewalks shall be restored to original or better conditions. All disturbed areas shall be re-vegetated.

3.04 MOBILIZATION

A. The Contractor shall mobilize all equipment, materials, and personnel necessary to install the HDPE pipe using the HDD process at the locations shown on the Plans.
   1. Entry and Exit Areas: The Contractor shall set up temporary workspace within the areas delineated on the Plans. Appropriate precautions and measures shall be employed by the Contractor to prevent erosion, surface drainage, and spillage of drilling fluids or other materials that could adversely impact the environmental quality of the site. The entry and exit area shall have drilling fluid pits for containing drilling fluids and cuttings. Containment and cleanup equipment shall be available to contain and clean up any surface spills and frac-outs. Silt fences, hay wattles, and hay bales shall be used to line the work area to minimize erosion and contain any spillages or runoff. Shovels, brooms, buckets, and barrels shall be kept on-site to facilitate containment and cleanup. A vacuum truck or trailer unit will be available on standby and capable of responding to any spill incident within one (1) hour.

2. Pipe Layout Area: Layout area shall be free of stones, wood, debris, and obstructions. Pipe rollers shall be provided by the Contractor as required to facilitate pipe pullback.

3.05 HORIZONTAL DIRECTIONAL DRILLING

A. Drill Rig Capacity: The capacity of the directional drilling system used by the Contractor shall be adequate to install the specified pipeline.

B. Pump Capacity: The pump used by the Contractor shall be adequate to supply the required flow rate and pressures at the anticipated drilling fluid viscosity at all times. Drilling speeds shall not exceed pump capacity.

C. Bore Tracking and Monitoring: At all times during the pilot bore the Contractor shall provide and maintain a bore tracking system that is capable of accurately locating the position of the drill head in the x, y, and z axes. The Contractor shall record these data at least once per drill pipe length or every fifteen (15) feet, whichever is more frequent.

1. Deviations between the recorded and design bore path shall be calculated and reported on the daily log. If the deviations exceed tolerances specified elsewhere, such occurrences shall be reported immediately to the Engineer. The Contractor shall undertake all necessary measures to correct deviations and return to design line and grade.
2. Drilling Speeds: Maximum allowable drilling speeds will be calculated for pilot boring and each reaming pass and shall not be exceeded for pilot boring or reaming passes. Position measurements shall be taken every thirty (30) feet or thirty (30) minutes, whichever is more frequent, and compared with maximum allowable drilling speeds.
3. Drilling Fluid Viscosity and Mud Weight: The Contractor shall measure and record drilling fluid viscosity and mud weights at least three (3) times per shift with at least two (2) hours between readings, using calibrated Marsh funnel and mud balance. These measurements shall be included in daily logs submitted to the Engineer. The Contractor shall document modifications to the drilling fluids, by noting the types and quantities of drilling fluid additives, dilutions or replacements and the dates and times of these actions. The reason for the addition of drilling fluid additives or other actions shall be documented and reported.

D. Location of Entry and Exit Points: The Contractor shall employ licensed, experienced surveyors to locate the entry and exit points, and to establish horizontal and vertical datum for the bore and the pipe layout and fabrication areas.

E. Entry and Exit Angles: Drill entrance and exit angles shall be in accordance with accepted good practices.

F. Pilot Bore: The pilot bore shall follow the design path of the bore shown on the Plans.

1. Horizontal and Vertical Tolerances: Horizontal and vertical deviations shall be less than plus or minus one (1) foot from the design path centerline. The Contractor shall continuously monitor horizontal and vertical position and record the position at least once per drill pipe length, or every fifteen (15) feet, whichever is most frequent.

2. Exit Tolerances: The Contractor shall be solely responsible for all work necessary to correct excessive deviations from line and grade at exit, including re-drilling, redesigning connections, and acquiring additional easement, at no additional cost to the Owner and without schedule extension.

G. Pre-reaming and Reaming: The pilot bore shall be pre-reamed and reamed using equipment and methods submitted by the Contractor. The Contractor shall completely ream the bore to the final diameter prior to pullback.

H. Pipe Pullback:
1. The two pipes for the double barreled siphons shall be installed by pulling them into the reamed bore path in a continuous operation, behind a final reaming tool selected by the Contractor.
2. The pipes shall be isolated from excessive torsional and axial stresses by a swivel device.
3. The Contractor shall cease operations if the pipes are damaged and shall remove the pipes from the bore and repair the pipes using the manufacturer's recommended procedure or replace the damaged pipes before resuming installation.
4. Damage to the pipes resulting before, during, or after installation, is the responsibility of the Contractor, including costs for replacement and labor and materials.

I. Obstructions: The Contractor shall notify the Engineer immediately in the event that any obstruction is encountered that prevents further advancement of the drill pipe, or pullback of the pre-reamer, reamer, and/or pipes. The Contractor shall make all diligent and reasonable efforts to advance past the object by drilling slowly through the object, pulling back and drilling along a new bore path that avoids the object, or excavating and exposing and removing the object, and all other reasonable attempts to continue the bore. The Contractor shall notify the Engineer of proposed measures to attempt to advance past the object, prior to initiating the attempt. If the Contractor attempts to pullback and re-drill, the Contractor shall adhere to line and grade tolerances established in this specification section, unless the Engineer approves variance, in writing, prior to the Contractor's attempt to re-drill. The Contractor and Engineer shall investigate the cause and together determine an appropriate response. Appropriate response may include revisions to equipment or methods, retraction and re-drilling of a portion of the bore, or abandonment of the hole. If abandonment is deemed necessary, the Contractor shall recover, to the extent practicable, any drill pipe, product pipe, and tools in the bore, and properly abandon the bore by contact grouting, unless otherwise directed in writing by the Engineer. If the bore is abandoned, the Contractor shall be allowed to begin a second attempt to install the pipeline at an alternate location subject to approval, in writing, by the Engineer. The Contractor shall take all reasonable actions to complete the installation with minimal delays. The extra costs and payments associated with encountering a confirmed obstruction shall be negotiated between the Owner and Contractor, based on reasonable time and materials.

J. Site Restoration and Demobilization: The Contractor shall remove all equipment, materials, drilling fluids, muck, waste, and debris from the site and restore the site to its original condition upon completion of the installation. Restoration and demobilization shall be completed by the Contractor within seven (7) days of the completion of the pipeline installation.

END OF SECTION

SECTION 40_05_00.01

COMMON WORK RESULTS FOR GENERAL PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic piping materials and methods.

B. Related sections:
1. Section 01_14_00 - Work Restrictions.
2. Section 01_33_00 - Submittal Procedures.
3. Section 01_75_17 - Commissioning.
4. Section 01_75_18 - Disinfection.
5. Section 01_78_36 - Warranties and Bonds.
6. Section 09_96_01 - High-Performance Coatings.
7. Section 40_05_00.09 - Piping Systems Testing.
8. Section 40_05_07.01 - Pipe Supports.
9. Section 40_05_07.03 - Preformed Channel Pipe Support System.
10. Section 40_05_19.01 - Ductile Iron Pipe : AWWA C151.
11. Section 40_05_31.01 - Plastic Piping and Tubing.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 Through 24.
2. B16.47 - Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard.

B. American Water Work Association (AWWA):
1. C105 – Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems.
2. C207 - Standard for Steel Pipe Flanges for Waterworks Services-Size 4 In. Through 144 In.

C. ASTM International (ASTM):
1. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
2. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
3. A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
4. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
5. F37 - Standard Test Methods for Sealability of Gasket Materials.

D. California Health and Safety Code.

E. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.
2. 372 - Drinking Water System Components - Lead Content.

1.03 DEFINITIONS

A. Buried pipe: Pipe that is buried in the soil, or cast in a concrete pipe encasement that is buried in the soil.

B. Exposed pipe: Pipe that is located above ground, or pipe that is located inside a structure, supported by a structure, or cast into a concrete structure.

C. Underground piping: Piping actually buried in soil or cast in concrete that is buried in soil.

D. Underwater piping: Piping below tops of walls in basins or tanks containing water.

E. Wet wall: Wall with water on at least 1 side.

1.04 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data:
   1. For each piping product in this Section as applicable:
      a. Design features.
      b. Load capacities.
      c. Material designations by UNS alloy number or ASTM Specification and Grade.
      d. Data needed to verify compliance with the Specifications.
      e. Catalog data.
      f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

C. Calculations:
   1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.

1.05 WARRANTY

A. Provide warranty as specified in Section 01_78_36.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01_60_00.

B. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

2.02 ESCUTCHEONS

A. Material: Chrome-plated steel plate.

B. Manufacturers: One of the following or equal:
   1. Dearborn Brass Company, Model Number 5358.

2. Keeney Manufacturing Company, Model Number 102 or Number 105.

2.03 LINK TYPE SEALS

A. Characteristics:
   1. Modular mechanical type, consisting of interlocking neoprene or synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
   2. Assemble links solely with stainless steel bolts and nuts to form a continuous rubber belt around the pipe.
   3. Provide a nylon polymer pressure plate with Type 316 stainless steel hardware. Isolate pressure plate from contact with wall sleeve.

B. Manufacturers: One of the following or equal:
   1. Calpico, Incorporated.
   2. Pipeline Seal and Insulator, Inc., Link-Seal.

2.04 FLANGE BOLTS

A. Ductile iron pipe:
   1. Bolts and nuts for ductile iron pipe flanges located indoors, outdoors above ground, or in dry vaults and structures and where pressures do not exceed 150 pounds per square inch shall be hot-dip galvanized carbon steel, ASTM A307, Grade B A 563 - Standard Specification for Carbon and Alloy Steel Nuts.
   2. Bolts and nuts for ductile iron pipe flanges located indoors, outdoors above ground, or in dry vaults and structures where the pressures exceed 150 pounds per square inch shall be alloy steel, ASTM A193, Grade B7 for bolts and in accordance with ASTM A194, Grade 2H for nuts.
   3. Bolts and nuts for ductile iron pipe flanges submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures shall be Type 316 stainless steel in accordance with ASTM A193, Grade B8M for bolts and in accordance with ASTM A194, Grade 8M for nuts.
   4. Bolts and nuts for buried ductile iron pipe flanges shall be Type 316 stainless steel in accordance with ASTM A193, Grade B8M for bolts and in accordance with ASTM A194, Grade 8M for nuts.
   5. Provide a washer for each nut. Washer shall be of the same material as the nut.
   6. Nuts shall be Heavy hex-head.
   7. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
   8. Tap holes for cap screws or stud bolts when used.

B. Plastic pipe:
   1. Bolts and nuts for flanges on plastic pipe located indoors, outdoors above ground, or in dry vaults and structures shall be hot-dip galvanized carbon steel, in accordance with ASTM A307, Grade B for bolts and in accordance with ASTM A563, Grade A for nuts.
   2. Bolts and nuts for flanges on plastic pipe submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures and plastic pipe carrying corrosive chemicals shall be

Type 316 stainless steel in accordance with ASTM A193, Grade B8M for bolts and in accordance with ASTM A194, Grade 8M for nuts.

3. Provide a washer for each nut. Washer shall be of the same material as the nut.
4. Nuts shall be Heavy hex-head.
5. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
6. Tap holes for cap screws or stud bolts when used.

C. Lubricant for stainless steel bolts and nuts:
   1. Chloride-free.
   2. Manufacturers: One of the following or equal:
      a. Huskey FG-1800.

2.05 GASKETS

A. Gaskets for non-steam cleaned ductile iron and steel piping:
   1. Suitable for pressures equal and less than 150 pounds per square inch gauge, temperatures equal and less than 250 degrees Fahrenheit.
   2. Gasket material:
      a. Neoprene elastomer with minimum Shore A hardness value of 70.
      b. Reinforcement: Inserted 13-ounce nylon fabric cloth for pipes 20 inch or larger.
      c. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe; minimum 1/8 inch thick for 10-inch and larger pipe.
   3. Manufacturers: One of the following or equal:
      a. Pipe less than 20 inches in diameter:
         1) Garlock, Style 7797.
         2) John Crane, similar product.
      b. Pipe 20 inches in diameter and larger:
         1) Garlock, Style 8798.
         2) John Crane, similar product.

B. Gaskets for non-steam cleaned grooved end ductile iron:
   1. Suitable for pressures equal to the encapsulating coupling or flange adapter.
   2. Material: Pressure responsive elastomer.
      a. Ductile iron piping: FlushSeal® type.
         1) Halogenated Butyl: Grade M; for temperatures to 200 degrees Fahrenheit.
         2) Nitrile: Grade S; for temperatures to 180 degrees Fahrenheit.
   3. Gaskets shall be verified as suitable for the intended service.
      a. Temperature ratings may vary depending on the fluid/media.
   4. Manufacturers: Gaskets shall be of the same manufacturer as the encapsulating couplings/flange adapters.
      a. Victaulic Company.

C. Gaskets for flanged joints in polyvinyl chloride and polyethylene piping:
   1. Suitable for pressures equal and less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal and less than 120 degrees Fahrenheit, and polymer, chlorine, caustic solutions, and other chemicals, except chemicals which liberate free fluorine including fluorochemicals and gaseous fluorine.

2. Material: 0.125-inch thick Viton rubber.
3. Manufacturers: One of the following or equal:
    a. Garlock.
    b. John Crane, similar product.

D. Gaskets for flanged joints in ductile iron drinking water piping meeting NSF requirements:
1. Suitable for hot or cold water, pressures equal to or less than 150 pounds per square inch gauge, and temperatures equal to or less than 160 degrees Fahrenheit.
2. Material:
    a. PTFE material with glass microsphere filler.
3. Manufacturers: One of the following or equal:
    a. Garlock, GYLON ® Style 3505.
    b. John Crane, similar product.

E. Provide gaskets suitable for the specific fluids and pressure and temperature conditions.

2.06 LEAD LIMITS

A. Comply with NSF 372.

B. Pipe, pipe or plumbing fittings or fixtures, solder, or flux used to convey water for human consumption shall be Lead-free as defined in Section 116875 of the California Health and Safety Code.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Piping drawings:
    a. Except in details, piping is indicated diagrammatically. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
    b. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed.
        1) Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.
2. Piping alternatives:
    a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.
    b. Alternative pipe ratings:
        1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
        2) Piping of different material may not be substituted in lieu of specified piping.

c. Valves in piping sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.
d. For grooved joints, use couplings, flange adapters, and fittings of the same manufacturer.
   1) The grooved joint manufacturer's factory trained representative shall provide on-site training for Contractor's field personnel.
   2) The representative shall periodically visit the jobsite and review Contractor is following best recommended practices in grooved product installation.
   3) A distributor's representative is not considered qualified to conduct the training or jobsite visit(s).
e. For flanged joints, where 1 of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.

3. Unless otherwise indicated on the Drawings, piping at pipe joints, fittings, couplings, and equipment shall be installed without rotation, angular deflection, vertical offset, or horizontal offset.

B. Wall and slab penetrations:
1. Provide sleeves for piping penetrations through aboveground masonry and concrete walls, floors, ceilings, roofs, unless specified or otherwise indicated on the Drawings.
2. For piping 1 inch in nominal diameter and larger, provide sleeves with minimum inside diameters of 1 inch plus outside diameter of piping. For piping smaller than 1 inch in nominal diameter, provide sleeve of minimum twice the outside diameter of piping.
   a. Arrange sleeves and adjacent joints so piping can be pulled out of sleeves and replaced without disturbing the structure.
   b. Cut ends of sleeves flush with surfaces of concrete, masonry, or plaster.
   c. Conceal ends of sleeves with escutcheons where piping runs through floors, walls, or ceilings of finished spaces within buildings.
   d. Seal spaces between pipes and sleeves with link-type seals when not otherwise specified or indicated on the Drawings.
   e. Seal openings around piping running through interior walls and floors of chlorine rooms and chlorine storage rooms gastight with synthetic rubber sealing compound.
3. Provide flexibility in piping connecting to structures to accommodate movement due to soil settlement and earthquakes. Provide flexibility using details indicated on the Drawings.
4. Core drilled openings:
   a. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by Engineer.
   b. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device.
   c. Remove dust and debris from hole using compressed air.

C. Exposed piping:
1. Install exposed piping in straight runs parallel to the axes of structures, unless otherwise indicated on the Drawings:
   a. Install piping runs plumb and level, unless otherwise indicated on the Drawings.
      1) Slope plumbing drain piping with a minimum of 1/4 inch per foot downward in the direction of flow.
      2) Slope digester gas piping to drip traps or low-point drains at a minimum of 1/2 inch per foot where condensate flows against the gas, or at a minimum of 1/4 inch per foot where condensate flows with gas.
2. Install exposed piping after installing equipment and after piping and fitting locations have been determined.
3. Support piping: As specified in Sections 40_05_07.01 and 40_05_07.03:
   a. Do not transfer pipe loads and strain to equipment.
4. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.
5. Assemble piping without distortion or stresses caused by misalignment:
   a. Match and properly orient flanges, unions, flexible couplings, and other connections.
   b. Do not subject piping to bending or other undue stresses when fitting piping.
   c. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
   d. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
   e. Alter piping assembly to fit, when proper fit is not obtained.
   f. Install eccentric reducers or increasers with the top horizontal for pump suction piping.

D. Buried piping:
1. Bury piping with minimum 3-foot cover without air traps, unless otherwise indicated on the Drawings.
2. Where 2 similar services run parallel to each other, piping for such services may be laid in the same trench.
   a. Lay piping with sufficient room for assembly and disassembly of joints, for thrust blocks, for other structures, and to meet separation requirements of public health authorities having jurisdiction.
3. Laying piping:
   a. Lay piping in finished trenches free from water or debris. Begin at the lowest point with bell ends up slope.
   b. Place piping with top or bottom markings with markings in proper position.
   c. Lay piping on an unyielding foundation with uniform bearing under the full length of barrels.
   d. Where joints require external grouting, banding, or pointing, provide space under and immediately in front of the bell end of each section laid with sufficient shape and size for grouting, banding, or pointing of joints.
   e. At the end of each day's construction, plug open ends of piping temporarily to prevent entrance of debris or animals.
4. Concrete encase all buried pipe installed under concrete slabs or structures.

E. Venting piping under pressure:
   1. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
   2. Install plug valves as air bleeder cocks at high points in piping.
      a. Provide 1-inch plug valves for water lines, and 2-inch plug valves for sewage and sludge lines, unless otherwise indicated on the Drawings.
   3. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling, disinfecting, and sampling.
   4. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion in as specified in Section 09_96_01.

F. Restraining piping:
   1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
      a. When piping is underground, use concrete thrust blocks, mechanical restraints, or push-on restraints.
      b. When piping is aboveground or underwater, use mechanical or structural restraints.
      c. Determine thrust forces by multiplying the nominal cross sectional area of the piping by design test pressure of the piping.
   2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
      a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
   3. Place concrete thrust blocks against undisturbed soil.
   4. Place concrete so piping joints, fittings, and other appurtenances are accessible for assembly and disassembly.
   5. Provide underground mechanical restraints where specified in the Piping Schedule.

G. Connections to existing piping:
   1. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings:
      a. Protect domestic water/potable water supplies from contamination:
         1) Make connections between domestic water supply and other water systems in accordance with requirements of public health authorities.
         2) Provide devices approved by Owner of domestic water supply system to prevent flow from other sources into the domestic supply system.
   2. Make connections to existing piping and valves after sections of new piping to be connected have been tested and found satisfactory.
   3. Provide sleeves, flanges, nipples, couplings, adapters, and other fittings needed to install or attach new fittings to existing piping and to make connections to existing piping.
   4. For flanged connections, provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

H. Connections to in-service piping:
   1. As specified in Section 01_14_00.

I. Connections between ferrous and nonferrous metals:
   1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings especially designed for the prevention of chemical reactions between dissimilar metals.
   2. Nonferrous metals include aluminum, copper, and copper alloys.

J. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
   1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

3.02 CLEANING

A. Piping cleaning:
   1. Upon completion of installation, clean piping interior of foreign matter and debris.
   2. Perform special cleaning when required by the Contract Documents.

B. Cleaning potable water piping:
   1. Flush and disinfect potable water piping as specified in Section 01_75_18.

C. Cleaning chlorine piping:
   1. Clean chlorine piping by pulling clean cloths saturated an approved solvent through piping:
      a. Do not use hydrocarbons or alcohols that may react with chlorine.
      b. Use solvents in accordance with manufacturer's safety recommendations to avoid serious physiological effects.
   2. Disassemble and clean valves and equipment that have oil residues before installation.
   3. Dry piping immediately before effecting final connections for service.
      a. Keep piping kept sealed to prevent moisture from entering chlorine piping.
      b. Drying procedure shall be as follows:
         1) Pass steam through piping from the high end until piping is thoroughly heated. While steaming, allow condensate and foreign matter to drain out.
         2) Stop steaming and drain pockets and low points.
         3) While piping is hot, blow dry air through piping until piping is dry.
            a) Use dry air with a dew point of minus 40 degrees Fahrenheit or below.
         4) Continue blowing dry air through piping until exhausted air has a dew point of minus 30 degrees Fahrenheit or below.
         5) Allow several hours for drying piping.

3.03 COMMISSIONING

A. As specified in Section 01_75_17 and this Section.

B. Functional testing:
   1. Piping system:
      a. Witnessed.
      b. Conduct pressure and leak test, as specified.

3.04 PIPING SCHEDULE

PIPING SCHEDULE											
Process Abbrev.	**Service**	**Nominal Diameter (inches)**	**Material**	**Pressure Class Special Thickness Class Schedule Wall Thickness**	**Pipe Spec. Section**	**Joints/ Fittings**	**Test Pressure/ Method**	**Lining**	**Coating**	**Service Conditions**	**Comments**
D	Drain										
	Underground	1-3	PVC	SCH 80	40_05_31.01	SW	200 v/HH	None	None		
	Underground	4-6	DIP	150	40_05_19.01	Mech Rest. MJ Rest. B&SP	200 psig/HH	CM	2 layers PEE		
	Aboveground	0.5-6	GSP	SCH 40		SCRD	15 feet/GR	None	EPP		
OF	Overflow	4-18	DIP	CL 53	40_05_19.01	FL	15 feet/GR	GL	EPP		
SD	Storm Drain										
	Underground	4-15	PVC	SDR 26	40_05_31.01	B&SP	5 psig/AM	None	None		
	Underground	18	PVC	PS 115	40_05_31.01	B&SP	5 psig/AM	None	None		
	Horizontal Directional Drill	18	HDPE	SDR 9	40_05_33.03		5 psig/AM	None	None		
SS	Sanitary Sewer										
	Underground	6	PVC	SDR 26	40_05_31.01	B&SP	5 psig/AM	None	None		
PW	Potable Water										
	Underground	1-3	PVC	SCH 80	40_05_31.01	SW	200 v/HH	None	None		
		4-18	DIP	150	40_05_19.01	Mech Rest. MJ Rest. B&SP	200 psig/HH	CM	2 layers PEE		

PIPING SCHEDULE											
Process Abbrev.	**Service**	**Nominal Diameter (inches)**	**Material**	**Pressure Class Special Thickness Class Schedule Wall Thickness**	**Pipe Spec. Section**	**Joints/ Fittings**	**Test Pressure/ Method**	**Lining**	**Coating**	**Service Conditions**	**Comments**
	Aboveground	0.5-3	PVC	SCH 80	40_05_31.01	SW	200 psig /HH	None	EPP		
		4-18	DIP	CL 53	40_05_19.01	FL	200 psig /HH	CM	EPP		

Abbreviations:

1. The following abbreviations used in the column of test method refer to the respective methods as specified in Section 40_05_00.09.
   - AM Air method
   - GR Gravity method
   - HH High head method
   - LH Low head method
   - SC Special case
2. Abbreviations to designate piping include the following:
   - B&SP Bell and spigot
   - CI Cast iron
   - CISP Cast iron soil pipe
   - CL Class, followed by the designation
   - CM Cement mortar
   - CTP Coal tar pitch
   - DIP Ductile iron piping
   - EPP Epoxy polyurethane coating
   - FL Flange
   - GA Gauge, preceded by the designation
   - GE Grooved end joint
   - GL Glass lined
   - GSP Galvanized steel pipe
   - MJ Mechanical joint
   - NPS Nominal pipe size, followed by the number in inches
   - psi pounds per square inch
   - psig pounds per square inch gauge
   - PE Polyethylene
   - PEE Polyethylene encasement
   - PTW Polyethylene tape wrap
   - PVC Polyvinyl Chloride
   - SCH Schedule, followed by the designation
   - SCRD Screwed-On
   - SST Stainless steel
   - SW Solvent welded
   - VCP Vitrified clay piping
   - WLD Weld

END OF SECTION

SECTION 40_05_00.03

PIPE IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pipe identification including the following:
   1. Pipe identification by color and legend.
   2. Underground warning tape.
   3. Tracer wire.
   4. Valve identification.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01_33_00 - Submittal Procedures.
      b. Section 01_60_00 - Product Requirements.
      c. Section 01_77_00 - Closeout Procedures.
      d. Section 09_96_01 - High-Performance Coatings.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. A13.1 - Scheme for the Identification of Piping Systems.

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Submit following:
   1. Product data.
   2. Samples.
   3. Manufacturer's installation instructions.
   4. Submit following as specified in Section 01_77_00:
      a. Operation and Maintenance Data.
      b. Warranty.

PART 2 PRODUCTS

2.01 ABOVE GROUND AND IN-CHASE PIPE IDENTIFICATION

A. Manufacturers:
   1. One of the following or equal:
      a. Seton, Opti Code Pipe Markers.
      b. Lab Safety Supply.
      c. Marking Services, Inc.

B. Materials:
   1. Pipe markers: Self-adhesive vinyl, suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; in accordance with ASME A13.1 requirements.
      a. Lettering:

Nominal Pipe Diameter	Lettering Size
Less than 1.5	1/2 inch
1.5 inches to 2 inches	3/4 inch
2.5 inches to 6 inches	1-1/4 inches
8 inches to 10 inches	2-1/2 inches
Over 10 inches	3-1/2 inches

      b. Marker colors:

Service	Lettering	Background
Flammables, chemicals, toxics	Black	Yellow
Water, nontoxic solutions or low hazard liquids	White	Green

   2. Coating: As specified in Section 09_96_01.
   3. Pipe identification tags: Aluminum or stainless steel with stamped-in 1/4 inch high identifying lettering.
   4. Pipe identification tag chains: Aluminum or stainless steel.
   5. Snap-on markers: Markers with 3/4 inch high letters for 3/4 to 4 inch pipe or covering, or 5 inch high letters for 5 inch or larger pipe or cover, as manufactured by one of following:
      a. Brady Bradysnap-On B-915.
      b. Seton Setmark.

2.02 BURIED PIPELINE IDENTIFICATION

A. Underground warning tape:
   1. Manufacturer: One of the following or equal:
      a. Seton Name Plate Company, Branford, CT.
      b. T. Christy Enterprises, Inc.
   2. Material:
      a. Polyethylene tape for prolonged underground use.
      b. Minimum tape thickness: 4 mils.
      c. Overall tape width: 6 inches.

d. Message: “CAUTION” with the name of the service followed by “LINE BURIED BELOW.” in black lettering on colored background in accordance with approved APWA colors.
   1) Water: Blue.
   2) Sewer: Green.
   3) Telephone: Orange.
   4) Gas and other services: Yellow.

B. Tracer wire:
   1. Manufacturers: One of the following or equal:
      a. Kris-Tech Wire.
      b. Corrpro.
   2. Materials: One of the following or equal:
      a. Solid copper conductor with 30 mil HMWPE.
      b. 10 gauge or thicker wire.
      c. Match insulation color to the color of the pipe being installed.

2.03 VALVE IDENTIFICATION

A. The Contractor shall furnish and install tags for all valves and gates required for the Work.
   1. Tags shall be 2-in diameter round, stainless steel, or PVC for buried applications.
   2. Tags shall be furnished with a non-corrosive metal wire suitable for attaching the tag to the operator base.
   3. Tags shall be stamped in 1/4-inch high letter
      a. Tags shall not be attached in such a way as to inhibit the operation of the valve or gate.
   4. Buried valve tags shall be secured to concrete s with the specified valve or gate number.
   5. Submit 2 samples of the type of tag proposed and the manufacturer’s standard color chart and letter styles to the Engineer for review.
   6. Manufacturer: The following or equal:
      a. Seton Name Plate Company, Branford, CT.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01_60_00.

3.02 PREPARATION

A. Prepare and coat surfaces as specified in Section 09_96_01.

B. Prepare surface in accordance with product manufacturer's instructions.

3.03 ABOVE GROUND AND IN-CHASE PIPING IDENTIFICATION

A. Identify exposed piping, valves, and accessories, and piping, valves, and accessories in accessible chases with lettering or tags designating service of each piping system with flow directional arrows and color code.

B. Color code:
   1. Paint all piping with colors as scheduled in Piping Color Code and Marker Schedule.

C. Lettering and flow direction arrows:
   1. Stencil lettering on painted bands or use snap-on markers on pipe to identify pipe. When stenciling, stencil 3/4 inch high letters on 3/4 through 4-inch pipe or coverings, or 5-inch high letters on 5-inch and larger pipe or coverings.
   2. Provide lettering and flow direction arrows near equipment served, adjacent to valves, both sides of walls and floors where pipe passes through, at each branch or tee, and at intervals of not more than 50 feet in straight runs of pipe.

D. Where scheduled, space 6-inch wide bands along stainless steel pipe at 10-foot intervals and other pipe at 5-foot intervals.

E. Label chemical tank fill pipelines at locations which are visible from chemical fill stations.

F. Metal tags:
   1. Where outside diameter of pipe or pipe covering is 5/8-inch or smaller, provide metal pipe identification tags instead of lettering.
   2. Fasten pipe identification tags to pipe with chain.
   3. Where tags are used, color code pipe as scheduled.

3.04 BURIED PIPING IDENTIFICATION

A. Underground warning tape:
   1. Place continuous run of warning tape in pipe trench, 12 inches above the pipe.

B. Tracer wire:
   1. Install on all non-metallic pipe.
   2. Install an electrically continuous run of tracer wire along the entire length of the pipe with wire terminations in valve boxes, vaults, or structures.
   3. Install tracer wire on top of the pipe and secure to pipe with tape a minimum of every 10 feet.
   4. Where approved by the Engineer, splice sections of wire together using approved direct bury wire nuts.
      a. Twisting the wires together is not acceptable.

3.05 APPLICATION

A. Identify piping with legend markers, directional arrow markers, and number markers; use self-adhesive arrow roll tape to secure ends of piping markers and indicate flow direction.

B. Provide legend markers, directional arrow markers, and number markers where piping passes through walls or floors, at piping intersections and at maximum 15 foot spacing on piping runs.

C. Provide piping marker letters and colors as scheduled.

D. Place markers on piping so they are visible from operator's position in walkway or working platform near piping. Locate markers along horizontal centerline of pipe, unless better visibility is achieved elsewhere.

3.06 PIPING COLOR CODE AND MARKER SCHEDULE

Service Fluid	Pipe Color	Marker Legend
Chemical Drain	Charcoal	CHEMICAL DRAIN
Drain	Charcoal	DRAIN
Sample	Green	FLUID BEING SAMPLED
Sanitary Drain	Charcoal	SANITARY DRAIN
Sodium Hypochlorite	Yellow	CHLORINE SOLUTION
Tank Drain	Charcoal	TANK DRAIN
Vent Pipe	Yellow	VENT PIPE

Letters	Color of Pipe	Color of Bands	Color of Letters
Finished or Potable (cold)	Light blue	None	Black
Service Water (lines downstream from backflow prevention unit	Dark Blue	White	Red
Sample	Dark Blue	Black	White
Drain	Dark Gray	None	White

END OF SECTION

SECTION 40_05_00.09

PIPING SYSTEMS TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Test requirements for piping systems.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01_33_00 - Submittal Procedures.
      b. Section 01_41_00 - Regulatory Requirements.
      c. Section 01_50_00 - Temporary Facilities and Controls.
      d. Section 40_05_00.01 - Common Work Results for General Piping.

1.02 REFERENCES

A. National Fuel Gas Code (NFGC).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.3 - Process Piping.
   3. B31.8 - Gas Transmission and Distribution Piping Systems.

C. Underwriters Laboratories Inc. (UL).

1.03 TESTING REQUIREMENTS

A. General requirements:
   1. Testing requirements are stipulated in Laws and Regulations; are included in the Piping Schedule in Section 40_05_00.01; are specified in the specifications covering the various types of piping; and are specified in this Section.
   2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
   3. Test plumbing piping in accordance with Laws and Regulations, the plumbing code, as specified in Section 01_41_00, and UL requirements.

B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.

C. Water for testing, cleaning, and disinfecting:
   1. Water for testing, cleaning, and disinfecting will be provided as specified in Section 01_50_00.

D. Pipes to be tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.

E. Unsuccessful tests:
   1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
   2. Repeat testing until tests are successful.

F. Test completion: Drain and leave piping clean after successful testing.

G. Test water disposal:
   1. Dispose of testing water at the J Street site at the storm drain basin northeast of the site. Temporary piping can be run through a hole that has been provided in the CMU wall behind Dollar General. Testing water shall be disposed in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site.
   2. Dispose of testing water at the Alpine Vista site at the storm drain south of the site in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site.

1.04 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Schedule and notification of tests:
   1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
   2. Notification of readiness to test: Immediately before testing, notify Engineer in writing of readiness, not just intention, to test piping.
   3. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

1.05 SEQUENCE

A. Clean piping before pressure or leak tests.

B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.

C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.

D. Backfill and compact trench, or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.

E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 TESTING ALIGNMENT, GRADE, AND DEFLECTION

A. Alignment and grade:
   1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
   2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.

B. Deflection test:
   1. Pull a mandrel through the clean piping section under test.
   2. Perform the test not sooner than 30 days after installation and not later than 60 days after installation.
   3. Use a 9-rod mandrel with a contact length of not less than the nominal diameter of the pipe within 1 percent plus or minus.
   4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by 1 person, without the aid of mechanical equipment.

3.02 AIR TESTING METHOD FOR PRESSURE PIPING

A. Air test piping, indicated with "AM" in the Piping Schedule, with air or another nonflammable or inert gas.

B. Test liquid chlorine piping by the air test method:
   1. Test chlorine piping with dry air or nitrogen having a dew point of minus 40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.

C. Test at pressure as specified in Piping Schedule in Section 40_05_00.01:
   1. Provide temporary pressure relief valve for piping under test:
      a. Set at the lesser of 110 percent of the test pressure or 50 pounds per square inch gauge over the test pressure.
   2. Air method test pressures shall not exceed 110 percent of the piping maximum allowable working pressure calculated in accordance with the most stringent of ASME B31.1, ASME B31.3, ASE B31.8, or the pipe manufacturer's stated maximum working pressure.
   3. Gradually increase test pressure to an initial test pressure equal to the lesser of 1/2 the test pressure or 25 pounds per square inch gauge.
   4. Perform initial check of joints and fittings for leakage.

5. Gradually increase test pressure in steps no larger than the initial pressure. Check for leakage at each step increase until test pressure reached.
6. At each step in the pressure, examine and test piping being air tested for leaks with soap solution.
7. Consider examination complete when piping section under test holds the test pressure for 15 minutes without losses.

3.03 TESTING GRAVITY FLOW PIPING

A. Test gravity flow piping indicated with "GR" in the Piping Schedule, as follows:
   1. Unless specified otherwise, subject gravity flow piping to the following tests:
      a. Alignment and grade.
      b. For plastic piping test for deflection.
      c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
   2. Inspect piping for visible leaks before backfilling.
   3. Provide temporary restraints when needed to prevent movement of piping.
   4. Pressure test piping with maximum leakage allowance after backfilling.
   5. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours:
      a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
      b. Maintain piping with water, or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
      c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of 4 hours while accurately measuring the volume of water added to maintain the test pressure:
         1) For polyvinyl chloride (PVC) gravity sewer pipe: 25 gallons per day per inch diameter per mile of piping under test:
            a) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
               (1) For concrete piping with rubber gasket joints: 80 gallons per day per inch of diameter per mile of piping under test:
                   (a) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
               (2) For vitrified claypiping: 500 gallons per day per inch of diameter per mile of piping under test.
               (3) For other piping: 80 gallons per day per inch diameter per mile of piping under test.

3.04 TESTING HIGH-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure in the Piping Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated "HH" in the Piping Schedule.

B. General:
   1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.
   2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
   3. Do not include valves, equipment, or piping specialties in test sections if test pressure exceeds the valve, equipment, or piping specialty safe test pressure allowed by the item's manufacturer.
   4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
   5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
   6. When test results indicate failure of selected sections, limit tests to piping:
      a. Between valves.
      b. Between a valve and the end of the piping.
      c. Less than 500 feet long.
   7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Testing procedures:
   1. Fill piping section under test slowly with water while venting air:
      a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
   2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.
   3. Raise pressure to the specified test pressure and inspect piping visually for leaks:
      a. Consider visible leakage testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
   1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
   2. Pressure test piping after completion of visible leaks test.
   3. For piping systems using joint designs other than flanged, threaded, or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
      a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
      b. Successful completion of the pressure test with maximum leakage allowance shall have been achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.
      c. When leakage is allowed, calculate the allowable leakage by the following formula: $L = S \times D \times P^{1/2} \times 133{,}200^{-1}$ – wherein the terms shall mean:

         L = Allowable leakage in gallons per hour.

         S = Length of the test section in feet.

D = Nominal diameter of the piping in inches.

P = Average observed test pressure in pounds per square inches gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

x = The multiplication symbol.

3.05 TESTING LOW-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated "LH" in the Piping Schedule.

B. General:
   1. Test pressures shall be as scheduled in Section 40_05_00.01.
   2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
   3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
   4. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Visible leaks test:
   1. Subject piping under test to the specified pressure measured at the lowest end.
   2. Fill piping section under test slowly with water while venting air:
      a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
   3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
   4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
   1. Pressure test piping after completion of visible leaks test.
   2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
      a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test after 24 hours, and no damage to piping and appurtenances has occurred.
      b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

E. Optional joint test:
   1. When joint testing is allowed by note in the Piping Schedule, the procedure shall be as follows:
      a. Joint testing will be allowed only for low head pressure piping.

b. Joint testing does not replace and is not in lieu of any testing of the piping system or trust restraints.

2. Joint testing may be performed with water or air.
3. Joint test piping after completion of backfill and compaction to the top of the trench.
4. Joint testing with water:
   a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
   b. Maintain test pressure for 1 minute.
   c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
   d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
   e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.
5. Joint testing with air:
   a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
   b. Maintain test pressure for 2 minutes.
   c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION

SECTION 40_05_06.01

PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Piping specialties including:
   1. Slip type expansion joints.
   2. Rubber expansion joints.
   3. Transition fittings.
   4. Sight glasses.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_60_00 - Product Requirements.
   3. Section 01_75_17 - Commissioning.
   4. Section 01_78_36 - Warranties and Bonds.
   5. Section 40_05_00.01 - Common Work Results for General Piping.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24.

B. American Water Works Association (AWWA):
   1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   2. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.

C. ASTM International (ASTM):
   1. A148 - Standard Specification for Steel Castings, High-Strength, for Structural Purposes.
   2. A536 - Standard Specification for Ductile Iron Castings.

D. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects, Includes Errata.
   2. 372 - Drinking Water System Components - Lead Content.

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data:
   1. For each piping product in this Section as applicable:
      a. Design features.
      b. Load capacities.
      c. Material designations by UNS alloy number or ASTM Specification and Grade.
      d. Data needed to verify compliance with the Specifications.
      e. Catalog data.

f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

C. Calculations:
 1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.

D. Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17:
 1. Provide as specified in this Section.

1.04 WARRANTY

A. Provide warranty as specified in Section 01_78_36.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01_60_00.

B. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

2.02 SLIP TYPE EXPANSION JOINTS

A. PVC expansion joints:
 1. Flexible bellows type with equalizing rings.
 2. Manufacturers: One of the following or equal:
  a. Flo Control, Flo-Span.
  b. Chemtrol.
 3. Materials: PVC with EPDM O-ring.
 4. Design:
  a. 150 pound per square inch pressure rating.
  b. Double O-ring seal.
  c. Axial travel: Not less than 1.5 inches.
  d. Ends: 150 pound ASME flanges, or plain end suitable for solvent welding connections.

2.03 RUBBER EXPANSION JOINTS

A. Manufacturers: One of the following or equal:
 1. Mercer Rubber Company, Style 500 or 700.
 2. Red Valve Company, Inc., Type J-1.

B. Provide rubber expansion joints complete with control units and split retaining rings.

C. Design:
 1. Material: Neoprene rubber, reinforced with embedded steel rings, and a strong synthetic fabric.

2. Expansion rings, suitable for pressures of at least 125 pounds per square inch gauge, except as follows:
   a. Expansion joints in pump suction piping and where indicated on the Drawings suitable for minimum 90 pounds per square inch gauge pressure, and minimum 30 inches mercury vacuum.
   b. Split retaining rings, galvanized.
   c. Ends of expansion joints, 150 pound ASME flanges with drilling to match that of the piping.

D. Rubber expansion joints for blowers: Butyl type rubber formulated for service application and for maximum temperature of 250 degrees Fahrenheit, suitable for minimum 40 pounds per square inch gauge pressure, and minimum 15 inches mercury vacuum.

2.04 TRANSITION FITTINGS

A. Manufacturers: One of the following or equal:
   1. Spears.

B. Materials:
   1. Slip socket: Schedule 80 PVC.
   2. Collar: Type 316 stainless steel.
   3. Threaded insert: Type 316 stainless steel.

2.05 SIGHT GLASSES

A. Assembly: Body casting with ASME standard adapter flanges, borosilicate Pyrex™ glass section, cleaning assembly with scalloped neoprene wipers, operating rod and handle, packing gland with packing and suitable adapter, and cock with solvent hand pump.

B. Suitable for a minimum pressure of 30 pounds per square inch gauge.

C. Manufacturers: One of the following or equal:
   1. EIMCO Process Machinery Division of Envirotech Corporation.
   2. Ernst, Type K2 or K3 Cleanable Sight Glass.

2.06 SHIPPING

A. As specified in Section 01_60_00.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01_60_00.

B. Drawings supersede conflicts with this Section.

C. Bellows type expansion joints and vibration control joints:
   1. Protect joints against damage during pressure test.

3.02 INSTALLATION

A. Expansion control joints:
   1. Install bellows type expansion control joints at piping connections to mechanical equipment to prevent damaging stresses due to normal expansion and contraction with temperature changes in piping and connected equipment.
   2. Install bellows type expansion joints so as to allow 2-1/4 inch expansion per 100 linear feet of piping.
   3. Install expansion joints adjacent to an anchor, and provide 1 concentric guide on piping within 12 pipe diameters, but not more than 5 feet, from the end of the joint opposite the anchor.
      a. Locate a similar guide approximately 30 diameters but not more than 10 feet from the first.
   4. For expansion joints not installed adjacent to an anchor provide 2 concentric guides similarly located at each end of the joint.
   5. Provide control rods and additional guides where indicated on the Drawings, but at no greater intervals than recommended by the joint manufacturer in published instructions.
   6. Space intermediate supports a minimum of 10 feet, and tack weld the protective saddles to the pipe.

B. Transition couplings:
   1. Application:
      a. Use transition couplings with function and design similar to flexible couplings and flanged coupling adapters for connecting piping having different outside diameters.
   2. Install transition-coupling products specifically designed and manufactured for that application.

3.03 COMMISSIONING

A. As specified in Section 01_75_17 and this Section.

B. Manufacturer services:
   1. Required only for:
      a. Transition couplings.
      b. Tapping sleeves for large diameter pipe.
   2. Provide Manufacturer’s Certificate of Installation and Functionality Compliance.
   3. Provide Manufacturer’s Representative Onsite:
      a. Installation: 2 trip / 1 day each:
         1) Installation consultation and advice.
         2) Installation inspection.

C. Field testing:
   1. As specified in Section 40_05_00.01.
   2. Protect bellows type expansion joints and vibration control joints.

END OF SECTION

SECTION 40_05_06.03

PIPE COUPLINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pipe couplings for ductile iron piping.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_60_00 - Product Requirements.
   3. Section 01_75_17 - Commissioning.
   4. Section 01_78_36 - Warranties and Bonds.
   5. Section 09_96_01 - High-Performance Coatings.
   6. Section 40_05_00.01 - Common Work Results for General Piping.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.9 - Building Services Piping.

C. American Water Works Association (AWWA):
   1. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   2. C207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In.
   3. C606 – Standard for Grooved and Shouldered Joints.

D. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   4. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   5. A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
   6. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   7. A449 - Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/9 ksi Minimum Tensile Strength, General Use.
   8. A536 - Standard Specification for Ductile Iron Castings.

9. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
10. A576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
11. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
12. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
13. F594 - Standard Specification for Stainless Steel Nuts.

E. NSF International (NSF).
  1. 61 - Drinking Water System Components - Health Effects.
  2. 372 - Drinking Water System Components - Lead Content.

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data:
  1. For each product in this Section as applicable:
    a. Design features.
    b. Load capacities.
    c. Material designations by UNS alloy number or ASTM Specification and Grade.
    d. Data needed to verify compliance with the Specifications.
    e. Catalog data.
    f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

C. Calculations.
  1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.

1.04 WARRANTY

A. Provide warranty as specified in Section 01_78_36.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01_60_00:
  1. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

B. Known acceptable manufacturers are listed by specific products.

C. Provide references as specified in this Section by specific product.

D. Manufacturer’s representatives’ requirements as specified in Section 01_75_17 and this Section by specific product.

E. Gaskets for flexible couplings and flanged coupling adapters:
   1. Provide gasket materials for piping applications as follows:
      a. Low-pressure and high-pressure air, steam, hot water: EPDM.
      b. All other piping applications: Neoprene rubber or Buna-N, or EPDM.

F. Exterior coatings for underground and submerged applications:
   1. Manufacturers: One of the following or equal:
      a. Tapecoat Company, Inc., T.C. Mastic.
      b. Kop-Coat Company, Inc., Bitumastic Number 50.
   2. Thickness: Minimum 0.040 inch.

2.02 PIPE COUPLINGS FOR DUCTILE IRON PIPING

A. Flanged coupling adapters: 12-inch size and smaller:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 227.
      b. Romac Industries, Inc., Style FCA501.
      c. Smith-Blair, Inc., Series 912.
   2. Materials:
      a. Flanged body: Ductile iron in accordance with ASTM A536.
      b. Follower ring: Ductile iron in accordance with ASTM A536.
      c. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
   4. Coating and lining: Manufacturer’s standard fusion bonded epoxy, NSF 61 certified.

B. Flanged coupling adapters: Greater than 12-inch size:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 128-W.
      b. Romac Industries, Inc., Style FC400.
      c. Smith-Blair, Inc., Series 913.
   2. Materials:
      a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
      b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
      c. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
   4. Coating and lining: Manufacturer’s standard fusion bonded epoxy, NSF 61 certified.

C. Flexible couplings:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 253.
      b. Romac Industries, Inc., Style 501.
      c. Smith-Blair, Inc., Series 441.
   2. Materials:
      a. Center rings: Ductile iron in accordance with ASTM A536.
      b. Follower rings: Ductile iron in accordance with ASTM A536.
      c. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel in accordance with ASTM F593.
   3. Coating and lining: Manufacturer’s standard fusion bonded epoxy, NSF 61 certified.
   4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

Nominal Pipe Size	Sleeve Length
3 inch and smaller	Manufacturer’s standard
4 inch through 8 inch	7 inches
10 inch through 14 inch	12 inches
Greater than 16 inch	Use steel flexible coupling per Pipe Couplings for Steel Piping

D. Restrained flange coupling adapter:
   1. Manufacturers: One of the following or equal:
      a. Romac Industries, Inc., Style RFCA.
      b. Star Pipe Products, 3200 StarFlange.
   2. Materials:
      a. Flange and flanged body: Ductile iron in accordance with ASTM A536.
      b. Follower ring: Lug type restraint system.
         1) Follower ring: Ductile iron in accordance with ASTM A536.
         2) Restraining lugs: Ductile iron in accordance with ASTM A536.
            a) Designed to contact the pipe and apply forces evenly.
         3) Restraining bolts:
            a) Ductile iron in accordance with ASTM A536.
            b) Bolt heads shall be designed to twist off when the proper torque has been applied.
      c. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
   4. Coating and lining: Manufacturer’s standard fusion bonded epoxy, NSF 61 certified.
   5. Angular deflection: Restrained flange coupling adapter must allow angular deflection after assembly.

E. Grooved joint couplings:
  1. Manufacturers:
     a. Victaulic Company, Series 31 or equal.
  2. Materials:
     a. Housings: Ductile iron in accordance with ASTM A536.
     b. Gasket:
        1) FlushSeal® type, or equal. Elastomer in accordance with ASTM D2000.
        2) Neoprene or BUNA-N,orEPDM.
     c. Bolts and nuts: Electroplated steel in accordance with ASTM A449.
     d. Coating: As specified in Section 09_96_01.
  3. For use with rigid or flexible radius grooved components in accordance with AWWA C606.
  4. For connection to IPS steel pipe sizes, Victaulic Style 307.

PART 3 EXECUTION

3.01 INSTALLATION

A. In underground and underwater installations, coat the exterior of coupling with a protective coating in accordance with manufacturer's instructions.

B. Joints and flexible connections shall be installed centered with no angular deflection unless otherwise indicated on the Drawings.

C. Flexible couplings and flange coupling adapters: Install with gap between pipe ends in accordance with the following table unless a greater gap is indicated on the Drawings. Maximum gap tolerance shall be within 1/8 inch.
  1. Install flexible coupling with pipe gap located in middle of center sleeve.
  2. Install flanged coupling adapter with end of plain end pipe in middle of flanged coupling body.

Center Ring Length	Gap Dimension and Tolerance
4 inch through 6 inch	3/8 inch
7 inch	5/8 inch
10 inch and greater	7/8 inch

D. Provide harnesses (tie-downs) for flexible couplings unless otherwise indicated on the Drawings with a written note.
  1. Design harnesses (tie-downs) for the test pressures as specified in the Piping Schedule in Section 40_05_00.01.

E. Grooved joint couplings:
  1. Grooved ends: Clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
  2. Gaskets: Elastomer grade suitable for the intended service, and molded and produced by the coupling manufacturer.

F. Bolted, split-sleeve couplings:
   1. Inspect each coupling to insure that there are no damaged portions of the coupling.
      a. Pay particular attention to the sealing pad/sealing plate area.
      b. Before installation, thoroughly clean each coupling of any foreign substance which may have collected thereon and shall be kept clean at all time.
   2. Wrenches:
      a. Conform to manufacturer instructions.
      b. Bolts and studs shall be tightened so as to secure a uniform gasket compression between the coupling and the body of the pipe with all bolts or studs tightened approximately the same amount.
      c. Final tightening shall be done by hand (no air impact wrenches) and is complete when the coupling is in uniform contact with the outside surface of the pipe all around the circumference of the pipe.
   3. No joint shall be misfit in any plane.
   4. On the fixed ends of bolted, split-sleeve couplings, the shoulders shall bear on the restraint rings all around with no visible gap.
   5. Ends of piping where coupler are installed shall be smooth and free of defects.
      a. Remove weld splatter and grind smooth.
      b. Grind pipe seam welds flush with pipe wall and smooth.

END OF SECTION

SECTION 40_05_06.10

STRAINERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Strainers.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 40_05_00.01 - Common Work Results for General Piping.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A420 - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Low-Temperature Service.

B. Society of Automotive Engineers (SAE).

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 40_05_00.01.

PART 2 PRODUCTS

2.01 Y-TYPE STRAINERS

A. Y-type strainers less than 4 inches in diameter:
   1. Materials:
      a. Bodies: Cast iron or semi-steel.
      b. Ends: Flanged or threaded.
      c. Screen: Brass or Type 304 stainless steel.
   2. Suitable for minimum pressure of 250 pounds per square inch gauge.
   3. Screens: Perforations: 1/32 inch.
   4. Manufacturers: One of the following or equal:
      a. Armstrong, Y-Type Strainer.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with the manufacturer's recommendations.

3.02 COMMISSIONING

A. As specified in Section 01_75_17 and this Section.

B. Manufacturer services for mechanically cleaned strainers, only:
   1. Provide certificates:
      a. Manufacturer’s Certificate of Installation and Functionality Compliance.

END OF SECTION

SECTION 40_05_06.55

PIPING INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Insulation for piping and related systems.

B. Related sections:
1. Section 01_33_00 - Submittal Procedures.
2. Section 01_60_00 - Product Requirements.
3. Section 01_78_36 - Warranties and Bonds.
4. Section 31_23_17 - Trenching.
5. Section 40_05_00.01 - Common Work Results for General Piping.
6. Section 40_05_00.03 - Pipe Identification.
7. Section 40_05_19.01 - Ductile Iron Pipe: AWWA C151.
8. Section 46_05_10 - Common Work Results for Mechanical Equipment.

1.02 REFERENCES

A. ASTM International (ASTM):
1. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
2. C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
3. C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
4. C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
5. C547 - Standard Specification for Mineral Fiber Pipe Insulation.
6. C552 - Standard Specification for Cellular Glass Thermal Insulation.
7. C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
8. C929 - Standard Practice for Handling, Transporting, Shipping, Storage, Receiving, and Application of Thermal Insulation Materials for Use in Contact with Austenitic Stainless Steel.
9. C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
10. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
11. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
12. E96 - Standard Test Methods for Water Vapor Transmission of Materials.

1.03 DEFINITIONS

A. Buried: Piping that is installed below buildings, foundations, or finish grade, either in soil or encased in concrete in soil.

B. Concealed: Piping above suspended ceilings and within walls, partitions, shafts, or service spaces and spaces not normally exposed to view but not buried.

C. Exterior: Piping that is installed outside a building.

D. Flame spread and smoke density: Burning characteristics determined in accordance with ASTM E84. No units apply to value.

E. Interior: Piping that is installed inside a building.

F. K factor: Thermal conductivity determined in accordance with ASTM C177 or C518 and expressed in units of hour-square feet -degrees Fahrenheit.

G. Mineral fiber: Fibers manufactured of glass, rock, or slag processed from a molten state, with or without a binder.

H. Water vapor permeance: Water vapor transmission determined in accordance with ASTM E96 and expressed in units of perm-inch.

1.04 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 46_05_10.
1. Insulation properties: Include K factor, thickness, density, operating temperature limits, tensile strength, compressive strength, moisture absorption, flame spread, and smoke developed in accordance with ASTM E84 and corrosivity to stainless steel piping in accordance with ASTM C795.
2. Jacket properties: Include covering material, cover thickness, tensile strength, tear strength, permeability in accordance with ASTM E96, flame spread, and smoke developed in accordance with ASTM E84, closure type or devices, and accessories.
3. Insulating blankets: Include materials, performance characteristics, method of attaching to equipment, listing of locations where insulating blankets will be installed.
4. Manufacturer's application instructions: Include assembly and application drawings and detailed instructions.
5. Laboratory report: Provide certified laboratory report stating that insulation is not manufactured using chlorinated polymers and does not contain chlorides, bromides, sulfates, or fire-rated materials.

C. Provide warranty as specified in Section 01_78_36.

1.05 REGULATORY REQUIREMENTS

A. Projects located in California comply with California Energy Commission Energy Efficiency Standards for Residential and Non-Residential Buildings.

PART 2 PRODUCTS

2.01 PIPE INSULATION, GENERAL REQUIREMENTS

A. As specified in Section 01_60_00.

B. Insulation thicknesses: Provide insulation thickness in inches in accordance with the following table. Insulation thickness shown is nominal. Manufacturing tolerance of 15 percent variation is permissible.

Required Insulation Thicknesses (inches)					
Service Temperature Range as Designated in Insulation Schedule at End of this Section	**Nominal Pipe Diameters**				
	1 inch and Less	**1.25 to 2 inch**	**2.5 to 4 inch**	**5 to 10 inch**	**Over 10 inch**
Above 200 degrees Fahrenheit	2.0	2.5	3.0	3.5	3.5
100 to 200 degrees Fahrenheit	1.5	1.5	1.5	2.0	2.5
40 to 100 degrees Fahrenheit	0.5	1.0	1.0	1.5	2.0
Below 40 degrees Fahrenheit	1.0	1.0	1.5	2.0	2.0
Heat Traced Pipes	1.0	1.0	1.0	1.5	2.0
Aeration Air Pipes	0.5	0.5	1.0	1.0	1.0

2.02 PIPE INSULATION

A. Insulation types: Provide in accordance with the insulation types listed and scheduled.

B. Insulation, Type 1:
1. Insulation material: Closed cell elastomeric insulation.
2. Manufacturers: One of the following or equal:
   a. Armstrong World Industries, AP Armaflex.
   b. Apache Products Company, ISO-25.
3. Minimum temperature range: Minus 40 degrees Fahrenheit to plus 220 degrees Fahrenheit.
4. K factor at 75 degrees Fahrenheit: Not more than 0.27 BTU-inch/hour-square feet-degrees Fahrenheit.
5. Fire ratings:
   a. Flame spread: 25 or less.
   b. Smoke density: 50 or less for insulation thicknesses up to 1.5 inches.
6. Joints: Seal with manufacturer's recommended contact adhesive to form continuous water barrier.

C. Insulation, Type 4:
1. Insulation material: Asbestos-free, rigid calcium silicate in accordance with ASTM C533; Type I for process temperatures up to 1,200 degrees Fahrenheit.
2. K factor at 500 degrees Fahrenheit: 0.55 for Type I.
3. Maximum average (dry) density: 14.5 pounds per cubic foot.
4. Compressive strength: 100 pounds per square inch, to produce a 5 percent compression.

5. Manufacturers: One of the following or equal: In accordance with ASTM C533 Type I:
   a. Industrial Insulation Group, LLC, Thermo-12 Gold.

2.03 INSULATION JACKETS

A. Jacket, Type 2:
   1. Material: Ultraviolet-resistant polyvinyl chloride jacketing, 20 mil minimum thickness.
   2. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
   3. Color: White.
   4. Overlap: 1-inch minimum at joints and fittings.
   5. Joint seal: PVC solvent welded or adhesive as recommended by the manufacturer.
   6. Fittings: Factory made with full thickness insulation.
   7. Manufacturers: One of the following or equal:
      a. Johns Manville, Zeston 2000 PVC.
      b. Proto Corp., LoSMOKE PVC.
      c. Speedline Smoke Safe PVC Jacketing System.
      d. Knauf Covering System.

B. Jacket, Type 3:
   1. Material: Aluminum, Alloy 5005; 0.016-inch (26 gauge) minimum thickness.
   2. Overlap: Overlap circumferential joints 4 inches minimum; overlap longitudinal joints 1-inch minimum; longitudinal joints oriented to minimize water entry.
   3. Bands: 0.5 inch wide, 0.0508 inch (16 gauge) thick aluminum, same alloy as jacket or 0.0179 inch thick Type 304 stainless steel; install on 18-inch centers, uniformly spaced and at all fitting joints.
   4. Joint seal: Apply waterproof adhesive at joints and overlaps.
   5. Fittings: Custom fit of same materials.
   6. Manufacturers: One of the following or equal:
      a. Childers Products.
      b. Premetco International.

2.04 RELATED MATERIALS

A. Cover adhesive: Premium adhesive as recommended by the insulation cover supplier for heavy-duty service in corrosive, wet environments. Standard-duty adhesives are not permitted.

2.05 REMOVABLE INSULATING BLANKETS

A. In piping systems specified to be insulated, use removable insulating blankets for valves, meters, strainers, filters, catalytic converters, engine exhaust silencers, and other in-line piping appurtenances and equipment requiring periodic servicing.

B. Size limits: Use removable insulating blankets for equipment and piping appurtenances 3-inch in nominal size and larger. Insulate equipment and piping appurtenances less than 3-inch with molded sections of insulation or by field cutting insulation to conform to the shape of the component and to fit tightly around the component.

C. Manufacturers: One of the following, or equal:
   1. Pittsburgh Corning, Temp-Mat.
   2. Accessible Products, Thermazip 2000 Jacket.
   3. Thermal Energy Products, Inc., Energy Wrap.

D. Low temperature insulating blankets rated up to 800 degrees Fahrenheit:
   1. Use: For service temperatures up to 800 degrees Fahrenheit.
   2. Insulation: Fiberglass fiber, K factor 0.27 at 75 degrees Fahrenheit.
   3. Cover: 17-ounce fabric with both sides covered with silicone-impregnated glass cloth suitable for temperatures up to 800 degrees Fahrenheit.
   4. Cover fasteners: Use one of the following systems:
      a. Grommets in the blanket and stainless steel wire.
      b. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

E. High temperature insulating blankets rated up to 1,400 degrees Fahrenheit:
   1. Rated for sustained service temperatures up to 1,400 degrees Fahrenheit.
   2. Insulation: Ceramic fiber, K factor 0.50 at 600 degrees Fahrenheit, insulation material suitable for up to 2,300 degrees Fahrenheit, thickness to match adjacent piping insulation specified thickness.
   3. Cover: 17-ounce silicone impregnated fiberglass cloth suitable for temperatures up to 1,400 degrees Fahrenheit.
   4. Cover fasteners: Use one of the following systems:
      a. Grommets in the blanket and stainless steel wire.
      b. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

2.06 SHIPPING

A. As specified in Section 01_60_00.

PART 3 EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01_60_00.

B. Store insulation materials and accessories under cover and protected from moisture.

C. Handle and store insulation for use on stainless steel in accordance with ASTM C929.

3.02 PREPARATION

A. Pressure test piping and complete application of coating system before applying insulation.

B. When piping is to be heat traced, install and functionally test heat tracing before installation of insulation.

C. Before beginning installation of piping insulation, verify that the Engineer has accepted piping tests, pipe coating applications, and heat tracing tests.

3.03 INSULATION SCHEDULE

Service Designation(1)	Location(2)	Insulation Type(3)	Jacket Type(3)	Service Temp. °F(4)	Vapor Barrier
Water (W)	Exterior (1-inch diameter)	1	2	40 to 100	None
Engine Exhaust	Interior	4	3	Note 5	None

Notes:
1. Refer to Piping Schedule in Section 40_05_00.01 for service designations.
2. Insulation jackets are not required for interior installations that are concealed. See definitions for description of concealed locations.
3. Contractor may select from options listed.
4. Unless noted otherwise, use service temperature range provided in this table to establish insulation thickness as required by Table in Article 2.01, Paragraph A.
5. Service temperature based on engine rating. Use Type I calcium silicate for exhaust temperatures up to 1,000 degrees Fahrenheit; use Type II calcium silicate for exhaust temperatures above 1,000 degrees Fahrenheit.

3.04 INSTALLATION

A. Install insulation and jacket materials in accordance with manufacturers' written instructions.

B. Apply insulation in smooth, clean manner with tight and finished smooth joints. Fit insulation tightly against surfaces. Insulate each continuous run of pipe with full-length sections of insulation with a single piece cut to length to complete the run of pipe. Do not use cut pieces or scraps to complete the installation.

C. Butt longitudinal and circumferential insulation joints firmly together.

D. Apply sealant or cement when previous applications of adhesives and cement have thoroughly dried.

E. Apply insulation to permit expansion or contraction of pipelines without damage to insulation or jacketing.

F. Fittings:
1. Insulate fittings by covering with mitered sections of insulation or utilize factory-made prefabricated fitting shapes.
2. Terminate preformed pipe jackets or covering at sufficient distance from flanges to permit removal of bolts.
3. Overlap flange and flanged fitting insulation on adjacent pipe covering by at least 2 inches.

G. Valves:
1. Insulate valves 3-inch in nominal size and larger with removable insulating blankets.

2. Size blanket to extend up to packing gland only so that replacement of packing does not require removal of insulating blanket.

H. Provide continuous insulation through and over pipe supports and provide protection saddles at supports.

I. Extend insulation against insulation end protection shields or covers so that insulation voids do not exist and provide watertight end seals and covers where insulation terminates.

J. Insulate pipeline strainers to permit removal of strainer basket without disturbing insulation on strainer body.

K. Provide continuous pipe insulation and covering through sleeves or openings in walls and floors. When buried pipe enters a building through a below grade wall or slab penetration, begin insulation system on interior side of penetration.

L. Apply premolded pipe insulation with extended legs when used on pipe traced with either tubing or electric cable type.

M. Thermally isolate all insulation closure locations (end caps, transitions, etc.) Type 1 or 2 jacket installation on piping with potential reach temperatures greater than 150 degrees Fahrenheit.

N. Apply piping identification on jackets as specified in Section 40_05_00.03.

END OF SECTION

SECTION 40_05_07.01

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Supports for pipe, fittings, valves, and appurtenances.

B. Related sections:
1. Section 01_33_00 - Submittal Procedures.
2. Section 01_41_00 - Regulatory Requirements.
3. Section 01_60_00 - Product Requirements.
4. Section 01_78_36 - Warranties and Bonds.
5. Section 05_12_00 - Structural Steel.
6. Section 09_96_01 - High-Performance Coatings.

1.02 REFERENCES

A. ASTM International (ASTM):
1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
2. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
3. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.

B. Manufacturer's Standardization Society (MSS):
1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data.
1. Design features.
2. Load capacities.
3. Material designations by UNS alloy number or ASTM Specification and Grade.
4. Data needed to verify compliance with the Specifications.
5. Catalog data.
6. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

1.04 WARRANTY

A. Provide warranty as specified in Section 01_78_36.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01_60_00.

2.02 MATERIALS

A. General:
   1. Hot dip galvanized:
      a. Fabricate as specified in Section 05_12_00.
      b. Hot dip after fabrication of support in accordance with ASTM A123.
      c. Repair galvanized surface as specified in Section 05_12_00.
   2. Stainless steel.
      a. Fabricate as specified in Section 05_12_00.
      b. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
      c. At the shop, perform pickling and passivation on all surfaces inside and out in accordance with ASTM A380 or A967.
         1) Passivation treatments using citric acid are not allowed.
      d. Field welding is prohibited unless specifically allowed by the Owner. All field welds shall be passivated.

B. Outdoor areas: Areas exposed to the natural outdoor environment:
   1. Hot Dip Galvanized.

C. Indoor areas: Areas exposed to an indoor environment including galleries and tunnels:
   1. Hot Dip Galvanized.

D. Submerged, 3 feet or less above water level in a structure, or inside a water bearing structure:
   1. Type 304L Stainless Steel.

E. Chemical containment areas and chemical piping:
   1. Type 316L Stainless Steel.

F. Fasteners:
   1. As specified in Section 05_12_00.

2.03 PIPE SUPPORTS

A. Hanger rods: Sized to match suspended pipe hanger, or as indicated on the Drawings:
   1. Manufacturers: One of following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 133.
         2) Nibco-Tolco, Figure 103.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 140.
         2) Bergen-Power, Figure 133.
         3) Cooper B-Line Systems, Inc., Figure B3205.

B. Hanger rods, continuously threaded: Sized to match suspended pipe hanger, or as indicated on the Drawings:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 94.
         2) FM Stainless Fasteners.
      b. For steel and ductile iron piping:
         1) Anvil International, Figure 146.
         2) Bergen-Power, Figure 94.

C. Eye bolts:
   1. For all piping, unless indicated on the Drawings:
      a. Welded and rated equal to full load capacity of rod.

D. Welded eyebolt rod:
   1. Manufacturers: One of the following or equal:
      a. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure 278.
         2) Bergen-Power, Figure 93.
         3) Cooper B-Line Systems, Inc., Figure B3210.

E. Adjustable ring hangers: MSS SP-58, Type 7 or Type 9 (system dependent):
   1. Manufacturers: One of the following or equal:
         1)
      b. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure 97.
         2) Cooper B-Line Systems, Inc., Figure B3172.

F. Adjustable clevis hangers: MSS SP-58, Type 1:
   1. Manufacturers: One of the following or equal:
      a. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure 260 or Figure 590.
         2) Bergen-Power, Figure 100.
         3) Cooper B-Line Systems, Inc., Figure B3100 or B3102.

G. Adjustable clevis hangers for insulated pipe: Oversize:
   1. Manufacturers: One of the following or equal:
      a. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure 300.
         2) Bergen-Power, Figure 100EL.
         3) Cooper B-Line Systems, Inc. Figure B3108.

H. Brackets: MSS SP-58, Type 32 with back plate; rated for 1,500 pounds:
   1. Manufacturers: One of the following or equal:
      a. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure 195.
         2) Cooper B-Line Systems, Inc., Figure B3066.

I. Brackets, heavy duty: MSS SP-58, Type 33 with back plate; rated for 3,000 pounds:
   1. Manufacturers: One of following or equal:
      a. Anvil International, Figure 199.
      b. Cooper B-Line Systems, Inc., Figure B3067.

J. Standard U-bolt: MSS SP-58, Type 24:
   1. Manufacturers: One of the following or equal:
      a. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure 137.
         2) Bergen-Power, Figure 283.
         3) Cooper B-Line Systems, Inc., Figure B3188.

K. Riser clamps: MSS SP-58, Type 8:
   1. Manufacturers: One of the following or equal:
      a. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure 261.
         2) Bergen-Power, Figure 126.
         3) Cooper B-Line Systems, Inc., Figure B3373.

L. Pipe clamps: MSS SP-58, Type 4:
   1. Manufacturers: One of the following or equal:
         1)
      b. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure 212.
         2) Bergen-Power, Figure 175.
         3) Cooper B-Line Systems, Inc., Figure B3140.

M. Adjustable offset pipe clamp:
   1. Manufacturers: One of the following or equal:
      a. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure 100.
         2) Cooper B-Line Systems, Inc., Figure B3149.

N. Offset pipe clamp:
   1. Manufacturers: One of the following or equal:
      a. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure 103.
         2) Cooper B-Line Systems, Inc., Figure B3148.

O. Floor stand or stanchion saddles: MSS SP-58, Type 37. Provided with U-bolt hold down yokes:
   1. Manufacturers: One of the following or equal:
      a. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure 259.
         2) Bergen-Power, Figure 125.
         3) Cooper B-Line Systems, Inc., Figure B3090.
      b. Threaded pipe stand support stanchion. Match pipe support material.
         1) Anvil International, Figure 63T.
         2) Bergen-Power, Figure 138.
         3) Cooper B-Line Systems Inc., Figure B3088ST.

P. Spring hangers:
   1. Manufacturers: One of the following or equal:
      a. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure B-268, Type G.
         2) Bergen-Power, Figure 920.

Q. Welded beam attachment: MSS SP-58, Type 22:
   1. Manufacturers: One of the following or equal:
      a. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure 66.
         2) Bergen-Power, Figure 113A or 113B.
         3) Cooper B-Line Systems, Inc., Figure B3083.

R. Heavy pipe clamp: MSS SP-58, Type 4:
   1. Manufacturers: One of the following or equal:
      a. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure 216.
         2) Bergen-Power, Figure 298.

S. PTFE pipe slide assembly: MSS SP-58, Type 35 with lateral and vertical restraint:
   1. Manufacturers: One of the following or equal:
      a. For all piping, unless indicated on the Drawings:
         1) Anvil International, Figure 257, Type 3.
         2) Cooper B-Line Systems, Inc., Figure B3893.

T. Anchor bolts, concrete anchors, concrete inserts, powder-actuated fasteners, and sleeve anchors: As specified in Section 05_12_00.

PART 3 EXECUTION

3.01 INSTALLATION

A. Support, suspend, or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment.

B. Field verify support location, orientation, and configuration to eliminate interferences prior to fabrication of supports.

C. Carefully determine locations of inserts. Anchor to formwork prior to placing concrete.

D. Use flush shells only where indicated on the Drawings.

E. Do not use anchors relying on deformation of lead alloy.

F. Do not use powder-actuated fasteners for securing metallic conduit or steel pipe larger than 1 inch to concrete, masonry, or wood.

G. Suspend pipe hangers from hanger rods and secure with double nuts.

H. Install continuously threaded hanger rods only where indicated on the Drawings.

I. Use adjustable ring hangers or adjustable clevis hangers, for 4 inch and smaller diameter pipe.

J. Use adjustable clevis hangers for pipe larger than 4 inches in diameter.

K. Secure pipes with double nutted U-bolts or suspend pipes from hanger rods and hangers.
   1. For stainless steel piping, use stainless steel U-bolts.
   2. For all other piping, use galvanized U-bolts.

L. Support spacing:
   1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
   2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
   3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
   4. Support tubing, PVC pipe 1-inch and smaller, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4 inch between supports.
   5. Do not suspend or support valves, pipe and fittings from another pipe or conduit.

M. Install supports at:
   1. Any change in direction.
   2. Both sides of flexible pipe connections.
   3. Base of risers.
   4. Floor penetrations.
   5. Connections to pumps, blowers, and other equipment.
   6. Valves and appurtenances.

N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.

O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.

P. Provide elbows or tees supported from floors with base fittings where indicated on the Drawings.

Q. Support base fittings with metal supports or when indicated on the Drawings support on concrete piers.

R. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.

S. Support plumbing drainage and vents in accordance with plumbing code as specified in Section 01_14_00.

T. Supports, clamps, brackets, and portions of support system bearing against copper pipe: Copper plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.

U. Where pipe is insulated, install over-sized supports and hangers.

V. Install insulation shield in accordance with MSS SP-58, Type 40. Shield shall be galvanized steel unless otherwise specified or indicated on the Drawings.

W. Install riser clamps at floor penetrations and where indicated on the Drawings.

X. Coat support system components as specified in Section 09_96_01.

END OF SECTION

SECTION 40_05_07.03

PREFORMED CHANNEL PIPE SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Preformed channel pipe support system consisting of preformed channels, fittings, straps, and fasteners engineered to support piping.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_81_02 - Seismic Design Criteria.

1.02 REFERENCES

A. American Institute of Steel Construction (AISC).

B. American Iron and Steel Institute (AISI).

C. Manufacturer's Standardization Society (MSS):
   1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.
   2. SP-69 - Pipe Hangers and Supports - Selection and Application.

1.03 SYSTEM DESCRIPTION

A. Design responsibility:
   1. The manufacturer of the preformed channel pipe support system is responsible for the design of the support system.
   2. Prepare design calculations utilizing the design criteria included in these Specifications.
   3. Prepare detailed shop drawings illustrating the layout of the support system and identifying the components of the support system.

B. Design criteria:
   1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
   2. Minimum gauge thickness: 12-gauge.
   3. Allowable stress of channels:
      a. Steel channels: The lesser of 25,000 pounds per square inch, or 0.66 times yield stress of steel.
      b. Stainless steel channels: 0.66 times the yield stress of the stainless steel alloy.
   4. Maximum deflection: 1/240 of span.
   5. Allowable column loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
   6. Future loads:
      a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.

b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
7. Seismic design criteria: As specified in Section 01_81_02 as specified for mechanical equipment.
8. Spacing of supports: As required to comply with design requirements but not more than 5 feet.

C. Supports below the top of walls of water bearing structures: Use Type 316 stainless steel for support system components.
1. Supports in other locations: Use hot-dipped galvanized components unless other materials are specifically indicated on the Drawings.

1.04 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data.

1.05 QUALITY ASSURANCE

A. Design preformed channel pipe support system for loads in accordance with applicable provisions of:
1. AISC Manual of Steel Construction.
2. AISI Cold-Formed Steel Design Manual.

B. Product standards:
1. Pipe support components: In accordance with MSS SP-69.
2. Pipe support materials: In accordance with MSS SP-58.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Fabricate preformed channel pipe support system using, as a minimum, parts specified below and meeting the requirements specified under Design Criteria.
1. Manufacturers: One of the following or equal:
a. Unistrut, Series P1000 or P1001; P5500 or P5501.
b. Allied Support Systems, Power Strut, Figure PS-200 or PS-200 2TS; PS-150 or PS-150 2TS.
c. Cooper Industries, B-Line, Channel Type B22 or B22A; B12 or B12A.

2.02 ACCESSORIES

A. Preformed channel concrete inserts: Minimum 12 inches long:
1. Manufacturers: One of the following or equal:
a. Unistrut, Series P-3200.
b. Allied Support Systems, Figure 282.
c. Cooper Industries, B-Line Series B32I.

B. 90-degree angle fittings:
   1. Manufacturers: One of the following or equal:
      a. Unistrut, P1026.
      b. Allied Support Systems, Power Strut, P603.

C. Pipe straps:
   1. For pipes 8 inches in diameter and smaller: Use 2-piece universal strap with slotted hex head screw and nut.
      a. Manufacturers: One of the following or equal:
         1) Unistrut, Series P1109 through P1126.
         2) Allied Support Systems, PS1100.
         3) Cooper Industries, B-Line Series B2000.
   2. For pipes greater than 8 inches in diameter: Unless different material is otherwise indicated on the Drawings use 1-piece 1 inch wide by 1/8 inch thick steel strap, hot-dip galvanized after fabrication.
   3. For stainless steel pipes: Use type of strap required for the pipe sizes specified above, but use Type 316 stainless steel materials.

D. Prefabricated double channel bracket:
   1. Manufacturers: One of the following or equal:
      a. Unistrut, P2542-P2546.
      b. Cooper Industries, B-Line Series B297.

E. Touch-up paint for galvanized surfaces:
   1. Manufacturers: One of the following or equal:
      a. Galvinox, Galvo-Weld.

F. Touch-up paint for painted surfaces: Same formulation as factory paint.

2.03 FABRICATION

A. Hot-dip galvanize support system components after fabrication to required length and shape.

B. Do not galvanize or paint stainless steel components.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install preformed channel concrete inserts for vertical support, quantity based on manufacturer's structural design calculations.

B. Fasten preformed channel pipe supports to existing walls using Z-fittings and concrete anchors as indicated on the Drawings.

C. Fasten preformed channel pipe supports to preformed channel concrete inserts embedded in ceiling using U-shaped fittings.

D. Suspend threaded rods from concrete inserts embedded in ceiling. Support preformed channel pipe supports with threaded rods.

E. Touchup cut or damaged galvanized surfaces.

F. Prevent contact between pipes and support components of dissimilar metals. Utilize rubber coated, plastic coated, or vinyl coated components, stainless steel components, or wrap pipe with PVC or polyethylene tape.

G. Install support as near as possible to concentrated loads.

H. Install support within 2 feet of horizontal and vertical changes in pipe alignment.

I. Adjust supports or install shims to obtain specified slope or elevation.

END OF SECTION

SECTION 40_05_19.01

DUCTILE IRON PIPE: AWWA C151

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Ductile iron pipe, joints, fittings, gaskets, and pipe linings and coatings.

B. Related sections:
1. Section 01_33_00 - Submittal Procedures.
2. Section 09_96_01 - High-Performance Coatings.
3. Section 31_23_17 - Trenching.
4. Section 40_05_00.01 - Common Work Results for General Process Piping.
5. Section 40_05_00.09 - Piping Systems Testing.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. American Water Works Association (AWWA):
1. C104 - Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
3. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
4. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
5. C115 - Flanged Ductile Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
6. C150 - Standard for Thickness Design of Ductile-Iron Pipe.
7. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
8. C153 - Standard for Ductile-Iron Compact Fittings for Water Service.
9. C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
10. C606 - Standard for Grooved and Shouldered Joints.

C. American Welding Society (AWS):
1. D11.2 - Guide for Welding Iron Castings.

D. ASTM International (ASTM):
1. A47 - Standard Specifications for Ferritic Malleable Iron Castings.
2. A183 - Standard Specifications for Carbon Steel Track Bolts and Nuts.
3. A536 - Standard Specifications for Ductile Iron Castings.
4. C283 - Standard Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
5. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

E. Ductile Iron Pipe Research Association (DIPRA):
   1. Thrust Restraint Design Manual.

F. NACE International (NACE):
   1. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

G. National Association of Pipe Fabricators, Inc. (NAPF):
   1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

H. Society for Protective Coatings (SSPC):
   1. PA-2 - Measurement of Dry Coating Thickness With Magnetic Gages.

1.03 SYSTEM DESCRIPTION

A. Thrust restraint system design:
   1. Design restrained joint thrust restraint system.
   2. Determine the length of pipe that must be restrained on each side of the focus of a thrust load in accordance with the procedures and criteria established by the DIPRA Thrust Restraint Design Manual as specified in Piping Schedule in Section 40_05_00.01 and the following additional criteria:
      a. Design pressure: Test pressure.
      b. Laying condition: Type 3 or Type 5 in accordance with AWWA C150.
      c. Soil designation: Sand Silt as defined by DIPRA.
      d. Unit friction resistance: Based upon polyethylene encasement of pipe.
      e. Safety factor: 1.5 (for thrust restraint calculations only).

1.04 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 40_05_00.01.

C. Shop drawings:
   1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, and connections to pipelines or structures.
   2. Thrust restraint systems layouts.
   3. Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings, pipe linings, and coatings.

D. Calculations:
   1. Calculations for thrust restraint system design.

E. Provide manufacturer's test reports:
   1. On lining certifying successful performance of holiday detection tests.
      a. This documentation shall identify each piece by mark designation, and show the actual test results during the final inspection by the manufacturer prior to shipment.
      b. Acceptance criteria for glass lining shall be as specified under Field Quality Control.

2. On glass-lined pipe certifying compliance with specified material requirements for glass-lining.
3. Include Coating Manufacturer's Technical Representative's reports.

1.05 QUALITY ASSURANCE

A. Pre-installation meeting:
   1. Arrange for Coating Manufacturer's Technical Representative to attend preconstruction conferences, and to make periodic visits to factory or shop to inspect surface preparation of pipe, fittings, and accessories; and to inspect application of linings to interior and coatings to exterior of pipe, fittings, and accessories.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Block piping and associated fittings for shipment to prevent damage to coatings and linings.

B. Carefully handle piping and associated fittings during loading, unloading, and installation:
   1. Do not drop piping material from cars or trucks.
   2. Lower piping by mechanical means.
   3. Do not drop or pound pipe to fit grade.

C. Protect gaskets and polyethylene encasement from long-term exposure to sunlight.

D. Store piping, fittings, and other accessories such that they do not accumulate and hold rainwater, dirt, and debris.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Ductile iron piping:
   1. Manufacturers meeting qualifications as specified in this Section.
   2. Typical type:
      a. In accordance with AWWA C150 and AWWA C151.
      b. Pressure class or special thickness class as indicated in the Piping Schedule provided in Section 40_05_00.01.
      c. Manufactured from greater than 90 percent recycled material.
   3. Type with screw-on flanges:
      a. In accordance with AWWA C115 with minimum special thickness Class 53 wall thickness as required for screw-on flanges.
      b. Special thickness class as indicated in the Piping Schedule as specified in Section 40_05_00.01.
      c. Manufactured from greater than 90 percent recycled material.
   4. Type with grooved couplings:
      a. Special thickness class as indicated in the Piping Schedule as specified in Section 40_05_00.01.
      b. Manufactured from greater than 90 percent recycled material.

B. Joints:
   1. Flanged joints:
      a. Screw-on flanges: Comply with the diameter, thickness, drilling, and other characteristics in accordance with ASME B16.1. In addition, comply with the following requirements:
         1) Ductile iron.
         2) Long hub, threaded, and specially designed for ductile iron pipe.
         3) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
      b. Bolt holes on flanges: 2-holed and aligned at both ends of pipe.
      c. Cap screw or stud bolt holes: Tapped.
      d. Bolts and nuts: As specified in Section 40_05_00.01.
      e. Gaskets: Standard styrene butadiene copolymer (SBR) unless specified otherwise in Section 40_05_00.01.
   2. Grooved joints: In accordance with AWWA C606, as complemented and modified below, radius-cut type, with following components:
      a. Couplings: Rigid type, cast from ductile iron in accordance with ASTM A536, Grade 65-45-12, or malleable iron in accordance with ASTM A47, Grade 32510.
      b. Bolts and nuts: In accordance with ASTM A183, Grade 2.
      c. Gaskets: Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure. Material to be used for following services:
         1) For liquid service: NBR or Halogenated butyl.
      d. Fittings: In accordance with AWWA C606, rigid radius-cut groove:
         1) Center-to-center dimensions: In accordance with AWWA C110.
         2) Wall thickness and other characteristics: In accordance with AWWA C606.
      e. Flanged unit connections: Flanged to grooved joint adapters or a long enough spool with one end flanged and the other end grooved to prevent interference with the operation of adjacent valves, pumps, or other items.
   3. Mechanical joints: In accordance with AWWA C111.
   4. Push-on rubber gasket joints: In accordance with AWWA C111.
   5. Integrally restrained mechanical joints:
      a. Application:
         1) Where designation Mech Rest.
         2) Where mechanical joint is specified in the Piping Schedule provided in Section 40_05_00.01 or is indicated on the Drawings, supply a restrained mechanical joint piping system, which includes restrained mechanical joints where necessary based upon thrust calculations.
         3) Standard mechanical joints as specified above can be used where thrust calculations demonstrate restraint is not required.
      b. Design:
         1) Integral retainer weldment type or lugged type joint with Type 304 stainless steel rods and nuts.
         2) Restrained mechanical joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
      c. Manufacturers: Where restrained mechanical joints are required, use one of the following or equal:
         1) American Cast Iron Pipe Company, MJ Coupled Joint.
         2) Pacific States Cast Iron Pipe Company, Lock Mechanical Joint.
         3) U.S. Pipe, Bolt-Lok.

4) U.S. Pipe, Mech-Lok.

6. Integrally restrained push-on joints:
   a. Application:
      1) Where designation restrained push-on is specified in the Piping Schedule provided in Section 40_05_00.01 or as indicated on the Drawings, supply a restrained push-on joint piping system, which includes restrained push-on joints where necessary based upon thrust calculations.
      2) Standard push-on rubber gasket joints as specified above can be used where thrust calculations demonstrate restraint is not required.
   b. Design:
      1) Restrained push-on joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
      2) Suitable for the following working pressures:
         a) For 4- through 24-inch pipe: 350 pounds per square inch gauge.
   c. Manufacturers: One of the following or equal:
      1) U.S. Pipe, TR Flex.
      2) McWane Ductile, TR Flex.
      3) American Cast Iron Pipe Company, Flex Ring or Lok-Ring.
   d. Limit buried joints to half the manufacturer's published allowable angular joint deflection for purposes of pipeline alignment and elimination of fittings.

C. Fittings:
1. Ductile iron in accordance with AWWA C110 or AWWA C153.
2. Joint type: Same as that of the associated piping as specified in Section 40_05_00.01.
3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

D. Pipe linings:
1. Cement-mortar lining:
   a. In accordance with AWWA C104, apply cement-mortar on clean bare metal surfaces. Extend to faces of flanges, ends of spigots, and shoulders of hubs.
   b. Minimum lining thickness: Double in accordance with AWWA C104.
   c. Type of cement: Type II orType V.
2. Asphaltic seal coat:
   a. Apply over cement mortar linings and to outside surface of pipes that will not receive another coating. Apply in accordance with AWWA C151.
3. Elastomeric polyurethane (100 percent solids) lining:
   a. As specified in Section 09_96_01.
4. Ceramic epoxy lining:
   a. Manufacturers: One of the following or equal:
      1) PROTECTO 401.
      2) SP-2000W.
   b. Material: Amine cured Novolac epoxy containing at least 20 percent by volume of ceramic quartz pigment.
   c. Minimum dry film thickness (DFT): 40 mills.
   d. Application:
      1) The lining shall only be applied by a manufacturer-authorized representative with no less than 5 years of experience in applying the specified material.

2) The application of the lining shall be preformed in accordance with manufacturer's published specifications.
3) Pipe and fittings shall be delivered to application facility with no interior lining.
4) Interior of pipe shall be abrasive blasted per manufacturer's specifications.

e. Coverage:
1) Gasket and spigot ends-on joints: Provide 6 mils minimum and 10 mils maximum coverage using joint compound as specified by the manufacturer for the gasket area and spigot ends.
2) Mechanical joints: Extend lining from spigot end to edge of gauging ring.
3) Number of coats: As recommended by the lining manufacturer.

f. Source quality control:
1) Test pipe and fitting lining with a magnetic film thickness gauge. Perform testing in accordance with the method outlined in SSPC PA-2 Film Thickness Rating.
2) Test lining integrity of pipes using a holiday detection testing instrument set at the voltage as specified by the coating manufacturer:
a) Repair all holidays with joint compound in accordance with the recommendations of the coating manufacturer, and re-test.
3) Discard piping or reline piping when pinholes or discontinuities are found.

5. Glass lining:
a. Manufacturers: One of the following or equal:
1) Water Works Manufacturing, Ferrock MEH-32 Lining.
2) Vitco Corporation, SG-14 Lining.

b. Material: Special glasses and inorganic materials suited for lining of sewage, sludge, and scum piping with the following characteristics:
1) Thickness: 0.008 to 0.012 inch.
2) Hardness: 5 to 6 on the Mohs Scale.
3) Density: 2.5 to 3.0 grams per cubic centimeter, measured in accordance with ASTM D792.
4) Thermal shock resistance: Capable of withstanding 350 degrees Fahrenheit change from 430 degrees Fahrenheit to 80 degrees Fahrenheit without crazing, blistering, or spalling.
5) Gloss retention: Capable of retaining gloss after immersion in an 8 percent sulfuric acid solution at 148 degrees Fahrenheit for 10 minutes.
6) Weight loss: Maximum 3 milligrams per square inch when tested in accordance with ASTM C283.

c. Fabrication:
1) Use piping that is suitable for glass lining with minimum Class 53 wall thickness after application of glass lining.
2) Machine interior of pipe. Bore or grit blast in accordance with NAPF 500-03 prior to application of glass lining.
3) Screw factory assembled flanges on pipe, align boltholes, and flange faces, unless otherwise specified.
4) Apply lining to surfaces free of chemicals.

5) Place piping in furnaces specially designed for heating piping until glass melts and fuses with an integral molecular bond to the base metal.

E. Coatings:
1. Asphalt varnish: Factory applied.
2. Primer:
a. Factory applied for field coating.
b. Compatible with materials as specified in Section 09_96_01.

2.02 POLYETHYLENE ENCASEMENT

A. General:
1. Polyethylene encasement shall be supplied by the pipe manufacturer.

B. Materials: Supply one of the following polyethylene encasements:
1. 2 layers of linear low-density polyethylene (LLDPE) film, minimum thickness of 8 mils in accordance with AWWA C105; or
2. Single layer of high-density, cross-laminated polyethylene (HDCLPE) film, minimum thickness of 4 mils in accordance with AWWA C105.
3. Single layer of V-Bio® enhanced polyethylene encasement (3 layers of co-extruded LLDPE film with anti-microbial additive and volatile corrosion inhibitor infused on the inside surface), meeting all requirements of AWWA C105.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Install ductile iron piping in accordance with AWWA C600, modified as specified in Section 40_05_00.01.
2. For underground piping, the trenching, backfill, and compaction: As specified in Section 31_23_17.

B. Polyethylene encasement:
1. Wrap all buried ductile iron pipe and fittings in 2 layers of loose low density polyethylene wrap or a single layer of high-density polyethylene wrap in accordance with AWWA C105.
2. Polyethylene encasement shall be continuous and terminated neatly at connections to below grade equipment or structures.
3. At wall penetrations, extend encasement to the wall and neatly terminate.
4. At slab penetrations, extend encasement to 2 inches below the top of slab and neatly terminate.
5. When rising vertically in unimproved areas, extend encasement 6 inches above existing grade and neatly terminate.
6. Repair tears and make joints with 2 layers of plastic tape.
7. All work shall be inspected prior to backfilling of pipe and associated items.

C. Joints:
1. Install types of joints as specified in the piping schedule provided in Section 40_05_00.01.
2. Mechanical joints are not acceptable in above ground applications.

3. Field closure for restrained push-on pipe:
   a. Locate field closures in areas where thrust calculations demonstrate restraint is not required.
4. Grooved joints:
   a. Install piping with grooved joints where specified in the piping schedule as specified in Section 40_05_00.01 or indicated on the Drawings.
   b. Assemble grooved joints in accordance with manufacturer's published instructions.
   c. Support grooved-end pipe in accordance with manufacturer's published instructions.
      1) Install at least 1 support between consecutive couplings.

D. Tapping ductile iron pipe:
1. Direct tapping of ductile iron pipe may be performed but is limited to the following conditions:
   a. Maximum allowable tap diameter by pipe diameter and pressure class:

Pipe Size (inches)	**Pressure Class**				
	150	**200**	**250**	**300**	**350**
	Maximum Allowable Direct Tap Size (inches)				
3	-	-	-	-	3/4
4	-	-	-	-	3/4
6	-	-	-	-	1
8	-	-	-	-	1
10	-	-	-	-	1
12	-	-	-	-	1-1/4
14	-	-	1-1/4	1-1/2	1-1/2
16	-	-	1-1/2	2	2
18	-	-	2	2	2
20	-	-	2	2	2
24	-	2	2	2	2

   b. The maximum allowable tap diameter for pipelines greater than 24 inches is 2 inches.
   c. Two layers of 3-mil thread sealant are required to minimize the torque required to effect a watertight connection.

3.02 FIELD QUALITY CONTROL

A. Testing ductile iron piping:
1. Test as specified in Section 40_05_00.01 and Section 40_05_00.09.
2. Do not test sections longer than 1/2 mile in total pipe length.

B. Repair damaged cement mortar lining to match quality, thickness, and bonding of original lining in accordance with AWWA C104.
1. When lining cannot be repaired or repairs are defective, replace defective piping with undamaged piping.

C. Verify that interior surfaces of glass lined pipe and fittings have continuous coverage:

1. Verify with low voltage wet sponge holiday detector in accordance with NACE SP0188.
2. Discard glass lined ductile iron piping and fittings with voids or casting anomalies. that exceed the maximum non-visible pinholes allowances below:

	Maximum Pinholes	
Diameter	**Fittings**	**Pipe (per 20-foot length of pipe)**
4- to 8-inch	3-5	10-12
10- to 18-inch	5-8	18-20
20-inch and Larger	8-10	25-28

3. Discard lined piping and fittings found to have pinholes, crazing, or fish scales, which expose the metal substrate.

END OF SECTION

SECTION 40_05_31.01

PLASTIC PIPING AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Plastic pipe, tubing, and fittings.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 40_05_00.01 - Common Work Results for General Piping.
   3. Section 40_05_19.01 - Ductile Iron Pipe: AWWA C151.
   4. Section 40_05_00.09 - Piping Systems Testing.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.12 - Cast Iron Threaded Drainage Fittings.

B. ASTM International (ASTM):
   1. D1248 - Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable.
   2. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   3. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
   4. D1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.
   5. D2241 - Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated (SDR Series.
   6. D2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
   7. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   8. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   9. D2513 - Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings.
   10. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
   11. D2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
   12. D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride)(PVC) Pipe and Fittings.
   13. D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
   14. D3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
   15. D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.

16. D3350 - Standard Specification for Polyethylene Plastic Pipes and Fittings Materials.
17. D4101 – Standard Specification for Polypropylene Injection and Extrusion Materials.
18. F438 - Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
19. F439 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
20. F441 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
21. F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
22. F493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
23. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.
24. F679 - Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
25. F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

C. American Water Works Association (AWWA):
    1. C900 - Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inches to 12 Inches (100 mm Through 300 mm), for Water Transmission Distribution.

D. NSF International (NSF).

E. Plastics Pipe Institute (PPI):
    1. TR 31 - Underground Installation of Polyolefin Piping.

1.03 ABBREVIATIONS

A. ABS: Acrylonitrile-butadiene-styrene.

B. CPVC: Chlorinated polyvinyl chloride.

C. DR: Dimension ratio.

D. DWV: Drain, waste, and vent.

E. ID: Inside diameter of piping or tubing.

F. NPS: Nominal pipe size followed by the size designation.

G. NS: Nominal SIZE of piping or tubing.

H. PE: Polyethylene.

I. PP: Polypropylene.

J. PVC: Polyvinyl chloride.

K. SDR: Standard dimension ratio; the outside diameter divided by the pipe wall thickness.

1.04 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 40_05_00.01.

C. Shop Drawings:
   1. Describe materials, pipe, fittings, gaskets, and solvent cement.
   2. Installation instructions.

1.05 QUALITY ASSURANCE

A. Plastic pipe in potable water applications: Provide pipe and tubing bearing NSF seal.

B. Mark plastic pipe with nominal size, type, class, schedule, or pressure rating, manufacturer and all markings required in accordance with ASTM and AWWA standards.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect piping materials from sunlight, scoring, and distortion.

B. Do not allow surface temperatures on pipe and fittings to exceed 120 degrees Fahrenheit.

C. Store and handle PE pipe and fittings as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. Fittings: Same material as the pipe and of equal or greater pressure rating, except that fittings used in drain, waste, and vent piping systems need not be pressure rated.

C. Unions 2-1/2 inches and smaller: Socket end screwed unions. Make unions 3 inches and larger of socket flanges with 1/8-inch full-face soft neoprene or EPDM gasket.

2.02 PVC PIPING, SCHEDULE TYPE

A. Materials:
   1. PVC Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
      a. Pipe and fittings: Extruded from Type I, Grade 1, Class 12454-B material in accordance with ASTM D1784.
      b. PVC Pipe: Schedule 80 unless otherwise indicated on the Drawings.
   2. Fittings:
      a. Supplied by pipe manufacturer.
      b. Pressure fittings: In accordance with ASTM D2466 or ASTM D2467.
      c. DWV fittings: In accordance with ASTM D2665.
   3. Solvent cement: In accordance with ASTM D2564:
      a. Chemical service: For CPVC or PVC pipe in chemical service, provide the following primer and cement, or equal:
         1) Primer: IPS Corp Type P70.
         2) Cement: IPS Corp Type 724 cement or another cement certified by the manufacturer for chemical service.

2.03 PVC PIPING, CLASS TYPE

A. PVC pipe, Class Type: In accordance with AWWA C900:
   1. Pressure Class: as scheduled in Section 40_05_00.01 with a minimum DR of 25.
   2. Fittings: Cast or ductile iron fittings as specified in Section 40_05_19.01, sized for the dimensions of the pipe being used.
   3. Joint design: Push-on or mechanical joint type as identified in Piping Schedule.
   4. Gaskets: Neoprene or EPDM in accordance with ASTM D1869 or ASTM F477.

2.04 PVC GRAVITY SEWER PIPING

A. Materials:
   1. Polyvinyl chloride (PVC) gravity sewer pipe and fittings: In accordance with ASTM D3034 for piping NPS 15 and smaller diameter, and to ASTM F679 for piping NPS 18 and larger diameter:
      a. Referenced standards apply as complemented and modified in this Section.
      b. Fittings: Supplied by the pipe manufacturer.
   2. PVC compounds: Class Number 12454-C, in accordance with ASTM D1784:
      a. Stabilizers, antioxidants, lubricants, colorants, and other additives and fillers: Not to exceed 10 parts by weight per 100 of PVC resin in the compound.
   3. Pipe NPS 15 and smaller diameter: Wall thickness SDR 26:
      a. Joints: Push-on joints in accordance with ASTM D3212.
   4. Pipe NPS 18 and larger diameter:
      a. PVC compound: Cell classification 12454-C in accordance with ASTM D1784.
      b. Minimum pipe stiffness: PS 115.
      c. Joints: Integral bell gasketed joints in accordance with ASTM F679.
      d. Bell: Fabricated from pipe sections, thickness of the wall of the bell equivalent to the pipe wall thickness.
      e. Gasket ring: Locked into the bell.

f. Spigot end of the pipe: Marked by the manufacturer to identify the final in-place position of the spigot in the bell.

5. Fittings, including wyes, tees, elbow caps, plug adapters, and manhole waterstops: Same wall thickness as the pipe:
   a. Fittings: Factory molded with joints and gaskets equal to those of the pipe.
6. Gasket: Neoprene or EPDM in accordance with ASTM D3212 or ASTM F477:
   a. Keep rubber gasket in place during pipe joining.
7. Gasket for connection to manhole: Stainless steel clamp with gasket or similar device to seal the penetration.

2.05 PE TUBING AND FITTINGS

A. Materials:
1. Small bore PE tubing: Black flexible virgin PE tubing, OD copper tubing size.
   a. Plastic tubing ID as follows:
      1) For NS 1/4 inch, ID of 0.170 inch.
      2) For NS 5/16 inch, ID of 0.187 inch.
      3) For NS 3/8 inch, ID of 0.251 inch.
      4) For NS of 1/2 inch, an ID of 0.375 inch.
2. Fittings: Compression fittings, Dekoron E-Z; or equal.
3. Protective sheath:
   a. Manufacturers: One of the following or equal:
      1) Dekoron, "Poly-Cor."
      2) Parker Hannifin Corp./Fluidconnector Products, Parflex Division, Multitube.
4. Plug-in fittings for connection to instruments: Brass quick-connect fittings.

2.06 SOURCE QUALITY CONTROL

A. PVC piping, Schedule Type:
1. Mark pipe and fittings in accordance with ASTM D1785.

B. PVC piping, Class Type:
1. Hydrostatic proof testing in accordance with AWWA C900: Test pipe and integral bell to withstand, without failure, two times the pressure class of the pipe for a minimum of 5 seconds.

C. PVC gravity sewer piping:
1. Mark pipe and fittings in accordance with ASTM D3034. Also mark the production control code on pipe and fittings.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Where not otherwise specified, install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
2. Provide molded transition fittings for transitions from plastic to metal or IPS pipe. Do not thread plastic pipe.

3. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
4. Provide serrated nipples for transition from plastic pipe to rubber hose.

B. Installation of PVC piping, Schedule Type:
1. Solvent weld joints in accordance with ASTM D2855:
   a. For PVC pipe in chemical service use IPS Corp. Type 724 cement in accordance with manufacturer's instructions.
2. Install piping in accordance with manufacturer's published instructions.

C. Installation of PVC piping, Class Type:
1. Install piping in accordance with the Appendix of AWWA C900 complemented with manufacturer's published instructions.

D. Installation of PVC gravity sewer piping:
1. Install piping in accordance with manufacturer's published instructions, as modified and complemented in this Section.
2. Install pipe and fittings not later than 4 months after their manufacture.
3. Provide for contraction and expansion at joints with a gasket ring.
4. Provide plugs or caps for stubs and branch pipes left unconnected to laterals.
5. Lubricate and assemble joints in accordance with the pipe manufacturer's published instructions.
6. Make connections to manholes with a manhole gasket that prevents infiltration and exfiltration through the penetrations:
   a. Provide opening for connection large enough to allow subsequent grouting around the manhole gasket.
   b. Grout around the manhole gasket and seal the opening.

E. Installation of polyethylene (PE) tubing and fittings:
1. Install small bore PE tubing in accordance with manufacturer's printed instructions, in neat straight lines, supported at close enough intervals to avoid sagging, and in continuous runs wherever possible.
2. Bundle tubing in groups of parallel tubes within protective sheath.
3. Tubes within protective sheath may be color coded, but protect tubing other than black outside the sheath by wrapping with black plastic electrician's tape.
4. Grade tubing connected to meters in one direction.

3.02 FIELD QUALITY CONTROL

A. Leakage test for PVC piping, Class Type:
1. Polyvinyl chloride (PVC) piping, Class Type: Subject to visible leaks test and to pressure test with maximum leakage allowance, as specified in Section 40_05_00.09.
2. Pressure test with maximum leakage allowance: Perform test after backfilling:
   a. Pressure: 125 pounds per square inch, gauge.
   b. Maximum leakage allowance as follows, wherein the value for leakage is in gallons per 100 joints per hour:

NPS, Inches	**1-1/2**	**2**	**2-1/2**	**3**	**4**	**6**	**8**	**10**	**12**
Leakage	0.41	0.52	0.63	0.76	0.98	1.45	1.88	2.35	2.80

B. Mandrel tests for PVC gravity sewer piping:
1. Perform initial mandrel test:
a. After cleaning and completion of other tests.
b. After placement and compaction of backfill.
c. Before construction of pavement or surfacing.
d. Not sooner than 30 days after pipe installation.
e. Not later than 60 days after installation.
2. Utilize a 9 rod mandrel with minimum length equal to NPS and diameter as follows:

Nominal Pipe Size (NPS)	**Mandrel Diameter, inches**
6	5.50
8	7.37
10	9.21
12	10.96
15	13.56

3. Test procedure: Pull the mandrel through the line under test by 1 person, by hand, with reasonable effort, without the aid of mechanical equipment.
4. Failing test: Where the mandrel test is not successful, remove and replace the section of piping with the obstruction; test the piping again, including visible leaks test, pressure test with maximum leakage allowance, mandrel tests, and other specified tests:
a. Correction of excessive deflection or obstructions by methods other than removal of the affected piping and replacement of the removed piping with new piping will not be accepted.

END OF SECTION

SECTION 40_05_31.17

POLYVINYL CHLORIDE (PVC) PIPE: SCHEDULE TYPE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Schedule type PVC pipe and fittings.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 40_05_00.01 - Common Work Results for General Piping.
   3. Section 40_05_00.09 - Piping Systems Testing.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   2. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
   3. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   4. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
   5. D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride)(PVC) Pipe and Fittings.
   6. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.

B. NSF International (NSF):
   1. 61 - Drinking Water System Components – Health Effects.

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 40_05_00.01.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Protect from sunlight, scoring, and distortion.

B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.

C. Store and handle as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
   1. Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
      a. Extruded from Type I, Grade 1, Class 12454-B material in accordance with ASTM D1784.
      b. Schedule 80 unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 40_05_00.01.
   2. Fittings: In accordance with ASTM D2467.
      a. Same material as the pipe and of equal or greater pressure rating.
      b. Supplied by pipe manufacturer.
      c. Unions 2-1/2 inches and smaller:
         1) Use socket end screwed unions.
      d. Unions 3 inches and larger:
         1) Use socket flanges with 1/8-inch full-face soft neoprene or EPDM gasket.
   3. Solvent cement:
      a. In accordance with ASTM D2564.
      b. Manufacturers: The following or equal:
         1) IPS Corporation.
      c. Certified by the manufacturer for the service of the pipe.
      d. In potable water applications: Provide solvent cement listed by NSF for potable water applications.
      e. Primer: As recommended by the solvent cement manufacturer.

2.02 SOURCE QUALITY CONTROL

A. Meets or exceeds all quality assurance test requirements stated in ASTM D1785.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable.

B. Provide molded transition fittings for transitions from plastic to metal pipe.
   1. Do not thread pipe.

C. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.

D. Provide serrated nipples for transition from pipe to rubber hose.

E. Solvent weld joints in accordance with ASTM D2855.

3.02 FIELD QUALITY CONTROL

A. Test pipe as specified in Section 40_05_00.01 and Section 40_05_00.09.

END OF SECTION

SECTION 40_05_33.03

HIGH DENSITY POLYETHYLENE PLASTIC (HDPE) PIPE: AWWA C906

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: High Density Polyethylene Pipe (HDPE), and fittings.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 40_05_00.01 - Common Work Results for General Piping.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D1238 - Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.
   2. D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.
   3. D1599 - Standard Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings.
   4. D1603 - Standard Test Method for Carbon Black Content in Olefin Plastics.
   5. D2122 - Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings.
   6. D2290 - Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe by Split Disk Method.
   7. D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
   8. D3350 - Standard Specification for Polyethylene Plastic Pipe and Fittings Material.
   9. F645 - Standard Guide for Selection, Design, and Installation of Thermoplastic Water-Pressure Piping Systems.
   10. F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

B. Plastic Pipe Institute (PPI):
   1. PE 4710.

1.03 ABBREVIATIONS

A. HDPE: High-density polyethylene pipe.

B. ID: Inside diameter of piping or tubing.

C. OD: Outside diameter.

D. SDR: Standard dimension ratio.

1.04 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 40_05_00.01:
   1. Describe materials and installation equipment including fusion machine. Include optimum range of fusion conditions such as fusion temperature, interface pressure, and cooling time Pipe loads and structural calculations.
   2. Installation instructions.

C. Qualifications of installation crew for high-density polyethylene pipe including qualifications of the fusion machine technician. Furnish proof of training in the use of fusion equipment.

1.05 QUALITY ASSURANCE

A. Markings on the pipe shall be in accordance with AWWA C906.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect piping materials from sunlight, scoring, and distortion.

B. Do not allow surface temperatures on pipe and fittings to exceed 120 degrees Fahrenheit.

C. Store and handle PE pipe and fittings as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. Fittings: Same material as the pipe and of equal or greater pressure rating.

2.02 HDPE PIPING

A. General:
   1. Pipe and fittings: High-density polyethylene.
   2. Dimensions of pipe and fittings: Based on controlled outside diameter in accordance with ASTM F714:
      a. SDR: As given in Piping Schedule, Section 40_05_00.01; or, if not given, minimum SDR = 9.

B. Materials:
   1. Manufacturers: One of the following or equal:
      a. Performance Pipe.
      b. Isco Industries.
      c. Pipe, fittings, and adapters: Furnished by the same manufacturer, or compatible with components in the same system and with components of other systems to which connected.

2. Polyethylene: As listed by the PPI under the designation PE 4710; and have a minimum cell classification, in accordance with ASTM D3350, of 445574C:
   a. Pipe and fittings: Manufactured from material with the same cell classification.
   b. Manufacturer shall certify that pipe and fittings meet the above classifications.
3. Polyethylene fittings and custom fabrications:
   a. Molded or fabricated.
   b. Butt fusion outlets shall be made to the same outside diameter, wall thickness, and tolerances as the mating pipe.
   c. All fittings and custom fabrications shall be fully rated for the same internal pressure as the mating pipe.
   d. Pressure de-rated fabricated fittings are prohibited.
4. Molded fittings:
   a. Manufactured in accordance with ASTM D3261, Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing, and shall be so marked.
   b. Each production lot of molded fittings shall be subjected to the tests required under ASTM D3261.
5. X-ray inspection: The manufacturer shall submit samples from each molded fittings production lot to x-ray inspection for voids, and shall certify that voids were not found.
6. Fabricated fittings:
   a. Made by heat fusion joining specially machined shapes cut from pipe, polyethylene sheet stock, or molded fittings.
   b. Rated for internal pressure service at least equal to the full service pressure rating of the mating pipe.
7. Polyethylene flange adapters:
   a. Flange adapters shall be made with sufficient through-bore length to be clamped in a butt fusion joining machine without the use of a stub-end holder.
   b. The sealing surface of the flange adapter shall be machined with a series of small v-shaped grooves to provide gasketless sealing, or to restrain the gasket against blowout.
8. Back-up rings and flange bolts:
   a. Flange adapters shall be fitted with Type 304 or 316 stainless steel back-up rings pressure rated equal to or greater than the mating pipe.
   b. The back-up ring bore shall be chamfered or radiused to provide clearance to the flange adapter radius.
   c. Flange bolts and nuts shall be the same material as backing flange and as specified in Section 40_05_00.01.

2.03 SOURCE QUALITY CONTROL

A. HDPE piping:
   1. Manufacturer's quality control: The pipe and fitting manufacturer shall have an established quality control program responsible for inspecting incoming and outgoing materials.
   2. Incoming polyethylene materials:
      a. Inspected for density, melt flow rate, and contamination.
      b. The cell classification properties of the material shall be certified by the supplier, and verified by manufacturer's quality control.
      c. Approved by quality control before processing into finished goods.

3. Outgoing materials shall be checked for:
   a. Outside diameter, wall thickness, and eccentricity in accordance with ASTM D2122 at a frequency of at least once per hour.
   b. Out of roundness at a frequency of at least once per hour.
   c. Straightness, inside and outside surface finish, markings and end cuts shall be visually inspected in accordance with ASTM F714 on every length of pipe:
      1) Quality control shall verify production checks and test for:
         a) Density in accordance with ASTM D1505 at a frequency of at least once per extrusion lot.
         b) Melt Index in accordance with ASTM D1238 at a frequency of at least once per extrusion lot.
         c) Carbon content in accordance with ASTM D1603 at a frequency of at least once per day in accordance with extrusion line.
         d) Quick burst pressure in accordance with ASTM D1599 at a frequency of at least once per day per line.
         e) Ring Tensile Strength in accordance with ASTM D2290 at a frequency of at least once per day per line.
   d. X-ray inspection shall be used to inspect molded fittings for voids, and knit line strength shall be tested. All fabricated fittings shall be inspected for joint quality and alignment.
4. Permanent records: The manufacturer shall maintain permanent QC and QA records.
5. Compliance tests:
   a. Manufacturer's inspection and testing of the materials.
      1) In case of conflict with manufacturer's certifications, the Contractor, Engineer, or Owner may request retesting by the manufacturer or have retests performed by an outside testing service.
      2) All retesting shall be at the requestor's expense, and shall be performed in accordance with this Section.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Where not otherwise specified, install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
   2. Provide molded transition fittings for transitions from HDPE to metal or IPS pipe. Do not thread or solvent weld HDPE pipe.

B. Installation of HDPE piping:
   1. Joining:
      a. Heat fusion joining:
         1) Joints between plain end pipes and fittings shall be made by butt fusion, and joints between the main and saddle branch fittings shall be made utilizing saddle fusion employing only procedures that are recommended by the pipe and fitting manufacturer.
         2) The Contractor shall certify, in writing, that persons making heat fusion joints have received training in the manufacturer's

recommended procedure and have had at least 3 years current experience in the heat fusion butt welding process.

3) The Contractor shall maintain records of trained personnel, and shall certify that training was received not more than 12 months before commencing construction.
4) External and internal beads shall not be removed.

b. Heat fusion training services: The manufacturer shall provide training in the manufacturer's recommended butt fusion and saddle fusion procedures to the Contractor's installation personnel, and to the inspector(s) representing the Owner, prior to the start of construction.

c. Mechanical joining:
1) Polyethylene pipe and fittings may be joined together or to other materials by means of flanged connections (flange adapters and back-up rings) or, where specifically indicated on the Drawings, flexible couplings designed for joining polyethylene pipe or for joining polyethylene pipe to another material.
2) Flexible couplings shall be fully pressure rated and fully thrust restrained such that when installed in accordance with manufacturer's recommendations, a longitudinal load applied to the mechanical coupling will cause the pipe to yield before the mechanical coupling disjoins.

2. Installation:

a. General:
1) The Manufacturer shall package products for shipment in a manner suitable for safe transport by commercial carrier.
2) When delivered, a receiving inspection shall be performed, and any shipping damage shall be reported to the manufacturer within 7 days.
3) Damaged pipe shall be promptly removed from the job site.
4) Installation shall be in accordance with manufacturer's recommendations, and this specification.
5) Prior to making a terminal connection of each individual run of HDPE pipe, the temperature of the pipe should be allowed to approach the service temperature at which the pipe is intended to operate.
6) All necessary precautions shall be taken to ensure a safe working environment in accordance with applicable codes and standards.

b. Large diameter fabricated fittings: Fabricated fittings shall be butt fused to the end of a pipe.

c. Mechanical joint and flange installation:
1) Mechanical joints and flange connections shall be installed in accordance with the manufacturer's recommended procedure.
2) Flange faces shall be centered and aligned to each other before assembling and tightening bolts.
3) Every effort shall be made to ensure that the opposing faces of the flange assemblies mate up securely at a temperature approximately the same as the service temperature.
4) In no case shall the flange bolts be used to draw the flanges into alignment.
5) Bolt threads shall be lubricated, and flat washers shall be fitted under the flange nuts.
6) Bolts shall be evenly tightened according to the tightening pattern and torque step recommendations of the manufacturer.

7) At least 1 hour after initial assembly, flange connections shall be re-tightened following the tightening pattern and torque step recommendations of the manufacturer.
8) The final tightening torque shall be 100 feet-pounds or less as recommended by the manufacturer.

d. Pipe handling:
1) Lift, move, or lower pipe and fittings only with wide fabric choker slings.
2) Wire rope or chain shall not be used.
3) Slings shall be of sufficient capacity for the load, and shall be inspected before use.
4) Worn or defective equipment shall not be used.

3.02 FIELD QUALITY CONTROL

A. Testing:
1. Butt fusion testing:
a. Pipe size 14 inch and larger:
1) The first fusion of each day shall be a trial fusion.
a) The trial fusion shall be allowed to cool completely.
b) Fusion test straps shall be cut out.
(1) The test strap shall be 12 inches (minimum) or 30 times the wall thickness in length with the fusion in the center, and 1 inch (minimum) or 1.5 times the wall thickness in width.
c) Bend the test strap until the ends of the strap touch.
2) If the fusion fails at the joint, a new trial fusion shall be made, cooled completely, and tested.
3) Butt fusion of pipe to be installed shall not commence until a trial fusion has passed the bent strap test.
b. Pipe size smaller than 14 inch:
1) Test daily using ultrasonic time-of-flight diffraction (TOFD) per ISO/DIS 10863, Welding – Use of time-of-flight diffraction technique.

B. Data logging and test data:
1. A data logger shall be installed on the fusion heated joining machine. Data on each joint shall be recorded by the data logger. Data to be recorded shall be minimum temperature of joint fusion and interface pressure of the fused joint.
2. Recorded data from the fusion data logger and the TOFD shall be transmitted to the Owner daily.

C. Pressure testing:
1. Test pressures as specified in Section 40_05_00.01.
2. Temperature of test water shall be no more than 73 degrees Fahrenheit.

END OF SECTION

SECTION 40_05_41.01

RUBBER HOSE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Hose.

1.02 SUBMITTALS

A. Product data: Manufacturer's data indicating service type, sizes, materials, and required accessories.

PART 2 PRODUCTS

2.01 HOSE

A. Hose material: Neoprene or acceptable oil resistant material suitable for a working pressure of minimum 100 pounds per square inch, gauge.

B. Size as indicated on the Drawings fit ends with appropriate combination clamped nipples and threaded ends as indicated on the Drawings.

C. Hose 1/2 inch through 1-1/2 inch nominal diameter: General purpose hose. Provide one 75 foot long hose for each utility station (hose bib and hose rack) provided.
   1. Manufacturers: One of the following or equal:
      a. Goodyear Rubber Products Corp.
      b. Uniroyal.
      c. Goodall Rubber Company.

D. Equip and fit hose ends with appropriate combination clamped nipples and threaded ends to make up the assembly indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install hose in accordance with manufacturer's published instructions.

END OF SECTION

SECTION 40_05_51.01

COMMON WORK RESULTS FOR VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic requirements for valves.

B. Related sections:
1. Section 01_33_00 - Submittal Procedures.
2. Section 01_75_17 - Commissioning.
3. Section 01_78_23 - Operation and Maintenance Data.
4. Section 09_96_01 - High-Performance Coatings.
5. Section 40_05_19.01 - Ductile Iron Pipe: AWWA C151.

1.02 REFERENCES

A. American Water Works Association (AWWA):
1. C111/A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe Fittings.

B. ASTM International (ASTM):
1. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
2. A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
3. A536 - Standard Specification for Ductile Iron Castings.

C. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.

D. Society for Protective Coatings (SSPC):
1. SP 7 - Brush-Off Blast Cleaning.
2. SP 10 - Near-White Blast Cleaning.

1.03 DESIGN REQUIREMENTS

A. Pressure rating:
1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.
2. When a piping system is specified in the Piping Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for that piping system with design working pressure which is sufficient to withstand the test pressure.

B. Valve to piping connections:
1. Valves 3 inch nominal size and larger: Flanged ends.
2. Valves less than 3 inch nominal size: Screwed ends.

3. Plastic valves in plastic piping:
   a. Up to 2.5 inches: Provide solvent or heat welded unions.
   b. 3 inches and above: Provide solvent or heat welded flanges.

1.04 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data:
   1. Submit the following information for each valve:
      a. Valve type, size, pressure rating, Cv factor.
      b. Coatings.
      c. Power valve actuators:
         1) Information on valve actuator including size, manufacturer, model number, limit switches, mounting; and motor enclosure, seating and unseating torque coefficient, dynamic torque, and bearing friction for calculation of maximum operating torque.
         2) Complete wiring diagrams and control system schematics.
      d. Manual valve actuators:
         1) Information on valve actuator including size, manufacturer, model number.
      e. Certified drawings with description of component parts, dimensions, weights, and materials of construction.
      f. Certifications of reference standard compliance:
         1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
      g. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
      h. Factory test data.

C. Provide vendor operation and maintenance manual as specified in Section 01_78_23.
   1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inch in nominal size and larger, and all non-manual valves. Include information on valve operators.

D. Provide Manufacturer’s Certificate of Source Testing as specified in Section 01_75_17.

E. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01_75_17.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications:
   1. Valves manufactured by manufacturers whose valves have had successful operational experience in comparable service.

1.06 DELIVERY STORAGE AND HANDLING

A. Protect valves and protective coatings from damage during handling and installation; repair coating where damaged.

PART 2 PRODUCTS

2.01 MATERIALS

A. Stainless steel: In accordance with ASTM A167, Type 316, or Type 304, UNS Alloy S31600 or S30400.

B. Valve and operator bolts and nuts:
   1. Fabricated of stainless steel for the following installation conditions:
      a. Submerged in sewage or water.
      b. In an enclosed space above sewage or water.
      c. In structures containing sewage or water, below top of walls.
      d. At openings in concrete or metal decks.
   2. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.
   3. Underground bolts: Low-alloy steel in accordance with AWWA C111/A21.11.

C. Bronze and brass alloys: Use bronze and brass alloys with not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts; UNS Alloy C83600 or C92200 unless specified otherwise.

D. Valve bodies: Cast iron in accordance with ASTM A126, Class 30 minimum or ductile iron in accordance with ASTM A536, Grade 65-45-12 minimum unless specified otherwise.

2.02 INTERIOR PROTECTIVE LINING

A. When specified in the particular valve specification, provide valves with type of protective lining specified in the particular valve Specification.

B. Apply protective lining to interior, non-working surfaces, except stainless steel surfaces.

C. Lining types:
   1. Fusion bonded epoxy:
      a. Manufacturers: One of the following or equal:
         1) 3-M Company, ScotchKote 134; certified to NSF 61 for drinking water use.
      b. Clean surfaces in accordance with SSPC SP 7 or SP 10, as recommended by epoxy manufacturer.
      c. Apply in accordance with manufacturer's published instructions.
      d. Lining thickness: 0.010 to 0.012 inches except that:
         1) Lining thickness in grooves for gaskets: 0.005 inches.
         2) Do not coat seat grooves in valves with bonded seat.
      e. Quality control:
         1) Lining thickness: Measured with a non-destructive magnetic type thickness gauge.
         2) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the lining manufacturer.
         3) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.

4) Correct defective lining disclosed by unsuccessful tests, and repeat test.
5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.

2. High solids epoxy:
   a. Product equivalent to high solids epoxy specified in Section 09_96_01.
      1) Certified in accordance with NSF 61 for drinking water use.
      2) Interior: Coat valve interior with manufacturer's equivalent high performance high solids epoxy coating system with a certifiable performance history for the service conditions and as approved by the Engineer. Manufacturer shall provide for approval, coating information sufficient to allow Engineer to assess equivalence to the specified high solids epoxy coating specified in Section 09_96_01.
   b. Clean surfaces to meet SP-7 or SP-10, or as recommended by coating manufacturer.
   c. Quality control: After coating is cured, check coated surface for porosity with a holiday detector set at 1,800 volts, or as recommended by coating manufacturer.
      1) Repair holidays and other irregularities and retest coating.
      2) Repeat procedure until holidays and other irregularities are corrected.

2.03 UNDERGROUND VALVES

A. Provide underground valves with flanged, mechanical, or other type of joint required for the type of pipe to which the valve is to be connected.

B. Coating and wrapping:
   1. After installation, encase valves in 2 layers of polyethylene wrap as specified for ductile iron piping in Section 40_05_19.01.
      a. Ascertain that polyethylene wrapping does not affect operation of valve.

2.04 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09_96_01.
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
   2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

2.05 VALVE BOXES

A. Provide cast-iron valve boxes at each buried valve to access valve and valve operators.

B. Do not support boxes on valve, valve operator, or pipe.

C. Boxes:
  1. 2-piece, fabricated of cast iron; provide cover, with asphalt varnish or enamel protective coating.
  2. Adjustable to grade, install centered around the upper portions of the valve and valve operator.

D. Manufacturers: One of the following or equal:
  1. Tyler Pipe Industries, Inc.
  2. Neenah Foundry Company.

2.06 VALVE OPERATORS

A. Valve operator "Open" direction: Open counterclockwise.

B. Provide valves located below operating level or deck with extensions for key operation or floor stands and handwheels.

C. Provide manually operated valves located not more than 6 feet above the operating level with tee handles, wrenches, or handwheels.
  1. Make the valve operator more conveniently accessible by rolling valves, located more than 5 feet but less than 6 feet above the operating level, toward the operating side.
  2. Secure tee handles and wrenches to the valve head or stem, except where a handle or wrench so secured constitutes a hazard to personnel; in which case, stow handle or wrench immediately adjacent to the valve on or in a suitable hanger, bracket, or receptacle.

D. Fit valves located more than 6 feet above operating level with chain operated handles or valve wheels.
  1. Chains: Sufficient length to reach approximately 4 feet above the operating level.
  2. Where chains constitute a nuisance or hazard to operating personnel, provide holdbacks or other means for keeping the chains out of the way.

E. Provide an operator shaft extension from valve or valve operator to finished grade or deck level when buried valves, and other valves located below the operating deck or level, are specified or indicated on the Drawings to be key operated; provide 2 inch square AWWA operating nut, and box and cover as specified, or a cover where a box is not required.

PART 3 EXECUTION

3.01 EXAMINATION

A. Preparation prior to installation:
  1. Install valves after the required submittal on installation has been accepted.
  2. Determine after flanged valves and flanged check valves are selected, the face-to-face dimensions of flanged valves and flanged check valves.

B. Fabricate piping to lengths taking into account the dimensions of flanged valves and flanged check valves.

3.02 INSTALLATION

A. Provide incidental work and materials necessary for installation of valves including flange gaskets, flange bolts and nuts, valve boxes and covers, concrete bases, blocking, and protective coating.

B. Where needed, furnish and install additional valves for proper operation and maintenance of equipment and plant facilities under the following circumstances:
   1. Where such additional valves are required for operation and maintenance of the particular equipment furnished by Contractor.
   2. Where such additional valves are required as a result of a substitution or change initiated by Contractor.

C. Install valves with their stems in vertical position above the pipe, except as follows:
   1. Butterfly valves, gate valves aboveground, globe valves, ball valves, and angle valves may be installed with their stems in the horizontal position.
   2. Install buried plug valves with geared operators with their stems in a horizontal position.

D. Install valves so that handles clear obstructions when the valves are operated from fully open to fully closed.

E. Place top of valve boxes flush with finished grade or as otherwise indicated on the Drawings.

F. Valves with threaded connections:
   1. Install valves by applying wrench on end of valve nearest the joint to prevent distortion of the valve body.
   2. Apply pipe joint compound or Teflon tape on external (male) threads to prevent forcing compound into valve seat area.

G. Valves with flanged connections:
   1. Align flanges and gasket carefully before tightening flange bolts.
   2. When flanges are aligned, install bolts and hand tighten.
   3. Tighten nuts opposite each other with equal tension before moving to next pair of nuts.

H. Valves with soldered connections:
   1. Do not overheat connection to prevent damage to resilient seats and metal seat rings.
   2. Position valves in full open position before starting soldering procedure.
   3. Apply heat to piping rather than to valve body.

3.03 COMMISSIONING

A. As specified in Section 01_75_17 and this Section.

B. Manufacturer services from each manufacturer for all valves supplied:
   1. Provide Manufacturer’s Certificate of Source Testing.
   2. Provide Manufacturer’s Certificate of Installation and Functionality Compliance.

C. As specified elsewhere for specific valve types, sizes or actuators.
   1. Source testing.
   2. Manufacturers on site services for Owner Training, Installation Testing, Functional Testing, and during the Process Operational Period.

END OF SECTION

SECTION 40_05_52

SPECIALTY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Specialty valves.

B. As specified in Section 40_05_51.01.

C. Related sections:
1. Section 01_33_00 - Submittal Procedures.
2. Section 01_75_17 - Commissioning.
3. Section 01_78_36 - Warranties and Bonds.
4. Section 40_05_06.55 - Piping Insulation.
5. Section 40_05_51.01 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
1. 25 - Earthquake-Actuated Automatic Gas Shutoff Devices.

B. American Society of Mechanical Engineers (ASME):
1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.

C. American Water Works Association (AWWA):
1. C511 - Standard for Reduced Pressure-Principle Backflow-Prevention Assembly.
2. C800 - Underground Service Line Valves & Fittings (Also Included: Collected Standards For Service Line Materials).

D. ASTM International (ASTM):
1. A48 - Standard Specification for Gray Iron Castings.
2. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
4. A536 - Standard Specification for Ductile Iron Castings.
5. B584 - Standard Specification for Copper Alloy Sand Castings for General Application.

E. National Electrical Manufacturers Association (NEMA):
1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 DEFINITIONS

A. NEMA Type 4 enclosure in accordance with NEMA 250.

1.04 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 40_05_51.01.

C. Commissioning submittals:
  1. Backflow preventer certification.
  2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17.

1.05 WARRANTY

A. Provide warranty as specified in Section 01_78_36.

PART 2 PRODUCTS

2.01 RESERVOIR FILL VALVES

A. Manufacturers: One of the following or equal:
  1. Cla-Val Co., E-131.

B. Operation:
  1. Altitude control: Close at high water level and allow filling at levels less than high water level.
  2. Valve will open based on the pressure in the domestic water system to fill the reservoir at an operator selectable flow rate.
     a. Valve will modulate to maintain an operator selectable minimum system pressure.
  3. Valve will close from:
     a. High level signal from the reservoir level sensor.
     b. High-high level from the hydraulic pilot system.
     c. Range of height control: 5 to 40 feet.
     d. Factory setting of the valve shall be 26-feet.
  4. Flow direction: 1 way.
  5. Suitable at rated working pressure of 150 psi.

C. Design:
  1. Maximum pressure: 250-pound per square inch.
     a. Valve Manufacturer to provide anti-cavitation trim if pressure drop causes cavitation.
  2. Maximum continuous flow: 5,600 gallons per minute.
  3. Minimum continuous flow: 1,400 gallons per minute.
  4. Pattern: Globe.
  5. Control:
     a. Electronically actuated with hydraulic altitude back up.
  6. Pilot valve strainer.
  7. Adjustable pilot valve with stainless steel trim.
  8. Flanged ends.
  9. Reservoir sensing line: Shall be minimum 3/4-inch copper tubing.
  10. Electric Valve position indicator.
  11. Pilot insulation. Provide insulation to protect control valve pilots from freezing.

D. Materials:
   1. Valve body: Cast or ductile iron.
   2. Body trim: Bronze.
   3. Stem, nut, and spring: Type 303 stainless steel.
   4. Disc guide, seat and cover bearing: Type 304 or Type 316 stainless steel.

2.02 BACKFLOW PREVENTERS

A. Manufacturers: One of the following or equal:
   1. Febco backflow prevention:
      a. Model 860 all sizes.
   2. Zurn/Wilkins:
      a. Model 975XL for 1/2-inch through 2-inch.
      b. Model 375AST for sizes 2 1/2 inch, 3 inch, 8 inch, and 10 inch.
      c. Model 375 and 375DA for sizes 4 inch and 6 inch.
   3. Watts regulator: Series LF909.

B. Design: Reduced pressure chamber type in accordance with AWWA C511.

C. Lead-Free: For potable water installations not more than a weighted average of 0.25 percent lead when used with respect to the wetted surfaces.

D. Include shutoff valves at each end of backflow preventer with properly located test cocks.

E. Shutoff valves:
   1. Backflow preventers 2-inch and smaller: Provide with full-port, quarter turn, resilient seated ball valves.
   2. Backflow preventers larger than 2-inch: Provide with resilient seated, outside stem and yoke gate valves.

2.03 FIELD IRRIGATION VALVES

A. Manufacturers: One of the following or equal:
   1. Waterman Industries, Inc., Red Top Alfalfa valves.
   2. Snow gates and valves:
      a. Valves: Similar to Waterman Type 3 when used with cement-motor lined and coated steel pipe fittings.

B. Design: Provide valve with through-arm removable arch.

C. Materials:
   1. Valves: Fabricated with high strength close-grained gray iron with neoprene or EPDM ring backing.
   2. Screw: Low zinc bronze with square head for wrench operation, with Acme threads.

2.04 PUMP CONTROL VALVES

A. Manufacturers: One of the following or equal:
   1. Cla-Val Co., Model 60-11.
   2. GA Industries, Inc., Model 1730-D.

B. Operation:
   1. Opening and closing rates: Adjustable over a minimum range of 30 seconds to 2 minutes.
   2. Suitable at rated working pressure of 150 psi.
   3. Function as a check valve during power failure.

C. Design:
   1. Pilot valve strainer.
   2. Adjustable pilot valve with stainless steel trim.
   3. Flanged ends.
   4. Valve position indicator.
   5. Solenoid valve: 120 volts alternating current, Class F coil, NEMA Type 4 enclosure.
   6. Limit switch: 120 volts alternating current, NEMA Type 4 enclosure.

D. Materials:
   1. Valve body: Cast or ductile iron.
   2. Body trim: Bronze.
   3. Diaphragm: Buna-N rubber or EPDM.

2.05 SOLENOID VALVES

A. 2-way solenoid valves:
   1. Manufacturers: One of the following or equal:
      a. Automatic Switch Company, Series 8210.
      b. Skinner Electric Valve Division, Series C.

B. 3-way solenoid valves:
   1. Manufacturers: One of the following or equal:
      a. Automatic Switch Company, Series 8320.
      b. Skinner Electric Valve Division, Type A4.

C. 4-way solenoid valves:
   1. Manufacturers: One of the following or equal:
      a. Automatic Switch Company, Bulletin 8344.
      b. Skinner Electric Valve Division, Series V9.

D. Design:
   1. Valves: Suitable for service under the following conditions:
      a. Fluid: potable water.
      b. Temperature of fluid: 75 degrees Fahrenheit.
      c. Piping test pressure: 150 pounds per square inch gauge.
   2. Unless otherwise indicated on the Drawings, provide valves that:
      a. Minimum NEMA Type 4 enclosure.
      b. 120 VAC operation.
      c. Suitable for use as indicated on the Drawings.
      d. Minimum Class F coil insulation.
   3. 2-way valves: Furnish with openings of size equal to or larger than the nominal size designation of the valve.
   4. Furnish with manual/bypass operators.

E. Materials:
   1. Body: Brass or bronze.

2. Seats: Resilient material.

2.06 CORPORATION STOPS

A. Type: In accordance with AWWA C800.
   1. Manufacturers: One of the following or equal:
      a. Ford.
      b. Mueller Company.

2.07 COCKS

A. Gauge cock:
   1. Manufacturers: One of the following or equal:
      a. Lunkenheimer Company, Figure 1178 or Figure 1180.

B. Air cock:
   1. Manufacturers: One of the following or equal:
      a. Whitey Research Tool Company, Model B-42S4.
      b. Hoke, Inc., 7122G4B.

C. Plug cock:
   1. Manufacturers: One of the following or equal:
      a. Lunkenheimer Company, Figure 454.
   2. Design: Plug cocks: Bronze, straightway pattern complete with lever.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 40_05_51.01 in accordance with manufacturer's published instructions.

B. Install sensing line insulation as specified in Section 40_05_06.55 and as indicated on the Drawings.

C. Plastic body diaphragm valves for sodium hypochlorite service:
   1. When valves are installed horizontally, install valves with valve stem position rotated as necessary such that no internal valve obstruction prevents the passage of vapors traveling along the top of adjacent piping from traveling through the valve.

3.02 COMMISSIONING

A. As specified in Section 01_75_17 and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer’s Certificate of Installation and Functionality Compliance.
   2. Manufacturer’s Representative onsite requirements:
      a. For the following valves:
         1) Reservoir fill valves and pump control valves
      b. Installation: 1 trip, 1 day minimum.

c. Functional Testing: 1 trips, 1 day minimum each.
d. Training:
1) Maintenance: 2 hours per session, 2 sessions.
2) Operations: 2 hours per session, 2 sessions.

C. Functional testing:
1. Reservoir fill valves:
a. Test witnessing: Witnessed.
b. Conduct pressure and leak test as specified in Section 40_05_51.01.
2. Pump control valves:
a. Test witnessing: Witnessed.
b. Conduct pressure and leak test as specified in Section 40_05_51.01.

END OF SECTION

SECTION 40_05_57.13

MANUAL ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
1. Valve actuators.
2. Handwheel actuators.
3. Hand-cranked geared actuators.
4. Accessory equipment and floor boxes.

B. Related sections:
1. Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete And Masonry.
2. Section 09_96_01 - High-Performance Coatings.

1.02 REFERENCES

A. Aluminum Association (AA):
1. DAF-45 - Designation System for Aluminum Finishes.

B. American Water Works Association (AWWA).

C. National Electrical Manufacturers Association (NEMA):
1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

D. National Electrical Code (NEC).

1.03 DEFINITIONS

A. NEMA:
1. Type 4X enclosure in accordance with NEMA 250.
2. Type 7 enclosure in accordance with NEMA 250.

1.04 SUBMITTALS

A. Shop drawings: Include shop drawings and product data with associated gate or valve as an integrated unit.

1.05 QUALITY ASSURANCE

A. Provide valve actuators integral with valve, except for valve actuators utilizing T-wrenches or keys, and portable actuators intended to operate more than 1 valve.

B. Provide similar actuators by 1 manufacturer.

C. Provide gates and hand operating lifts by 1 manufacturer.

D. Provide hydraulic gate lifts by 1 manufacturer.

E. Provide hydraulic valve actuators and motorized actuators by 1 manufacturer.

1.06 MAINTENANCE

A. Extra materials:
   1. Key operated valve keys or wrenches: Furnish a minimum 4 keys with 4-foot shafts and 3-foot pipe handles or wrenches with 4-foot shafts and 3-foot handles for operating key operated valves.

PART 2 PRODUCTS

2.01 VALVE ACTUATORS

A. Valve actuators:
   1. Manual actuators:
      a. Material: Type 316 stainless steel.
      b. Design: Hand lever
      c. Spring release handle: 12-inch.
      d. Notch plate: 10 position.
      e. Secure with mounting bolts.
      f. Locking device so that valve can be locked in any position with a wing nut.
   2. Limit switches: Provide limit switches on manually actuated valves where indicated on the Drawings:
      a. Limit switches: Heavy-duty, industrial grade, oiltight, with not less than 2 auxiliary contacts.
      b. Rating: Rated for 10 amps, 120 volts alternating current.
      c. Enclosure: NEMA Type 4X enclosure and with stainless steel levers and arms.

B. Stem covers:
   1. Aluminum pipe:
   2. Threaded cap on top.
   3. Bolted aluminum flange on bottom.
   4. Slots cut 1- by 12-inch at 18 inches on center in front and back of pipe.
   5. Capable of covering threaded portion of greased stems that project above actuators when gates or valves are opened or closed.
   6. Ultraviolet light resistant, clear butyrate plastic or polycarbonate pipe:
      a. Capped on the upper end.
      b. Either threaded into the top of the gate operators or held in place by bolt-down aluminum brackets.
      c. Capable of covering threaded portion of greased stems that project above actuators when gates or valves are opened or closed.
   7. Staff gauges:
      a. Adhesive-backed mylar, suitable for outdoor service.
      b. Calibrated in hundredths of feet.
      c. Read the weir crest elevations directly.
      d. Gauge range: 1.5 feet minimum.
      e. Indicate the following elevations on each staff gauge:
         1) -0.75, -0.50, -0.25, 0.0, 0.25, 0.50, 0.75.

f. Supplement with a stem-mounted pointer or indicator that permits direct observation of the weir gate crest elevation.
g. Apply staff gauges to each stem cover after installation of the cover and after calibration and testing of the weir gates.
h. Set gauges precisely by a survey crew using instruments acceptable to the Engineer.

C. Stem cover flanges, pipes and caps:
1. After fabrication, etch and anodize to produce the following chemical finishes in accordance with AA publication DAF-45:
a. A 41 - Clear Anodic Coating.
b. C 22 - Medium Matte Finish.

D. Gate stem covers: Concentric with stem.

E. Position indicators:
1. For all aboveground worm gear or traveling nut manual actuators, provide position indication on the actuator enclosure.
2. Tail rods on hydraulic cylinders, or dial indicators with clear full-open and closed position indicators, calibrated in number of turns or percentage of opening.

F. Manual or power actuator size:
1. Sized to deliver maximum force required under most severe specified operating condition, including static and dynamic forces, seat and wedge friction, and seating and unseating forces with safety factor of 5, unless otherwise specified.

G. Actuator size: Capable of supporting weight of suspended shafting unless carried by bottom thrust bearings; shaft guides with wall mounting brackets.

H. Provisions for alternate operation: Where specified or indicated on the Drawings, position and equip crank or handwheel operated geared valve actuators or lifts for alternate operation with tripod mounted portable gate actuators.

I. Operation: Counterclockwise to open with suitable and adequate stops, capable of resisting at least twice normal operating force to prevent overrun of valve or gate in open or closed position.

J. Open direction indicator: Cast arrow and legend indicating direction to rotate actuator on handwheel, chain wheel rim, crank, or other prominent place.

K. Buried actuator housing: Oil and watertight, specifically designed for buried service, factory packed with suitable grease, completely enclosed space between actuator housing and valve body so that no moving parts are exposed to soil; provide actuators with 2-inch square AWWA operating nut.

L. Worm gear actuators: Provide gearing on worm gear actuators that is self-locking with gear ratio such that torque in excess of 160 foot-pounds will not need to be applied to operate valve at most adverse conditions for which valve is designed.

M. Traveling nut actuators: Capable of requiring maximum 100 foot-pounds of torque when operating valve under most adverse condition; limit stops on input shaft of manual actuators for fully open and closed positions; non-moving vertical axis of operating nut when opening or closing valve.

2.02 HAND-CRANKED GEARED ACTUATORS

A. Type: Single removable crank; fully enclosed.

B. Mounting: Floor and bench stand. Unless otherwise indicated on the Drawings position actuator 36 inches (nominal) above top of walkway surface.

C. Operating nut: When scheduled for portable actuators.

D. Geared lifts: 2-speed with minimum ratio of 4 to 1.

E. Teeth on gears, spur pinions, bevel gears, and bevel pinions: Cut.

F. Lift nuts: Cast manganese bronze.

G. Exterior surfaces on cast-iron lift parts: Smooth.

H. Bearings above and below flange on lift nuts: Ball or roller; capable of taking thrust developed by opening and closing of gates under maximum operating head; with bronze sleeve bearings and sufficient grease fittings for lubrication of moving parts, including bearings and gears.

I. Crank rotation indicator: Cast arrow with word OPEN in prominent location readily visible indicating correct rotation of crank to open gate.

J. Hand cranks: 15-inch radius; requiring maximum 25 pounds pull to operate gate at maximum operating head; with:
   1. Revolving brass sleeves.
   2. Gears, spur pinions, bevel gears, and bevel pinions with cut teeth.
   3. Cast manganese bronze lift nuts.
   4. Cast-iron lift parts with smooth exterior surfaces.

K. Indicator: Dial position type mounted on gear actuator; enclosed in cast-iron or aluminum housing with clear plastic cover; marked with fully open, 3/4, 1/2, 1/4, and closed positions.

2.03 FLOOR BOXES

A. Manufacturers: One of the following or equal:
   1. Waterman industries, Inc.

B. Floor boxes: Cast-iron; with:
   1. Counter type indicator.
   2. Hinged, lockable lid with directional arrow.
   3. 2-inch square AWWA operating nut.
   4. Packing gland providing drip-tight seal around valve shaft.

2.04 BENCH STANDS

A. Manufacturers: One of the following or equal:
   1. Rodney Hunt Company.
   2. Waterman industries, Inc.

B. Bench stands: Handwheel actuators or hand crank, geared actuators conforming to hand-cranked geared actuator requirements, except capacity to be mounted on haunch, wall bracket, or self-contained gate yoke.

2.05 ACCESSORY EQUIPMENT

A. Wall brackets or haunches: As indicated on the Drawings.

B. Stems: Stainless steel; sized to match output of actuator; minimum gate or valve operating stem diameter; maximum 200 slenderness ratio.

C. Stem couplings: Stainless steel; internally threaded to match stem; lockable to stem by set screw.

D. Stem guides: Cast-iron with silicon bronze bushing; maximum 200 slenderness ratio; capable of being mounted with wall bracket; adjustable in 2 directions.

E. Wall brackets: Cast-iron, capable of withstanding output of actuator, adjustable in 2 directions.

F. Stem stuffing boxes: Cast-iron, with adjustable gland and packing.

G. Fasteners: Type 316 stainless steel.

H. Anchor bolts: As specified in Section 05_05_24 except that the material shall be Type 316 stainless steel.

I. Geared valve actuators: Provided with cut gears, either spur or worm; sized to operate valves at most adverse design condition; with maximum 40-pound pull at handwheel or chain wheel rim.

J. Geared valve traveling nut actuators: Acceptable only where specified or indicated on the Drawings.

K. Accessory equipment for valves and gates requiring remote actuators: Operating stems, stem couplings, stem guides, wall brackets, and stem stuffing boxes.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install floor boxes in concrete floor with lid flush with floor.

B. After installation of gate and stem covers, mark stem covers at point where top of stems are at full-open position and at closed position.

C. Attach floor stand to structure with anchor bolts.

D. Install stem stuffing boxes where operating stems pass through intermediate concrete floor slabs.

3.02 SCHEDULES

A. Geared actuators: Provide geared actuators for following valves:
   1. Butterfly valves larger than 6 inches, nominal size, on liquid service.
   2. Butterfly valves larger than 10 inches, nominal size, on gas and air service.
   3. Plug valves 6 inches, nominal size, and larger.

B. Handwheel actuators: Provide handwheel actuators for valves mounted 6 feet or less above floors.

C. Chain wheel actuators: Provide chain wheel actuators for valves mounted more than 6 feet to centerline above floors.

END OF SECTION

SECTION 40_05_63

BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Ball valves.

B. As specified in Section 40_05_51.01.

C. Related sections:
1. Section 01_33_00 - Submittal Procedures.
2. Section 01_75_17 - Commissioning.
3. Section 01_78_36 - Warranties and Bonds.
4. Section 09_96_01 - High-Performance Coatings.
5. Section 40_05_00.01 - Common Work Results for General Piping.
6. Section 40_05_51.01 - Common Work Results for Process Valves.
7. Section 40_05_57.23 - Electric Motor Actuators.
8. Section 40_05_57.64 - Pneumatic Controllers and Control Valves.
9. Section 40_05_57.65 - Hydraulic and Pneumatic Cylinder Operators.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

B. American Water Works Association (AWWA):
1. C507 - Standard for Ball Valves 6 Inch Through 48 Inch.

C. ASTM International (ASTM):
1. A48 - Standard Specification for Gray Iron Castings.
2. A216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
3. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.

1.03 SYSTEM DESCRIPTION

A. General: Unless otherwise indicated on the Drawings use:
1. Metal body ball valves on metallic pipelines.
2. Plastic body ball valves on plastic pipelines.

B. Do not use metal body ball valves in sodium hypochlorite or sodium bisulfite systems.

1.04 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 40_05_51.01:
   1. Metal body ball valves: 6 inches and larger only: Submit affidavit of compliance in accordance with AWWA C507.
   2. Operation and maintenance manual.

C. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17.

1.05 WARRANTY

A. Provide warranty as specified in Section 01_78_36.

PART 2 PRODUCTS

2.01 METAL BODY BALL VALVES, LESS THAN 6 INCH SIZE

A. Manufacturers: One of the following, or equal:
   1. Apollo Valves as manufactured by Conbraco Industries, Inc.
   2. Metso Automation/Jamesbury.
   3. NIBCO, Inc.
   4. Flow-Tek, Inc.

B. General:
   1. Type: Non-lubricated, full port and capable of sealing in either direction.
   2. End connections:
      a. Threaded or solder ends for sizes 3-inch and smaller.
      b. Class 150 flanged for sizes larger than 3 inch.
         1) Flanges: In accordance with ASME B16.1 standards.
   3. Stem packing: Manually adjustable while valve is under pressure.
   4. Shafts:
      a. Rigidly connected to the ball by a positive means.
         1) Design connection to transmit torque equivalent to at least 75 percent of the torsional strength of the shaft.
   5. Handles: Stainless steel latch lock handle with vinyl grip and stainless steel nut designed to open and close the valve under operating conditions.
   6. Temperature limits: Suitable for operation between minus 20 and 350 degrees Fahrenheit.

C. Materials:
   1. Valves in copper lines: Bronze body.
   2. Valves in steel and ductile iron piping: Ductile iron or cast steel body.
   3. Valves in stainless steel piping: Stainless steel body, material type to match piping material as specified in Section 40_05_00.01.
   4. Ball: Type 304 or 316 stainless steel, Type 316 in digester gas applications.
   5. Seats: PTFE.
   6. Stem seals: PTFE or Viton.

7. Bearings: Self-lubricated, corrosion resistant material that will not contaminate potable water.
8. Valves for combustible fluid applications (digester gas, natural gas, fuel oil, etc.) must be of fire safe design.

2.02 PLASTIC BODY BALL VALVES

A. Manufacturers: One of the following or equal:
   1. Asahi America.
   2. Chemtrol Division, NIBCO, Inc.
   3. Plast-O-Matic Valves, Inc.
   4. CRANE ChemPharma & Energy
   5. Georg Fischer Piping Systems.

B. General:
   1. Type: Non-lubricated and capable of sealing in either flow direction.
   2. End connections: True union; solvent or heat welded to piping.
   3. Operator handle: Lever.

C. Materials:
   1. Body: Polyvinyl chloride (PVC).
   2. Ball: Polyvinyl chloride (PVC).
   3. Seats: PTFE (Teflon).
   4. O-rings: FKM (Viton).

D. Valve actuator:
   1. Manually operated valves: Self-locking worm gear type actuator with position indicator. Permanently lubricate gearing. Provide adjustable screws to stop travel at both open and closed positions.
   2. Hydraulically operated valves: Provide hydraulic cylinder operator as specified in Section 40_05_57.65.
   3. Pneumatically operated valves: Provide pneumatic cylinder operator as specified in Section 40_05_57.64.
   4. Electric motor operated valves: Provide electric motor operator as specified in Section 40_05_57.23.

E. Factory testing:
   1. Shell test: With valve in the open position, conduct hydrostatic test of the valve body at 1.5 times the maximum rated pressure for 7 minutes.
   2. Seat test: With valve in the closed position, conduct hydrostatic test of the valve seat seals at 1.1 times the maximum rated pressure for 7 minutes. Test each seat independently.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install each type of valve in accordance with manufacturers' printed instructions.

B. Special techniques:
   1. PVC ball valves for hypochlorite service:
      a. Provide valve with factory drilled 0.125-inch hole in the upstream side of the ball.
      b. Provide an engraved plastic tag permanently attached to the valve stem stating "One side of ball drilled for hypochlorite service".

3.02 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09_96_01.
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
   2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

3.03 COMMISSIONING

A. As specified in Section 01_75_17 and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test, as specified in Section 40_05_51.01.

END OF SECTION

SECTION 40_05_64

BUTTERFLY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Butterfly valves.

B. As specified in Section 40_05_51.01.

C. Related sections:
1. Section 01_33_00 - Submittal Procedures.
2. Section 01_75_17 - Commissioning.
3. Section 01_78_36 - Warranties and Bonds.
4. Section 09_96_01 - High-Performance Coatings.
5. Section 40_05_19.01 - Ductile Iron Pipe: AWWA C151.
6. Section 40_05_51.01 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
1. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Classes 25, 125 and 250.
2. B16.5 - Pipe Flanges and Flanged Fittings, NPS 1/2 through NPS 24.

B. American Water Works Association (AWWA):
1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
2. C504 - Rubber-Seated Butterfly Valves.
3. C540 - Standard for Power-Actuating Devices for Valves and Sluice Gates.
4. C550 - Protective Interior Coatings for Valves & Hydrants.
5. C606 - Standard for Grooved and Shouldered Joints.

C. ASTM International (ASTM):
1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
2. A216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for Higher-Temperature Service.
3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
4. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
5. A395 - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
6. A479 - Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.
7. A515 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate - and Higher-Temperature Service.
8. A516 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate - and Lower-Temperature Service.
9. A536 - Standard Specification for Ductile Iron Castings.

10. A564 - Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
11. A582 - Standard Specification for Free-Machining Stainless Steel Bars.
12. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
13. A890 - Standard Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application.
14. B462 - Standard Specification for Forged or Rolled UNS N06030, UNS N06022, UNS N06035, UNS N06200, UNS N06059, UNS N10362, UNS N06686, UNS N08020, UNS N08024, UNS N08026, UNS N08367, UNS N10276, UNS N10665, UNS N10675, UNS N10629, UNS N08031, UNS N06045, UNS N06025, UNS R20033 Alloy Pipe Flanges, Forged Fittings, and Valves and Parts for Corrosive High-Temperature Service.
15. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
16. B691 – Standard Specification for Iron-Nickel-Chromium-Molybdenum Alloys (UNS N08366 and UNS N08367) Rod, Bar, and Wire.
17. D429 - Standard Test Methods for Rubber Property-Adhesion to Rigid Substrate.

D. Compressed Gas Association (CGA):
   1. Standard G-4.1 - Cleaning Equipment for Oxygen Service.

E. NSF International (NSF):
   1. Standard 61 - Drinking Water System Components - Health Effects.
   2. Standard 372 - Drinking Water System Components - Lead Content.

F. United States Code of Federal Regulations (CFR):
   1. 21 - Food and Drugs.

1.03 SYSTEM DESCRIPTION

A. Design requirements:
   1. General purpose AWWA butterfly valves:
      a. Design standard: Provide valves designed and manufactured in accordance with AWWA C504.
      b. Class:
         1) Provide butterfly valves in accordance with AWWA Class 150B, unless otherwise specified.

B. Usage:
   1. Provide and install butterfly valve types as outlined in the Butterfly Valve Application Schedule at the end of this Section.

C. Design requirements for all butterfly valves with power actuating devices:
   1. Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C540, using the following values:
      a. Maximum water velocity: 16 feet per second with valve fully open.

b. Maximum pressure differential across the closed valve equal to the pressure class designation.

c. Coefficient for seating and unseating torque, dynamic torque, and bearing friction in accordance with valve manufacturer's published recommendations.

2. Valve disc: Seat in an angular position of 90 degrees to the pipe axis and rotate an angle of 90 degrees between fully open and fully closed positions:

a. Do not supply valves with stops or lugs cast with or mechanically secured to the body of the valve for limiting the disc travel.

3. Unacceptable thrust bearings: Do not provide valves with thrust bearings exposed to the fluid in the line and consisting of a metal bearing surface in rubbing contact with an opposing metal bearing surface.

D. Performance requirements:

1. Tight shutoff at the pressure rating of the valve with pressure applied in either direction.

2. Suitable for the following service conditions:

a. Throttling.

b. Frequent operation.

c. Operation after long periods of inactivity.

d. Installation in any position and flow in either direction.

1.04 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 40_05_51.01.

1. For general purpose AWWA butterfly valves, include description of the method of attachment of the disc edge to the valve disc.

2. Interior epoxy coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of butterfly valves comply with all provisions in accordance with AWWA C550.

3. Certification, for valves and coatings in contact with potable water, that the products used are suitable for contact with drinking water in accordance with NSF Standard 61 and Standard 372.

C. Commissioning submittals:

1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01_75_17.

1.05 WARRANTY

A. Provide warranty as specified in Section 01_78_36.

PART 2 PRODUCTS

2.01 GENERAL PURPOSE AWWA BUTTERFLY VALVES

A. Manufacturers: One of the following or equal:

1. DeZurik/Sartell Model BAW.

2. Henry Pratt Company.

B. Valve body:
   1. Material: Cast iron, ASTM A126, Grade B, or ductile iron, ASTM A536, Grade 65-45-12.
   2. Body design:
      a. Flanged body valves:
         1) Usage: Comply with limitations specified in the Butterfly Valve Application Schedule.
         2) Flanges: In accordance with ASME B16.1 Class 125 flanges for Class 150B valves, in accordance with ASME B16.1 Class 250 flanges for Class 250B valves.
      b. Mechanical joint body valves:
         1) Usage: Comply with limitations specified in the Butterfly Valve Application Schedule.
         2) Mechanical joint design: In accordance with AWWA C110.
         3) When mechanical joint body valves are used, incorporate valve into thrust restraint analysis as specified in Section 40_05_19.01. Utilize test pressure on one side of valve and zero pressure on the opposite side of the valve. Restrain pipe joints on both sides of valve as determined by thrust analysis calculations.
      c. Grooved end body valves:
         1) Usage: Butterfly valves with grooved ends may be used in piping systems specified in the Piping Schedule to have grooved end joints. Comply with additional limitations specified in the Butterfly Valve Application Schedule.
         2) Grooved end joint design: In accordance with AWWA C606.

C. Disc:
   1. Material: Cast iron or ductile iron with Type 316 stainless steel edge that matches seat in valve body.
   2. Secure valve disc to shaft by means of smooth-sided, taper or dowel pins, Type 316 stainless steel, or Monel.
   3. Extend pins through shaft and mechanically secure in place.

D. Shaft and bearings:
   1. Shaft design:
      a. Valves 20-inch and less: 1 piece, through disc design.
   2. Shaft seal: Vee type, chevron design.
   3. Shaft material for Class 150B valves: Type 316 stainless steel, ASTM A276.
   4. Shaft material for Class 250B valves: Type 17-4 pH stainless steel, ASTM A564.
   5. Shaft bearings: Self-lubricating sleeve type:
      a. Valves 20-inch and less: Nylatron.

E. Seats:
   1. Seat materials:
      a. NBR or natural rubber, or EPDM.
   2. For valves 20 inches in nominal size and smaller, bond or vulcanize seat into the valve body.
   3. Resilient seat: Withstand 75 pound per inch pull when tested in accordance with ASTM D429, Method B.

F. Valve packing:
   1. Valves 4 inch to 48 inch nominal size: Self-adjusting V-type packing or chevron-type packing. NBR or EPDM to match seat material.

2.02 COATING

A. Shop coat interior and exterior metal surfaces of valves, except as follows:
   1. Interior machined surfaces.
   2. Surfaces of gaskets and elastomeric seats and stem seals.
   3. Bearing surfaces.
   4. Stainless steel surfaces and components.

B. Coating material for potable water applications:
   1. Formulate interior coating material from materials in accordance with CFR 21, AWWA C550, and NSF 61.
   2. Submit affidavit of compliance attesting that epoxy coatings applied to interior surfaces of butterfly valves in accordance with CFR 21, AWWA C550, and NSF 61.

C. Interior surfaces:
   1. Interior surfaces, except for valves used in low-pressure air service: High solids epoxy.
   2. Interior surfaces of valves used in low-pressure air service: High temperature coating for range of 150 to 350 degrees Fahrenheit.

D. Exterior surfaces:
   1. Exterior surfaces of valves, actuators, and accessories coating in accordance with Section 09_96_01 with the following coating types:
      a. Submerged valves: High solids epoxy.
      b. Buried valves: Coal tar epoxy.
      c. Other valves: High solids epoxy with polyurethane topcoat.
   2. Polished and machined surfaces: Apply rust-preventive compound,
      a. Manufacturers: One of the following or equal:
         1) Houghton, Rust Veto 344.
         2) Rust-Oleum, R-9.

E. Coating materials:
   1. High solids epoxy and coal tar epoxy:
      a. Products: As specified in Section 09_96_01:
         1) Coating product in contact with potable water must be in accordance with AWWA C550 and NSF 61.
   2. High temperature coating: As specified in Section 09_96_01 and in accordance with AWWA C550.
   3. Rust-preventive compound:
      a. Manufacturers: One of the following or equal:
         1) Houghton, Rust Veto 344.
         2) Rust-Oleum, R-9.

F. Field applied coatings of valve exterior:
    1. Match color and be compatible with manufacturer's coating system and as specified in Section 09_96_01.
        a. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
        b. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves with valve shafts horizontal, unless a vertical shaft is required to suit a particular installation, and unless a vertical shaft is indicated on the Drawings.

B. Install pipe spools or valve spacers in locations where butterfly valve disc travel may be impaired by adjacent pipe lining, pipe fittings, valves, or other equipment.

3.02 BUTTERFLY VALVE APPLICATION SCHEDULE

A. Acceptable butterfly valve types and body styles are listed in the Butterfly Valve Application Schedule provided at the end of this Section. Furnish and install butterfly valves in accordance with this Schedule.

3.03 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01_75_17 and this Section.

B. Manufacturer services:
    1. Provide certificates:
        a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
    1. Valves:
        a. Test witnessing: Non-Witnessed.
        b. Conduct pressure and leak test, as specified in Section 40_05_51.01.

BUTTERFLY VALVE APPLICATION SCHEDULE	
Valve Type and Style	**Acceptable Applications**
General Purpose AWWA Butterfly Valves – Flanged Body Design	Aboveground -or buried applications when required by the specified piping system.
General Purpose AWWA Butterfly Valves – Mechanical Joint Body Design	Buried in all service applications
General Purpose AWWA Butterfly Valves – Wafer (not lugged) Body Design	Not allowed.
General Purpose AWWA Butterfly Valves – Grooved End Body Design	Aboveground, in sizes 20-inch and less, with piping system test pressure less than 100 psi, and in the following service applications only: -

END OF SECTION

SECTION 40_05_65.01

GATE, GLOBE, AND ANGLE VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Gate, globe, angle, plug disc and plain hose valves, and yard hydrants.

B. As specified in Section 40_05_51.01.

C. Related sections:
  1. Section 01_33_00 - Submittal Procedures.
  2. Section 01_75_17 - Commissioning.
  3. Section 01_78_36 - Warranties and Bonds.
  4. Section 09_96_01 - High-Performance Coatings.
  5. Section 40_05_51.01 - Common Work Results for Valves.

1.02 REFERENCES

A. American Water Works Association (AWWA):
  1. C515 - Standard for Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Services.
  2. C 550 - Protective Interior Coatings for Valves and Hydrants.

B. ASTM International (ASTM):
  1. B98 - Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 40_05_51.01.

C. Commissioning submittals: For valves larger than 16-inch:
  1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01_75_17.

1.04 WARRANTY

A. Provide warranty as specified in Section 01_78_36.

B. Interior epoxy coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of valves comply in accordance with all provisions of AWWA C550.

PART 2 PRODUCTS

2.01 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer's coating system and as specified in Section 09_96_01.
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
   2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

2.02 GATE VALVES

A. Gate valves aboveground:
   1. Valves less than 3 inches in size for clean water and air service:
      a. Manufacturers: One of the following or equal:
         1) Crane, Figure 431.
         2) Jenkins, Figure 47.
         3) Lunkenheimer Company, Figure 2151.
      b. Design:
         1) Size and configuration: Indicated on the Drawings.
         2) Manufacturer's standard bronze, solid wedge disc, rising stem, screwed end, Class 150 pounds.
   2. Valves 3-inches in size and larger:
      a. Manufacturers: One of the following or equal:
         1) M&H/Kennedy Valve Company.
         2) Mueller.
         3) American Flow Control, Series 2500.
      b. Design:
         1) Size, material, configuration: Indicated on the Drawings.
         2) Resilient wedge type in accordance with AWWA C515.
         3) Flange, iron body, and bonnet rated for 200 pound working pressure.
            a) Provide O-ring seal between valve body and bonnet.
         4) Ductile or cast iron wedge encapsulated in nitrile rubber and capable of sealing in either flow direction.
         5) Bronze stem with double or triple O-ring or braided packing stem seals.
         6) Rising stem configuration with handwheel diameter sized to allow opening of valve with no more than a 40-pound pull.
         7) Coat interior and exterior surfaces of valve body and bonnet with fusion-bonded epoxy in accordance with AWWA C550.

B. Gate valves underground:
   1. Manufacturers: One of the following or equal:
      a. M&H/Kennedy Valve Company.
      b. Mueller Company.
      c. American Flow Control.

2. Design:
    a. Size, material, configuration: Indicated on the Drawings.
    b. Resilient wedge type in accordance with AWWA C515.
    c. Stem:
        1) Iron body, resilient seat, non-rising stem, double O-ring stem seal.
        2) Rising stem configuration with handwheel diameter sized to allow opening of valve with no more than a 40-pound pull.
    d. Ductile or cast iron wedge encapsulated in nitrile rubber and capable of sealing in either flow direction.
    e. Bronze stem with double or triple O-ring or braided packing stem seals.
    f. Coat interior and exterior surfaces of valve body and bonnet with fusion-bonded epoxy in accordance with AWWA C550.
    g. Valve operator: Provide standard AWWA 2-inch operating nut, matching valve key, and valve box for operating stem.

2.03 GLOBE AND ANGLE VALVES

A. General purpose globe and angle valves:
    1. Valves 3 inches and smaller:
        a. Manufacturers: One of the following or equal:
            1) Except in welded steel piping:
                a) Crane, No. 1 Globe or No. 2 Angle.
                b) Lunkenheimer Company Figure No. 2140 Globe or No. 2141 Angle.
            2) In Welded steel piping:
                a) Crane, No. 351.
                b) Lunkenheimer Company, Figure No. 1123; or equal with flanged ends.
        b. Design:
            1) Size and configuration: Indicated on the Drawings.
            2) Valve: Class 125 threaded ends, rated for 250 degrees Fahrenheit at pressure of 170 pounds per square inch.
    2. Valves larger than 3 inches:
        a. Manufacturers: One of the following or equal:
            1) Crane, No. 351.
            2) Lunkenheimer Company, Figure No. 1123.
        b. Design:
            1) Size and configuration: Indicated on the Drawings.

2.04 NEEDLE VALVES

A. Manufacturers: One of the following or equal:
    1. Powell, Figure No. 180.
    2. Lunkenheimer Company, Figure No. 906-BS or No. 907-BS.
    3. Crane No. 88 or No. 89.

B. Design:
    1. Size and configuration: Indicated on the Drawings.

2.05 HOSE VALVES AND YARD HYDRANTS

A. Hose valves:
   1. Manufacturers:
      a. Globe threaded valve: One of the following or equal:
         1) Crane, No. 7TF.
         2) Stockham, Figure No. B22T.
      b. Angle threaded valve: One of the following or equal:
         1) Crane, No. 17TF.
         2) Stockham, Figure No. B222T.
   2. Design:
      a. Size and configuration: Indicated on the Drawings.
      b. Valve: Globe or angle valve with threaded ends.
      c. Disc: Renewable, made of Teflon or Buna-N.
      d. Threaded ends rated for a pressure of 200 pounds per square inch.

B. Freezeless yard hydrant:
   1. Manufacturers: One of the following or equal:
      a. Kupferle Foundry Company.
         1) #1 Total Eclipse Yard Hydrant - 3/4 inch and 1 inch.
      b. Murdock Company:
         1) #M-75 – 3/4 inch or #M100 - 1 inch.
      c. Zurn Company:
         1) #1385 - 3/4 inch or 1 inch.
   2. Design:
      a. Self-draining, non-freezing, compression type.
         1) Inlet connection size: Indicated on the Drawings.
         2) Outlet connection size: Indicated on the Drawings.
         3) Materials:
            a) Exterior casing pipe material: Indicated on the Drawings.
            b) Interior operating rod material: Indicated on the Drawings.
            c) Casing guard material: Indicated on the Drawings.
            d) Principal interior operating parts material: brass and/or bronze and removable from yard hydrant for servicing without excavation.
         4) Provide 4 Spoke, Ball Wheel Handle operated.

C. Freezeless post hydrants:
   1. Manufacturers: The following or equal:
      a. Kupferle Foundry Company:
         1) #2 Eclipse Post Hydrant.
      b. Mueller Company:
         1) #A-411 Post Hydrant.
      c. Murdock Company:
         1) #M-200 Post Hydrant.
   2. Design:
      a. Self-draining, non-freezing, compression type with a 2-3/16 inch valve opening.
      b. Inlet connection size: Indicated on the Drawings.
      c. Outlet connection size: Indicated on the Drawings.
      d. Materials:
         1) Exterior casing pipe material: Indicated on the Drawings.

2) Interior operating rod material: Indicated on the Drawings.
3) Top stock material: Indicated on the Drawings.
4) Principal interior operating parts material: Brass and/or bronze and removable from hydrant for servicing without excavation.

e. Provide 1-1/2 inch pentagon operating nut operated by a hydrant wrench or 10 inch hand wheel:
1) Manufacturers: The following or equal:
a) Kupferle Foundry Company.

PART 3 EXECUTION

3.01 INSTALLATION

A. Mount yard hydrants on minimum 1 inch supply pipe or size indicated on the Drawings.

B. Mount Post hydrants on minimum 2 inch supply pipe or size indicated on the Drawings.

C. Set yard and post hydrants in 4 cubic feet of 3/4 inch minimum crushed stone surrounding valve body to allow for proper drainage.
1. Install in accordance with AWWA recommendations for hydrants.

3.02 COMMISSIONING

A. As specified in Section 01_75_17 and this Section.

B. Manufacturer services: For valves larger than 16-inch.
1. Provide certificates:
a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
1. Valves:
a. Test witnessing: Witnessed.
b. Conduct pressure and leak test as specified in Section 40_05_51.01.

END OF SECTION

SECTION 40_05_65.24

CHECK VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Check valves.

B. As specified in Section 40_05_51.01.

C. Related sections:
1. Section 01_33_00 - Submittal Procedures.
2. Section 01_75_17 - Commissioning.
3. Section 01_78_36 - Warranties and Bonds.
4. Section 09_96_01 - High-Performance Coatings.
5. Section 40_05_51.01 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Inch Standard.

B. American Water Works Association (AWWA):
1. C508 - Standard for Swing-Check Valves for Waterworks Service 2 Inch Through 24 Inch (50-mm Through 600-mm) NPS.

C. ASTM International (ASTM):
1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
2. A313 - Standard Specification for Stainless Steel Spring Wire.
3. A536 - Standard Specification for Ductile Iron Castings.
4. B582 - Standard Specification for Nickel-Chromium-Iron-Molybdenum-Copper Alloy Plate, Sheet, and Strip.
5. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

1.03 SYSTEM DESCRIPTION

A. Design requirements:
1. Check valves: When not otherwise specified as indicated on the Drawings, provide check valves suitable for service as follows:
   a. In either horizontal or vertical position.
   b. Suitable for service working pressures up to 150 pounds per square inch gauge.

1.04 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 40_05_51.01.

C. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17.

1.05 WARRANTY

A. Provide warranty as specified in Section 01_78_36.

PART 2 PRODUCTS

2.01 CENTER GUIDE (SILENT) CHECK VALVES

A. Manufacturers: One of the following or equal:
   1. APCO, Model Number 600.
   2. Crispin, Series GC.

B. Valve design:
   1. Center-guided, spring-loaded plug.
   2. Replaceable seat and plug.
   3. Shaft guide bushing.
   4. Non-slam, silent shutoff.
   5. Flanged body.

C. Materials:
   1. Body: Cast iron, ASTM A126 Grade B, or Type 316 stainless steel, ASTM A313.
   2. Plug and seat: Bronze, ASTM B584 C83600.
   3. Spring: Stainless steel, ASTM A313 Type 316.
   4. Shaft and bushing: Bronze, ASTM B584 C83600.
   5. Seat: Buna-N or EPDM.

2.02 SWING CHECK VALVES

A. Valves 1/4 inch through 3 inch:
   1. Manufacturers: One of the following or equal:
      a. Crane Valve Company, Number 36.
      b. Lunkenheimer Company, Figure 554Y.
   2. Valve design:
      a. Threaded joints.
      b. Y-pattern body with integral seat.
      c. Hinged disc.
      d. Access to valve seat for regrinding without disassembly of piping.
   3. Materials:
      a. Body, cap, hinge, and disc: Bronze.

B. Valves 4 inch through 24 inch:
   1. Manufacturers: One of the following or equal:
      a. Kennedy, Figure 106LW or M&H, Model 159.
      b. Mueller Company, Model A-2600.
      c. APCO Model 250.
      d. Crispin SWL Series.
   2. Valve design:
      a. In accordance with AWWA C508.
      b. Constructed to permit top entry and removal of internal components without removing the valve.
      c. Equipped with outside lever and weight.
   3. Materials:
      a. Body: Cast iron, ASTM A126 Class B or ASTM A536 Grade 65-45-12 Ductile Iron.
      b. Disc:
         1) Valve disc shall be ASTM A126 cast iron, ASTM A536 ductile iron, or ASTM B584 bronze.
         2) 4-inch valves: Bronze or stainless steel rings and seats.
         3) 6 inches and larger valves: Bronze-faced or stainless steel rings and seats.
         4) Rubber seat Buna-N or EPDM.
      c. Hinge pins: Stainless steel.

2.03 OIL-CUSHIONED SWING CHECK VALVES

A. Manufacturers: One of the following or equal:
   1. Crispin, Series SWC-BB.
   2. APCO, Swing-Check, Series 6000B.

B. Valve design 8 inches to 66 inches:
   1. Counterweighted:
      a. Single counterweight on sizes 8 inches to 12 inches (right side).
      b. Dual counterweights on sizes 14 inches and larger.
   2. Rubber-seated and driptight.
   3. Totally enclosed oil-dampening chambers with adjustment for closing speed.
   4. Bottom-mounted hydraulic oil cushion system:
      a. System shall permit free open, but positive non-slam controlled closure of the disc.
         1) Hydraulic cushion shall make contact with the disc during the last 10 percent of closure to control the disc until shutoff.
      b. System shall be externally adjustable to suit operating conditions.
      c. System shall be totally enclosed and removable without need to remove the entire valve.
         1) Oil system shall be totally independent from the main line to prevent corrosion or contamination to the process water.
   5. Materials:
      a. Valve body, cover, and disc: Ductile Iron ASTM A536 Grade 65-45-12.
      b. Disc seat: Bolted in replaceable seat, Buna N or EPDM.
         1) Disc attachment design:
            a) Single top-shaft disc mount with machined pin, (no bolts and nuts attachments on the disc are acceptable).

b) Dual device hinge pinning on linkage arm to disc pinning, (no bolts and nuts attachments on the disc are acceptable).

2) Shaft: Stainless steel: T303 high-strength stainless steel:

a) Shaft shall have large pin-shaft design for full rating of the valve fully extended through valve cast on each end of body casting.

(1) Shaft minimum sizing is:

Valve Size (per inch	8	10	12	14	16
Shaft Size (per inch)	1.75	2.125	2.5	3 10	3.5

c. Oil cushion bottom-mounted cylinder:

1) Corrosion-resistant metal with stainless steel control rod to slow closing function of the valve not connected to the disc.

2) Side-mounted oil reservoir to be oriented in the vertical position after valve installation.

d. Shaft packing seals: Shaft packing seals on both ends of body casting or O-rings.

e. Disc ring seat: Bronze or stainless steel.

f. Seat pins and lock screws: Stainless steel.

6. Pressure rating:

a. Swing check valve shall be rated for minimum 150 pounds per square inch differential pressure.

2.04 PLASTIC BALL CHECK VALVES

A. Manufacturers: One of the following or equal:

1. Chemtrol Division of Nibco.
2. Georg Fischer Piping Systems.
3. Plast-O-Matic Valves, Inc.

B. Valves: Ball type:

1. Material: Polyvinyl chloride.
2. End connection: Double-or single-union-type.
3. Seals: Viton.

C. Valve body material:

1. Polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), Polypropylene (PP) or polyvinylidene fluoride (PVDF), as best suited for each individual service condition.

D. Union connections material:

1. NPT or socket ends conforming to ASME B16.5 pipe flanges and flange fittings, Class 150.

E. Seats and seals material:

1. EPDM, Buna-N, or Viton.

F. Maximum inlet pressure rating:

1. PVC, CPVC, or PVDF: 150 pound per square inch at 77 degrees Fahrenheit.
2. PP: 100 pounds per square inch at 77 degrees Fahrenheit.

PART 3 EXECUTION

3.01 INSTALLATION

A. Flapper-type check valves:
   1. Install with proper orientation of flow direction arrow on valve body.
   2. When installed in horizontal pipelines, mount with shaft on vertical locations.
   3. When mounted in a vertical pipeline, directly downstream of an elbow, mount with the shaft perpendicular to the outermost portion of the elbow.
   4. Mount on downstream side of discharge silencer when used on positive displacement and centrifugal blowers.

3.02 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09_96_01.
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
   2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

3.03 COMMISSIONING

A. As specified in Section 01_75_17 and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test, as specified in Section 40_05_51.01.

END OF SECTION

SECTION 40_05_67.37

PRESSURE REDUCING AND PRESSURE RELIEF VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pressure reducing and pressure relief valves for water, air, sludge and chemical service.

B. As specified in Section 40_05_51.01.

C. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 01_78_36 - Warranties and Bonds.
   4. Section 09_96_01 - High-Performance Coatings.
   5. Section 40_05_51.01 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.

B. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A536 - Standard Specification for Ductile Iron Castings.

C. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 40_05_51.01.

C. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17.

1.04 WARRANTY

A. Provide warranty as specified in Section 01_78_36.

PART 2 PRODUCTS

2.01 WATER PRESSURE RELIEF VALVES

A. Water pressure relief valves:
   1. Manufacturers: One of the following, or equal:
      a. Cla-Val Model 50-01.
      b. Watts ACV Series 116.
   2. Design:
      a. Pilot controlled, hydraulically operated, diaphragm actuated, globe patterned valve.
      b. Rated for 125 pounds per square inch gauge.
      c. Pilot line: Equipped with a strainer.
      d. End connections:
         1) 2 1/2 inch and smaller: Screwed.
         2) 3 inch and larger: 150 pound rated flanges in accordance with ASME B16.42.
   3. Materials:
      a. Body and cover: Cast iron ASTM A48 or Ductile Iron ASTM A536.
      b. Valve trim: Bronze.
      c. Pilot control: Cast bronze with Series 303 stainless steel trim.
      d. Diaphragm: Nylon reinforced Buna N.

2.02 PRESSURE RELIEF VALVES FOR CHEMICAL SERVICE

A. Manufacturers: One of the following or equal:
   1. Plast-O-Matic, Series RVT, RVDT or TRVDT.
   2. Asahi/America.
   3. Georg Fischer Piping Systems.

B. Materials:
   1. Valve body: CPVC or PVC.
   2. U-cup seals:
      a. Polymer service: Viton.
      b. Hypochlorite service: Viton.
      c. Caustic service: EPDM.
      d. Sodium Bisulfite: EPDM.
   3. Adjusting bolt, locknut, control spring and fasteners: stainless steel.

C. Design:
   1. Pressure rating: Not less than 150 pounds per square inch.
   2. In-line or angle pattern design, size as indicated on the Drawings.
   3. End connections:
      a. 1 inch and smaller: Threaded.
      b. Larger than 1 inch: Flanged.
   4. Relief set point:
      a. Externally adjustable without removing valve from piping system.
      b. Set valve to open at 10 pounds per square inch more than pump discharge pressure at operating point, or as indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 40_05_51.01.

3.02 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer's coating system and as specified in Section 09_96_01:
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
   2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

3.03 COMMISSIONING

A. As specified in Section 01_75_17 and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test as specified in Section 40_05_51.01.

END OF SECTION

SECTION 40_05_67.40

AIR AND VACUUM RELIEF VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Air release valves, air and vacuum valves, and air vents.

B. As specified in Section 40_05_51.01.

C. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_75_17 - Commissioning.
   3. Section 01_78_36 - Warranties and Bonds.
   4. Section 09_96_01 - High-Performance Coatings.
   5. Section 40_05_51.01 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME).
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

B. American Water Works Association (AWWA).

C. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   3. A270 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Sanitary Tubing.
   4. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 40_05_51.01.

C. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17.

1.04 WARRANTY

A. Provide warranty as specified in Section 01_78_36.

PART 2 PRODUCTS

2.01 COMBINATION AIR VALVES, WATER SERVICE

A. Manufacturers: One of the following or equal:
   1. Valve and Primer Corporation, DeZurik/APCO, Series 140C.
   2. Multiplex Manufacturing Company, Crispin UL Series.

B. Design:
   1. Operation: Automatic exhaust of large quantities of air from pipelines during filling and draining and release of accumulated air while pipeline is under pressure.
   2. Utilize compound lever system in conjunction with large and small orifices.
   3. Internal parts removable through top cover without removing valve from pipeline.
   4. Pressure rating: 125 pounds per square inch.
   5. Inlet: Screwed, 3-inch size and smaller.

C. Materials:
   1. Body: Cast iron.
   2. Float: Type 316 stainless steel.
   3. Needle: Buna-N.
   4. Lever frame: Cast iron or Delrin.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 40_05_51.01 and manufacturer’s instructions.

B. Install air release valves and air and vacuum valves with suitable discharge lines to nearest drainage system.

3.02 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09_96_01.
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the manufacturer.
   2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, remove existing coating by abrasive blast cleaning and apply the coating system used for coating adjacent piping in accordance with Section 09_96_01.
      a. Submerged valves: SP-5 White Metal Blast cleaning.
      b. Other valves: SP-10 Near-white blast cleaning.

3.03 COMMISSIONING

A. As specified in Section 01_75_17 and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test as specified in Section 40_05_51.01.

END OF SECTION

SECTION 40_61_00

COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. General requirements applicable to all Process Control and Instrumentation Work.
   2. General requirements for process control and instrumentation submittals.

B. Related sections:
   1. Document 00_72_00 - General Conditions.
   2. Document 00_73_00 - Supplementary Conditions.
   3. Section 01_11_00 - Summary of Work.
   4. Section 01_29_73 - Schedule of Values.
   5. Section 01_31_19 - Project Meetings.
   6. Section 01_32_17 - Progress Schedules and Reports.
   7. Section 01_33_00 - Submittal Procedures.
   8. Section 01_35_22 - Safety Plan.
   9. Section 01_41_00 - Regulatory Requirements.
   10. Section 01_60_00 - Product Requirements.
   11. Section 01_75_17 - Commissioning.
   12. Section 01_77_00 - Closeout Procedures.
   13. Section 01_78_23 - Operation and Maintenance Data.
   14. Section 01_81_00 - Project Design Criteria.
   15. Section 01_81_02 - Seismic Design Criteria.
   16. Section 01_81_04 - Wind Design Criteria.
   17. Section 26_05_00 - Common Work Results for Electrical.
   18. Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
   19. Section 26_05_53 - Identification for Electrical Systems.
   20. Section 40_61_16 - Specific Control Strategies.
   21. Section 40_64_01 - Control Systems: Programmable Logic Controllers.
   22. Section 40_80_01 - Testing, Calibration, and Commissioning.

C. Interfaces to equipment, instruments, and other components:
   1. Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers, which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
   2. Provide all material and labor needed to install the actual equipment furnished, include all costs to add any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., which may be

necessary to make a complete, functional installation based on the actual equipment furnished:
    a. Make all changes necessary to meet the manufacturer’s wiring requirements.
3. Submit all such changes and additions to the Engineer for acceptance as specified in Document 00_72_00.
4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation and control systems are completely accounted for. Include any items indicated on the Drawings or in Specifications from another discipline in the scope of Work:
    a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
5. Loop drawings:
    a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and for all pre-purchased equipment.
    b. The form, minimum level of detail, and format for the loop drawings must match that of the sample loop drawings included in the Contract Documents.
    c. The Owner and Engineer are not responsible for providing detailed loop diagrams for Contractor furnished equipment.

D. All instrumentation, and control equipment and systems for the entire project to comply with the requirements specified in the Instrumentation and Control Specifications, whether referenced in the individual Equipment Specifications or not:
1. The requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in other Specifications, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
2. Inform all vendors supplying instrumentation, control systems, panels, and/or equipment of the requirements of the Instrumentation and Control Specifications.
3. The Owner is not responsible for any additional costs due to the failure of the Contractor to notify all subcontractors and suppliers of the Instrumentation and Control Specifications’ requirements.

E. Contract Documents:
1. General:
    a. The drawings and specifications are complementary and are to be used together in order to fully describe the Work.
2. Specifications:
    a. Documents 00_72_00 and 00_73_00 of the Contract Documents govern the Work.
    b. These requirements are in addition to all General Requirements.
3. Contract drawings:
    a. The Instrumentation and Control Drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the Instrumentation Work. Follow the drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the best possible installation, use the entire drawing set for construction purposes.

b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only, exercise professional judgment in executing the Work to ensure the best possible installation:
    1) The equipment locations and dimensions indicated on the Drawings and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all instrumentation and control equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
    2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual Specifications; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.

c. Installation details:
    1) The Contract Drawings include installation details showing means and methods for installing instrumentation and control equipment. For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary for completing the Work, and submit these details for review by the Engineer.

d. Schematic diagrams:
    1) All controls are shown de-energized.
    2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
    3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
    4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
    5) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences indicated on the Drawings or in the Specifications. Combine all information and furnish a coordinated and fully functional control system.

F. Alternates/Alternatives:
1. Substitute item provisions as specified in Document 00_72_00.

G. Changes and change orders:
1. As specified in Document 00_72_00.

1.02 REFERENCES

A. Code compliance:
   1. As specified in Section 01_41_00:
      a. The publications are referred to in the text by basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of Bid governs.
   2. The following codes and standards are hereby incorporated into this Section:
      a. American National Standards Institute (ANSI).
      b. American Petroleum Institute (API):
         1) RP 550 - Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5-Oxygen Analyzers.
         2) RP 551 - Process Measurement Instrumentation.
      c. International Organization for Standardization (ISO):
         1) 9001 - Quality Management Systems - Requirements.
      d. International Society of Automation (ISA):
         1) 5.1 - Instrumentation Symbols and Identification.
         2) 5.4 - Instrument Loop Diagrams.
         3) 20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
      e. National Electrical Manufacturers Association (NEMA):
         1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
      f. National Fire Protection Association (NFPA).
      g. National Institute of Standards and Technology (NIST).
      h. Underwriters Laboratories, Inc. (UL):
         1) 508 - Standard of Safety for Industrial Control Equipment.
         2) 508A - Standard of Safety for Industrial Control Panels.

B. Compliance with Laws and Regulations:
   1. As specified in Document 00_72_00.

1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations in accordance with:
   1. Factory Mutual (FM).
   2. International Electrotechnical Commission (IEC).
   3. Institute of Electrical and Electronics Engineers (IEEE).
   4. International Society of Automation (ISA).
   5. International Organization for Standardization (ISO).
   6. National Electrical Code (NEC).
   7. National Electrical Manufacturers Association (NEMA).
   8. InterNational Electrical Testing Association (NETA).
   9. National Fire Protection Association (NFPA).
   10. National Institute of Standards and Technology (NIST).
   11. Underwriters Laboratories (UL).

B. Specific definitions:
   1. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of

information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.

2. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems.
3. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
4. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.
5. Digital bus: A communication network, such as PROFIBUS, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.
6. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, 2-wire transmitter refers to a transmitter that provides a signal such as 4 to 20 mA 24 VDC regulation of a signal in a series circuit with an external 24 VDC driving potential:
   a. Fieldbus communications signal or both.
7. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 mA 24 VDC signal, a digital bus communications signal, or both.
8. System supplier - As specified in ICSC Qualifications in the Quality Assurance article of this Section.

C. Acronym definitions:

1. CCS: The PCS central computer system (CCS) consisting of computers and software. The personal computer-based hardware and software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software and functions.
2. DPDT: Double-pole, double-throw.
3. ES: Enterprise system: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
4. FAT: Factory acceptance test also known as Source Test.
5. HART: Highway addressable remote transducer.
6. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
7. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically information is displayed in a graphical format.
8. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and

control systems. Telstar integrated solutions is sole sourced for integration and programming.

9. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
10. I/O: Input/Output.
11. IP: Internet protocol or ingress protection.
12. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
13. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
14. LOI: Local Operator Interface is an operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The LOI is typically a flat panel type of display mounted on the front of an enclosure with either a touch screen or tactile button interface.
15. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the HOA. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
16. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO, etc.
17. P&ID: Process and instrumentation diagram.
18. PC: Personal computer.
19. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings. This includes all the PCS and instruments and networking components as well as the various servers, workstations, thin clients, etc.
20. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
21. PCS: Process Control System: A general name for the computerized system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOs, LOIs, HMIs, both LCPs, VCPs and all data management systems accessible to staff.
22. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.
23. PLC: Programmable logic controller.
24. RIO: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.
25. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
26. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment located outside of the facility, such as wells, lift stations, metering stations, etc.

27. SPDT: Single-pole, double-throw.
28. SPST: Single-pole, single-throw.
29. UPS: Uninterruptible power supply.
30. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, LOI, HMI, etc.
31. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

1.04 SYSTEM DESCRIPTION

A. General requirements:
   1. The Work includes everything necessary for and incidental to executing and completing the instrumentation and control system work indicated on the Drawings and specified in the Specifications and reasonably inferable there from including but not limited to:
      a. Preparing hardware submittals for field instrumentation.
      b. Design, develop, and draft loop drawings, control panel designs, and all other drawing submittals specified in the Instrumentation and Control Specifications.
      c. Prepare the test plan, the training plan, and the spare parts submittals.
      d. Procure all hardware.
      e. Provide all PCS system hardware.
      f. Fabricate panels.
      g. Perform factory tests on panels.
      h. Perform bench calibration and verify calibration after installation.
      i. Oversee and certify installation of the PCS system.
      j. Oversee, document, and certify loop testing.
      k. Oversee, document, and certify system.
      l. Installation Testing.
      m. Oversee and document Functional Testing.
      n. Conduct the Process Operational Period and the Instrumentation and Controls Process Performance Testing.
      o. Prepare operation and maintenance manuals.
      p. Conduct training classes.
      q. Integrate the PCS with instrumentation and control devices provided under other sections.
      r. Provide Record Drawings and Loop Drawings associated with Instruments and equipment:
         1) As specified in the Contract Documents.
         2) For Owner furnished items.
      s. Resolve signal, power, or functional incompatibilities between the PCS and interfacing devices.
      t. Perform all required corrective and preventative maintenance.
   2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of all equipment furnished by others, as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.

3. Provide the complete operating PCS to perform the specified monitoring, communications, alarm, control, display, and reporting functions in accordance with the PCS requirements.
4. Coordinate all aspects of the Work between Contractor and all subcontractors before bidding to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the ICSC, the other subcontractors, or suppliers.
5. Furnish detailed, complete, and thorough operations and maintenance documentation, including but not limited to operations manuals, maintenance manuals, as-built wiring drawings, training manuals, as-built software documentation, and all other documentation required to operate, modify, and maintain all parts of the PCS.
6. Revise in a manner as directed by the Engineer all I/O and addressing that the Engineer determines to be unacceptable as a result of a lack of Contractor coordination between Contract Documents and all suppliers.
7. Defective Work:
   a. As specified in Document 00_72_00.

B. Existing system:
   1. Program the Owners existing Wonderware SCADA system to provide the monitoring and controls shown and the drawings and specified in the Control Strategies.

C. New system:
   1. New RTUs and radio communications for the Alpine Vista and J Street water storage tanks and wells.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01_33_00 and this Section.

B. General:
   1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
   2. Furnish the submittals required by each section in the Instrumentation Specifications.
   3. Adhere to the wiring numbering scheme specified in Section 26_05_53 throughout the Project:
      a. Uniquely number each wire.
      b. Wire numbers must appear on all Equipment Drawings.
   4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

C. Submittal preparation:
   1. During the period of preparation of submittals, the Contractor shall authorize direct, informal liaison between Telstar and the Engineer for exchange of technical information. As a result of this liaison, certain minor refinements and revisions may be authorized informally by the Engineer, which do not alter the scope of Work or cause increase or decrease in the Contract price or times. During this informal exchange, no oral statement by the Engineer shall be construed to give formal approval of any component or method, nor shall any

statement be construed to grant exception to, or variation from, these Contract Documents.

2. In these Contract Documents, some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
   a. Employ the nomenclature and numbers designated in this Section and indicated on the Drawings exclusively throughout shop drawings, data sheets, and similar submittals.
   b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, suppliers, or subcontractor's standard methods with those identified in this Section and indicated on the Drawings.

D. Specific submittal requirements:
1. Shop drawings:
   a. Required for materials and equipment listed in this and other sections.
   b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
   c. Shop drawings requirements:
      1) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
      2) Locations of conduit entrances and access plates.
      3) Component layout and identification.
      4) Schematic and wiring diagrams with wire numbers and terminal identification.
      5) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
      6) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
      7) Weight.
      8) Finish.
      9) Nameplates:
         a) As specified in Section 26_05_53 or as indicated on the Drawings.
      10) Temperature limitations, as applicable.
   d. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
   e. Adhere to wiring numbering scheme outlined in Section 26_05_53 throughout the Project:
      1) Uniquely number each wire per the Specifications.
   f. Wire numbers must appear on all equipment drawings.
   g. Organize the shop drawing submittals for inclusion in the Operation and Maintenance Manuals:
      1) Furnish the initial shop drawing submittal bound in one or more standard size, 3-ring, D-ring, loose leaf, vinyl plastic, hard cover binders suitable for bookshelf storage.
      2) Binder ring size: 2 inches.
   h. Include the letterhead and/or title block of the firm responsible for the preparation of all shop drawings. Include the following information in the title block, as a minimum:
      1) The firm's registered business name.
      2) Firm's physical address, email address, and phone number.

3) Owner's name.
4) Project name and location.
5) Drawing name.
6) Revision level.
7) Personnel responsible for the content of the drawing.
8) Date.

i. The work includes modifications to existing circuits:
   1) Clearly show all modifications to existing circuits.
   2) In addition, show all existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.

2. Product data:
   a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
   b. Include:
      1) Catalog cuts.
      2) Bulletins.
      3) Brochures.
      4) Quality photocopies of applicable pages from these documents.
      5) Identify on the data sheets the Project name, applicable specification section, and paragraph.
      6) Identify model number and options for the actual equipment being furnished.
      7) Neatly cross out options that do not apply or equipment not intended to be supplied.
   c. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
   d. Adhere to wiring numbering scheme outlined in Section 26_05_53 throughout the Project:
      1) Uniquely number each wire per the Specifications.
   e. Wire numbers must appear on all equipment drawings.
3. Detailed sequence of operation for all equipment or systems.
4. Operation and maintenance manuals:
   a. As specified in Section 01_78_23.
   b. Operational Manual:
      1) Prepare and provide a simplified version of the standard manufacturer's HMI software and system operations manual that includes basic instructions in the application of the system as required for operators in day-to-day operations.
   c. Control System Software Record Documents:
      1) Include complete documentation of all the software programs provided for the entire control and PCS system, including:
         a) Listings of all application software on both hard copy and DVD, DVD-ROM, and CD-ROM.
         b) Database, both hard copy and DVD, DVD-ROM, and CD-ROM.
         c) Communication protocols.
         d) All documentation necessary to maintain, troubleshoot, modify, or update the software system.
   d. Organize the operation and maintenance manuals for each process in the following manner:
      1) Section A - Process and Instrumentation Diagrams.
      2) Section B - Control Descriptions.

3) Section C - Loop Drawings.
4) Section D - Instrument Summary.
5) Section E - Instrument Data Sheets and Brochures.
6) Section F - Sizing Calculations.
7) Section G - Instrumentation Installation Details.
8) Section H - Test Results.
9) Section I - Operational Manual.
10) Section J - Spare Parts List.
11) Section K - Control System Software.

5. Material and equipment schedules:
   a. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
      1) Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
6. Itemized instrument summary:
   a. Submit a hard copy of the instrument summary.
   b. List all of the key attributes of each instrument including:
      1) Tag number.
      2) Manufacturer.
      3) Model number.
      4) Service.
      5) Area location.
      6) Calibrated range.
      7) Loop drawing number.
   c. Associated LCP, VCP, PCM, or PLC.
7. Instrument data sheets and cut sheets:
   a. Furnish fully completed data sheets, both electronically in Microsoft Word or Excel and in hard copy, for each instrument and component according to ISA-20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves. The data sheets provided with the instrument specifications are preliminary and are not complete. They are provided to assist with the completion of final instrument data sheets. Additional data sheets may be required. Include the following information on the data sheet:
      1) Component functional description specified in this Section and indicated on the Drawings.
      2) Manufacturers model number or other product designation.
      3) Tag number specified in this Section and indicated on the Drawings.
      4) System or loop of which the component is a part.
      5) Location or assembly at which the component is to be installed.
      6) Input and output characteristics.
      7) Scale range with units and multiplier.
      8) Requirements for electric supply.
      9) Requirements for air supply.
      10) Power consumption.
      11) Response timing.
      12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
      13) Special requirements or features, such as specifications for ambient operating conditions.
      14) Features and options that are furnished.

b. Provide a technical brochure or bulletin (“cut sheet”) for each instrument on the project. Submit with the corresponding data sheets:
    1) Where the same make and model of instrument is used in 2 or more applications on the project, and the process applications are nearly identical, and the materials, features and options are identical submit one brochure or bulletin for the set of identical instruments.
    2) Include a list of tag numbers for which it applies with each brochure or bulletin.
    3) Furnish technical product brochures that are complete enough to verify conformance with all Contract Document requirements, and to reflect only those features supplied with the device.
    4) Cross out models, features, options, or accessories that are not being provided.
    5) Clearly mark and identify special options and features.
c. Organization: Index the data sheets and brochures in the submittal by systems or loops.

8. Control panel hardware submittal:
    a. Submit the following in 1 submittal package.
    b. Complete and detailed bills of materials:
        1) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
        2) Include all items within an enclosure.
    c. Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and Control System equipment.
    d. Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium voltage power cables.
    e. UPS and battery load calculations to show that the backup capacity and time meet the specified requirements.
    f. Provide a data sheet for each control system component together with a technical product brochure or bulletin, which include:
        1) The manufacturer's model number or other identifying product designation.
        2) Tag and loop number.
        3) System to which it belongs.
        4) Site to which it applies.
        5) Input and output characteristics.
        6) Requirements for electric power.
        7) Device ambient operating requirements.
        8) Materials of construction.
9. Schedule of values:
    a. In addition to completing all items referred to in the schedule of values, Section 01_29_73, submit per unit instrument and labor costs used in developing the final bid for the PCS system, for the express purpose of pricing and cost justification for any proposed change orders. It is the responsibility of the ICSC subcontractor to prove to the Engineer’s satisfaction that said per unit costs were used in the development of the final Bid amount.
10. Installation recommendations:
    a. Submit the manufacturer’s printed recommendations for installation of instrumentation equipment.

11. Training submittals:
    a. Develop and submit for review a general training plan for approval by Owner within 14 calendar days from Notice to Proceed. Include complete descriptions of all planned training classes, a preliminary training schedule, a list of all proposed instructors along with resumes, examples of proposed training manuals, and a description of any special training tools to be used (simulators, self-paced modules, personal computer-based training, etc.).
    b. The Engineer will review the general training plan. Special emphasis will be placed on review of the qualifications of the proposed instructors and the timing of the individual courses to maximize their effectiveness. If, in the opinion of the Engineer, the proposed instructors are not sufficiently qualified to conduct the specified training courses, or lack experience, where required, on the specific configuration of the system, provide more qualified instructors.
    c. The general training plan and schedule shall be updated by the Contractor at the beginning of each Phase and approved by the Owner a minimum of 30 days prior to commencement of training.
    d. Training course plan submittals:
        1) For each training course or other training activity, submit a detailed, complete outline and agenda for each lesson as specified in Section 01_75_17.
        2) Describe any student pre-requisites for the course or training activity.
        3) Provide an updated schedule for all sessions of the course, including dates, times, durations, and locations.
        4) Submit training materials.
    e. Incorporate all submittal review comments into the course.
    f. Do not conduct training courses before review and acceptance of the Course Plan submittal for the course.
12. Project Record documents:
    a. Furnish as specified in Section 01_77_00.
    b. Record Drawing requirements:
        1) Provide Project Record Drawing of all Instrumentation Drawings.
        2) Update Record Drawings weekly.
        3) Record Drawings must be fully updated as a condition of the monthly progress payments.
        4) Clearly and neatly show all changes including the following:
            a) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
13. Loop Drawings:
    a. Submit loop drawings for every analog and discrete, signal and control circuit:
        1) Provide a loop drawing submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop on this Project.
        2) This requirement applies to all signal and control circuits associated with equipment on this Project including vendor supplied equipment packages and control panels.
        3) Provide loop drawings in the format indicated in the contract drawings. Provide all tagging in accordance with the Owner's standard.
    b. Show every instrument and I/O point on at least one loop diagram.

c. Provide a complete index in the front of each bound volume:
   1) Index the loop drawings by systems or process areas.
d. Provide drawings showing definitive diagrams for every instrumentation loop system:
   1) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
   2) Furnish a separate drawing sheet for each system or loop diagram.
e. In addition to the ISA-5.4 requirements, show the following details:
   1) Functional name of each loop.
   2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
   3) Show all terminal numbers, regardless of the entity providing the equipment.
   4) Circuit, and breaker numbers for all power feeds to the loops and instrumentation.
   5) Designation of and, if appropriate, terminal assignments associated with, every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
   6) Show vendor control panel, instrument panel, conduit, junction box, equipment, and PCS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
   7) If a circuit is continued on another drawing, show the name and number of the continuation drawing on the loop drawing. Provide complete references to all continuation drawings whether vendor control panels, other loop drawings, existing drawings provided by the Owner, or other drawings.
f. In addition to the above requirements, provide loop diagrams in accordance with the example loop diagram as indicated on the Drawings.

14. Instrument Installation Drawings:
   a. Submit, instrument installation, mounting, and anchoring details for all components and assemblies, including access requirements and conduit connection or entry details.
   b. Furnish for each instrument a dedicated 8 1/2-inch by 11-inch installation detail that pertains to the specific instrument by tag number.
   c. For each detail, provide certification and the hard copies, by the instrument manufacturer, that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable.
   d. For each detail, provide, as a minimum, the following contents:
      1) Necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
      2) Ambient temperature and humidity where the instrument is to be installed.
      3) Corrosive qualities of the environment where the instrument is to be installed.
      4) Process line pipe or tank size, service and material.
      5) Process tap elevation and location.
      6) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
      7) Routing of tubing and identification of supports.

8) Mounting brackets, stands, anchoring devices, and sun shades.
9) Conduit entry size, number, location, and delineation between power and signal.
10) NEMA ratings of enclosures and all components.
11) Clearances required for instrument servicing.
12) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

15. Control Panel Drawings:
    a. Layout Drawings:
        1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
        2) As a minimum, include the following information:
            a) To scale front, side, and plan views.
            b) Dimensions.
            c) Interior and exterior arrangements.
            d) Mounting information, including conduit entrance location.
            e) Finish data.
            f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
            g) Nameplate legend including text, letter size, materials, and colors.
    b. Wiring and piping diagrams:
        1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.
        2) Include the following information:
            a) Name of panel.
            b) Wiring and piping sizes and types.
            c) Terminal strip numbers.
            d) Wire tags and labels.
            e) Functional name and manufacturer's designation for items to which wiring and piping are connected.
            f) Electrical control schematics in accordance with ANSI standards.
    c. Installation drawings:
        1) Provide site-specific installation drawings for all control equipment panels, including dimensions.
        2) Provide scaled drawings and show the position of the equipment at its intended installation location.
        3) Show the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas.
        4) Show all required access and clearances associated with the equipment with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.
16. Schematic Diagrams:
    a. Submit schematic diagrams for all electrical equipment in ladder diagram format.
    b. Include device and field connection terminal numbers on all schematic diagrams.
    c. Incorporate equipment manufacturer’s shop drawing information into the schematic diagrams in order to document the entire control system.

17. Control System Diagram:
    a. Submit a complete set of control system diagrams including the following information:
        1) All PLCs, workstations, printers, communication devices, and communication links:
            a) Show all PLCs with their current I/O allocation, and future I/O allocation, current plus spares provided, and maximum potential I/O based on available slots.
        2) All cables required for communication requirements.
        3) Show each component fully annotated with conduit size and number associated with the power source.
18. Process Control Software Submittal:
    a. In accordance with Product Data and Shop Drawing general requirements.
    b. Submit a complete description of the standard application software programs, operating system and utility programs, including modifications and explanation of how the specific functional requirements are met:
        1) Provide a cross-reference between the Specification requirements and the software submittal, in order to provide the Engineer the ability to identify how each specified requirement or function is met.
    c. A complete listing of the PCS system point I/O database:
        1) Include for each data point, relevant parameters such as range, contact orientation, limits, incremental limits, I/O card byte, I/O hardware address, and PLC assignment.
        2) Organize on a site-by-site basis, separate by point type.
        3) In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
    d. Detailed descriptions of procedures used to implement and modify control strategies and database construction.
    e. Preliminary overview, screens, station graphic displays, and preliminary reports.
19. Control Descriptions:
    a. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls as shown on the P&IDs:
        1) Include all functions depicted or described in the Contract Documents.
        2) Include within the Control Description content:
            a) All specific requirements.
            b) All common requirements that pertain in general to all loops.
            c) Listing all ranges, setpoints, timers, values, counter values, etc.
20. Test Procedure Submittals:
    a. Submit the proposed procedures to be followed during tests of the PCS and its components in 2 parts:
        1) Preliminary Submittal: Outline of the specific proposed tests and examples of proposed forms and checklists.
        2) Detailed Submittal: After successful review of the Preliminary Submittal, submit the proposed detailed test procedures, forms, and checklists. Include a statement of test objectives with the test procedures.
21. Test reports:
    a. As specified in Section 01_33_00.

1.06 QUALITY ASSURANCE

A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.

B. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

C. Telstar integrated solutions has been sole sourced. All panels must be fabricated at Telstar's UL listed panel fabrication facility and meet all UL 508/508A requirements.

D. ICSC:
   1. The Contractor, through the ICSC, is responsible for the implementation of the PCIS and the integration of the system with other required instrumentation, control devices, and software.
   2. The ICSC assumes full responsibility, through the Contractor, to perform all work to select, furnish, install, program, test, calibrate, and place into operation all instrumentation, controls, telemetry equipment, control panels, and control system including application software, for a complete, integrated and functional PCIS system.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01_60_00.

B. Special instructions:
   1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

C. Tagging:
   1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.
   2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment constituting the PCS.
   3. Tag instruments immediately upon receipt in the field.
   4. Prominently display identification on the outside of the package.
   5. Utilize the Tag and Loop Number identifications shown on the P&IDs.

D. Delivery and inspection:
   1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

1.08 PROJECT OR SITE CONDITIONS

A. Site conditions:
   1. Provide a PCS, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
   2. Seismic classification:
      a. Provide all equipment and construction techniques suitable for the seismic requirements for the site, as specified in Section 01_81_02.

3. Wind:
   a. Provide all equipment and construction techniques suitable for the site wind loading criteria, as specified in Section 01_81_04.
4. Altitude, temperature and humidity:
   a. As specified in Section 01_81_00.
   b. Provide all equipment and instrumentation fully rated for continuous operation at this altitude, temperature and humidity conditions with no additional derating factors applied.
   c. Provide additional temperature conditioning equipment to maintain all equipment and instrumentation in non-conditioned spaces or outdoors subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment manufacturer’s guidelines:
      1) Provide all power wiring for these devices (e.g., heaters, fans, etc.), whether or not indicated on the Drawings.
5. Area classifications:
   a. Furnish enclosures that match the area classifications as specified in Section 26_05_00.
6. Site security:
   a. Abide by all security and safety rules concerning the Work on the Site, as specified in Section 01_35_22.

1.09 SEQUENCING

A. General:
   1. As specified in Sections 01_31_19 and 01_75_17.
   2. Testing requirements are specified in Sections 01_75_17, 40_80_01 and other sections.
   3. General scheduling requirements are specified in Section 01_32_17.
   4. Work restrictions and other scheduling requirements are specified in Section 01_14_00.
   5. Commissioning requirements as specified in Section 01_75_17.

B. Source Testing:
   1. Before the delivery and installation of the PCS system to the job site, but after the procurement, assembly, and configuration of all components; perform the Source Test.
   2. Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
   3. Notify the Engineer of scheduled tests a minimum of 15 days before the date of the test.

C. General Field Start-Up and testing procedures:
   1. As specified in Section 01_75_17.

D. Installation testing:
   1. As specified in Section 01_75_17.
   2. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.

3. Acceptance of the PCIS Installation testing must be provided in writing by the Owner before the performance testing may begin.

E. Training:
   1. As specified in Section 01_75_17.

F. Functional testing:
   1. Representatives from each of the following groups shall be in attendance during the functional Testing: Programmer, System Supplier Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
   2. Loop validation test.
   3. As specified in Section 40_80_01.
      a. Notify the Owner of scheduled tests a minimum of 21 days before the estimated completion date of installation and wiring of the PCIS.
      b. Complete loop validation testing a minimum of 5 days before the pre-commissioning phase of the project.
      c. Loop validation certifications:
         1) After the field device loop tests have been successfully completed as specified in Section 40_80_01 for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, Vendor, and the Owner's representative with test data entered, together with a clear and unequivocal statement that all instrumentation, including all control and signal wiring, has been successfully calibrated, inspected, and tested.
            a) Acceptance of the PCIS Installation Testing must be provided in writing by the Engineer before the Process Operational Period may begin.

G. Provide all special tools and spare parts, as specified in the Maintenance paragraph of this Section, before Process Operational Period commences, suitably wrapped, and identified.

H. Process Operational Period:
   1. Upon completion of the Process Operational Period, conduct an Instrumentation and Controls Process Performance Test as a condition for Project final completion.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. Provide additional warranty as specified in the individual Instrumentation and Control Specifications that extends beyond the Correction Period, as specified in Documents 00_72_00 and 00_73_00.

1.12 SYSTEM PROCESS START-UP

A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
   1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Before Substantial Completion, perform all maintenance activities required by the Contract Documents including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

B. Furnish all spare parts as required by the Contract Documents.

C. Spare parts:
   1. Furnish the spare parts selected by the Engineer from the priced list of spare parts in the hardware submittal.
   2. Furnish a price list of all special tools required to calibrate and maintain all of the instrumentation provided under the Contract Documents. Furnish the special tools selected by the Engineer from the priced list.

D. Provide additional spare parts specified in other sections of the Instrumentation and Control Specifications.

E. Submit all special tools and spare parts, suitably wrapped and identified, before Process Operational Period commences.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide similar items from a single manufacturer throughout the PCIS portion of the Project.

B. Allowable manufacturers are specified in individual instrument and equipment specifications.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these devices and that bear all approvals and labels as required by the Specifications.

B. Provide materials complying with the applicable industrial standard as specified in the Contract Documents.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Furnish all meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of submittal of the shop drawings unless otherwise specified to match existing equipment.

B. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of within 0.5 percent of full scale and a minimum repeatability of within 0.25 percent of full scale.

C. Signal transmission:
1. Analog signals:
    a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
    b. Furnish electrical analog signals outside control panels that are 4 to 20 milliamperes 24 VDC, except as indicated.
    c. Analog signals within enclosures may be 1 to 5 VDC.
    d. Electrically or optically isolate all analog signals from other signals.
    e. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
    f. Maintain the total 4 to 20 milliamperes loop impedance to 10 percent below the published value at the loop operating voltage.
    g. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
2. Pneumatic signals:
    a. All pneumatic signals: 3 to 15 pounds per square inch gauge.
3. Discrete input signals:
    a. As indicated in the controller hardware specification.
4. Discrete output signals:
    a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
    b. Provide external terminal block mounted fuse with blown fuse indication for all discrete outputs.
    c. Provide interposing relays for all discrete outputs for voltage and/or current compatibilities.
    d. Provide interposing relays as required for functionality of the control circuit.
5. Signal performance and design criteria:
    a. Stability:
        1) After Controls have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.

b. Response:
   1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.
c. Agreement:
   1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
d. Repeatability:
   1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.
e. Sensitivity:
   1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.
f. Performance:
   1) All instruments and control devices shall perform in accordance with the manufacturers' specifications.

D. Discrete circuit configuration:
   1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
   2. Alarm contacts: Fail to the alarm condition.
   3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.

E. Grounding:
   1. Provide control panels with a signal ground bus, isolated from the power ground bus:
      a. Provide multiple panels in one location with a common point for signal ground bus connection to ground.
   2. Ground single point ground shields and measurement loops at the source panel external terminals, unless otherwise noted, by bonding to the control panel signal ground bus.
   3. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

F. Instrument air:
   1. Where indicated on the Drawings, provide dry, filtered control air at 30 pounds per square inch gauge nominal pressure piped to all field instruments and instrument panels requiring air:
      a. Provide each field instrument with an integral, non-adjustable filter/regulator assembly to provide regulated air.
      b. Provide each instrument panel requiring air with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments.
      c. Filter all air to 5 micron maximum particle size.
      d. Provide low pressure switch to alarm on insufficient air supply.

2.07 ACCESSORIES

A. Provide flow conditioning devices or other required accessories if necessary to meet the accuracy requirements in the Contract Documents.

B. Nameplates:
   1. Provide a nameplate for each controller, instrument transducer, instrument power supply, solenoid, or any other control device located either in the field or within panels.
   2. All nameplates shall be of identical style, color, and material throughout the facility.
   3. Device nameplates shall include:
      a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
         1) Device tag and loop number ID (e.g., FIT-60.011).
         2) PLC ID (e.g., PLC-11).
         3) Power information (e.g., PCM-11, 120VAC).
      b. White lettering on a black background, laminated plastic.
   4. All instruments shall be equipped with Type 316 stainless steel nameplate with the instrument tag stamped in 3/8-inch letters and connected to the instrument using Type 316 stainless steel wire.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products that bear all approvals and labels as required by the Specifications.

B. Arrange with all manufacturers of the equipment and fabricators of panels and cabinets, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
   1. Equipment includes the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices.

C. Source Test is specified in Section 40_80_01.

PART 3 EXECUTION

3.01 EXAMINATION

A. The ICSC is encouraged to visit the site and examine the premises completely before bidding. It is the ICSC's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

B. Review the existing Site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

C. Provide a complete instrumentation and control system:
   1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, and process control and instrumentation system.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Equipment locations indicated on the Drawings may change due to variations in equipment size or minor changes made by others during construction:
   1. Verify all dimensions as indicated on the Drawings:
      a. Actual field conditions govern all final installed locations, distances, and levels.
   2. Review all information indicated on the Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
   3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.

B. Perform all related Electrical Work in accordance with the applicable sections of the Electrical Specifications.

C. The PCIS configurations are diagrammatic:
   1. The locations of equipment are approximate unless dimensioned.
   2. Where Project conditions require, make reasonable changes in locations and arrangements.

D. Field instruments installation:
   1. Install field instruments as specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer’s instructions.
   2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
      a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
      b. Provide sun shields for all field electronic instruments exposed to direct sunlight.
   3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
      a. Type of flexible conduit required for the area classification:
         1) Area classification as specified in Section 26_05_00.
      b. Maximum length of 18 inches.
   4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
      a. Special cable applications shall be in accordance with the NEC.

5. Verify the correctness of each installation:
    a. Polarity of electric power and signal connections.
6. Ensure all process connections are free of leaks.

E. Process sensing lines and air tubing:
1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
2. Provide supports for rigid tubing at intervals of not more than 3 feet.
3. Slope horizontal runs of instrument tubing at a minimum of 1/16th inch per foot to allow for draining of any condensate.
4. Bends:
    a. Use proper tool.
    b. Make bends for parallel lines symmetrical.
    c. Make bends without deforming or thinning the walls of the tubing.
5. Square-cut and clean all ends of tubing before being inserted in the fittings.
6. Provide bulkhead fittings at all panels requiring pipe and/or tubing entries.
7. Use stainless steel tubing for all piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
    a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.

F. Conduit, cables, and field wiring:
1. Provide all PCS equipment cables, and process LAN communication networks under the Instrumentation and Control Specifications.
2. Provide terminations and wire identification as specified in the Electrical Specifications.
3. Protect all wiring from sharp edges and corners.
4. Provide all conduits, fittings, boxes, etc. in accordance with all the requirements of the Electrical Specifications.

G. Equipment tie-downs:
1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the Site.
2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.

H. Instrument tagging:
1. As specified in Section 26_05_53.
2. Provide all field-mounted instruments with nameplates:
    a. Nameplates engraved with the instrument’s full tag number as indicated on the Drawings:
        1) Affix tags with stainless steel wire fasteners.
3. Provide all back of panel instruments with nameplates:
    a. Engraved with the instrument’s full tag number as indicated on the Drawings:
4. Provide all front of panel instruments with a nameplate:
    a. Engraving to include the following:
        1) Instrument’s full tag number.
        2) Service description.

b. Nameplates:
   1) Secure nameplates to the panel with stainless steel screws.
   2) Use an accepted adhesive if screws would violate the NEMA or other ratings of the enclosure.

I. Cable and conductor termination:
   1. Terminate all cables and conductors on terminal blocks.
   2. Terminal block enclosures:
      a. Suitable for the area classification as specified in Section 26_05_00.

J. Surge protection:
   1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments and the panel.
   2. Individually fuse each 4 to 20 milliamperes direct current loop with a 1/16 ampere fuse between power supplies and receiver surge protectors.
   3. Provide voltage surge protection for 4 wire transmitters and analyzers:
      a. Protect both power source and signal loop.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01_75_17.

B. Owner Training:
   1. Demonstration requirements are specified in Section 40_80_01.
   2. General:
      a. Provide system maintenance and operator training courses for all the instrumentation and control equipment and systems furnished, as described below.
         1) All training described below shall be provided by the Contractor.
         2) The Programmer is not responsible for the training described in this Section.
         3) The Programmer will provide training on software provided by the Programmer.
      b. Conduct all training at the Project Site unless another location is accepted by the Engineer and Owner:
         1) Include instruction on the use of all maintenance equipment and special tools provided under the Contract.
      c. Tailor training classes to the specific needs of the class participants:
         1) Develop separate courses for operators, maintenance staff, and supervisors:
            a) The specific categories and number of personnel in each category are identified below.
         2) Furnish training courses that are a combination of classroom and hands-on training:
            a) Limit classes that include extensive hands-on activities to a maximum of 5 students per class.

3) Present the minimum number of sessions, specified in Table 40_61_00-3.10-T1, for each course in order to satisfy class size restrictions and limitations scheduling Owner staff.
4) Furnish additional sessions if required to accommodate the total number of personnel identified for each course.

d. Schedule individual training classes:
1) Coordinate with the Owner at least 3 weeks before the start of the class:
2) Schedule training classes Monday - Friday between 7:30 a.m. and 3:30 p.m.
3) Each individual daily training session, travel time excluded:
a) Minimum duration of 4 hours.
b) Maximum duration of 7 hours.
c) Breaks scheduled at least every 90 minutes and 1 hour for lunch.
4) Complete training for maintenance personnel 90 days before Process Operational Period.
5) Complete operator training classes before process start-up of the control system software, or any part of it:
a) As specified in the Sequencing article of this Section.
6) Schedule follow-up training classes after the PCS start-up on a schedule determined by the Owner.

e. Instructor qualifications:
1) Highly qualified training instructors for technical training with demonstrated expertise in not only control system functionality but also professional training techniques:
a) Instructor qualifications are subject to the approval of the Engineer.
2) Furnish training instructors thoroughly familiar with the PCIS system, who are members of the implementation team.
3) One of the individuals conducting the PCIS training course must be the same individual responsible for the majority of the programming that was performed for the instrumentation and control system.

3. Training manuals and materials:
a. Furnish training manuals and other materials for training courses.
b. Manuals are to be professionally written to present the course material in a format that is easy to comprehend.
c. The manuals are to serve as teaching aids during presentation of the training classes.
d. Manuals are to serve as reference material after the training has been completed.

Table 1			
Course Title	**Minimum Course Length (hours per session)**	**Personnel (Estimated Number of Students)**	**Minimum Number of Sessions**
System Overview	8	10	1
Operator Training - Basic	24	10	2
Operator Training - Advanced	16	5	2

Table 1			
Course Title	**Minimum Course Length (hours per session)**	**Personnel (Estimated Number of Students)**	**Minimum Number of Sessions**
PLC Hardware	16	4	1
PLC Software	32	6	1
LOI Hardware and Software	16	5	1
Network Equipment	16	4	1
Follow-Up Training	8	5	5
Instrument Training	24	3	1
Analytical Instrument Training	8	3	3

4. Training course requirements:
   a. System overview training:
      1) Furnish training courses that give the Owner's supervisory level personnel an overview of all elements of the PCIS system that focus on the overall functional aspect of elements of the control system and provide an understanding of the interaction of the various components.
   b. Operator training:
      1) Furnish training courses that instruct system operators in the efficient operation of all aspects of the PCIS that include not only the general operation of the control system but also the operation of specific system features.
         a) Control system overview: Architecture, equipment functions, software components, etc.
         b) Display navigation, overview, and types of displays.
         c) Process and equipment monitoring and control: Basic principles and operation.
         d) Logging ON and OFF the system and description of the security and access system.
         e) Alarm subsystem.
         f) Trending: Provide a thorough session on how to use all trending functions.
         g) Reports: How to access, print, and review content.
         h) Control strategies: Present an average 15-minute review of each control strategy, including a hands-on demonstration of screens and operator functions for each.
   c. PLC hardware training:
      1) Furnish training on PLC hardware and on related components, including battery backup equipment, UPSs, LOI hardware, control circuits, and analog circuits.
      2) Furnish training on PLC hardware principles, product features, proper installation, operation, troubleshooting, and maintenance.
      3) PLC training may be provided by manufacturer's certified trainers.

d. PLC software training:
   1) Furnish training on PLC software.
   2) Two types of training are required, basic and project-specific:
      a) Basic PLC software training covers the principles of PLC programming and the specific features and function of the PLC products used on this Project, provided by one of the PLC manufacturer’s certified trainers.
      b) Project-specific PLC software training covers the programming conventions, new standardized software modules, specific control strategy programs, and documentation created for the Work performed under this Contract. This training includes the specific knowledge needed to modify, expand, duplicate, troubleshoot, and repair the PLC programs provided under this Contract, provided by a qualified individual who is thoroughly familiar with the delivered system, and is one of the senior programmers who programmed the PLCs for this Project.
e. LOI hardware and software training:
   1) Provide the following:
      a) Overview of hardware and firmware, including starting, stopping, and PLC interface.
      b) Configuration of tag database.
      c) Creating, editing, and saving display screens.
      d) Troubleshooting.
f. Network equipment training:
   1) Furnish basic training on all network hardware, switch and router configuration and software, and network monitoring software.
   2) Include a detailed description and explanation of the installed network architecture, media, and functions.
   3) Furnish an overview of the function and operation of each piece of network equipment.
   4) Furnish training on network maintenance troubleshooting and repair.
   5) Furnish training on how to install spare or off-line backup equipment.
g. Follow-up training:
   1) Provide a series of on-site follow-up training classes beginning after process start-up of the SCADA/PCIS system. The intent for these classes is to provide the Owner’s personnel the opportunity for a review and “refresher” of the training topics and material after they have had some experience using the system.
   2) Mutually schedule and develop the content of these classes with the Owner no later than 1 month before the beginning of the first session:
      a) Schedule at the Owner’s discretion on non-consecutive days spaced out over the process start-up and warranty period.
h. Instrumentation training:
   1) Furnish training covering all instruments and control panels.
   2) Furnish the specified quantity of training, allocated to cover new instruments and hardwired controls as specified in this Section and specifically determined in the accepted training plan.
   3) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the instruments furnished within this Project.
   4) Furnish training on the operation of new hardwired controls.

i. Analytical instrument training:
    1) Furnish training covering all analytical instruments.
    2) Furnish the specified quantity of training, allocated to cover new analytical instruments as specified in this Section and specifically determined in the accepted training plan.
    3) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the analytical instruments furnished within this Project.
    4) Provide training by manufacturer.

3.08 FIELD QUALITY CONTROL

A. Inspection:
1. Allow for inspection of PCIS installation as specified in Section 01_45_00.
2. Provide any assistance necessary to support inspection activities.
3. Engineer inspections may include, but are not limited to, the following:
    a. Inspect equipment and materials for physical damage.
    b. Inspect installation for compliance with Drawings and Specifications.
    c. Inspect installation for obstructions and adequate clearances around equipment.
    d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
    e. Inspect equipment nameplate data to verify compliance with design requirements.
    f. Inspect cable terminations.
    g. Inspect/witness instrument calibrations/verifications.
4. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 40_80_01.

B. Instrument Installation Inspection:
1. Provide any assistance necessary to support inspection activities.
2. Inspections may include, but are not limited to, the following:
    a. Inspect equipment and materials for physical damage.
    b. Inspect the installed arrangement, lay lengths, orientation, piping obstructions, etc., that could affect the instruments accuracy or repeatability.
    c. Inspect installation for compliance with Drawings and Specifications.
    d. Inspect installation for obstructions and adequate clearances around equipment.
    e. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
    f. Inspect equipment nameplate data to verify compliance with design requirements.
    g. Inspect cable terminations.
    h. Inspect/witness instrument calibrations/verifications.
3. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 40_80_01.
4. Field acceptance testing: (Functional Testing) is specified in Section 40_80_01. Additional general requirements are specified in Section 01_75_17.

C. Installation supervision:
  1. Ensure that the entire PCIS is installed in a proper and satisfactory manner. At a minimum, the ICSC shall provide the following services:
    a. Installation resources:
      1) Coordinate with the Contractor regarding installation requirements of the Contract Documents.
    b. Provide technical assistance to installation personnel by telephone:
      1) Furnish installation personnel with at least one copy of the accepted submittals, including all installation details.
    c. Periodic inspections during the construction period.
    d. A complete check of the completed installation to ensure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
    e. Field verify accuracy and calibration of all instruments.

3.09 ADJUSTING

A. Control valves:
  1. Stroke all control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
  2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.

B. Make all revisions necessary to the control system software, as directed by the Engineer.
  1. It is understood that the Contractor knows and agrees that changes will be required in the control system software during the Source Testing, Functional Testing, Process Operational Period, Process Start-Up, and during the Project Correction Period.

3.10 CLEANING

A. As specified in Section 01_77_00.

B. Vacuum clean all control panels and enclosures before process start-up and again after final completion of the project.

C. Clean all panel surfaces.

D. Return to new condition any scratches and/or defects.

E. Wipe all instrument faces and enclosures clean.

F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
  1. Neatly coil and label all spare wiring lengths.
  2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

G. As specified in other sections of the Contract Documents.

3.11 PROTECTION

A. Protect all Work from damage or degradation until date of Substantial Completion.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 40_61_16

SPECIFIC CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Section 40_61_00.

1.03 DEFINITIONS

A. As specified in Section 40_61_00.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01_33_00 and 40_61_00.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.
   3. Loop description format: As specified in this Section.

B. Loop number and title.
   1. References:
      a. List P&IDs that are specifically referenced.
   2. Abstract:
      a. General description of how the loop works, what devices are involved, and how the process will be controlled.

b. Process values, setpoints, and limits, including units and ranges:
   1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.

3. Hardwired control:
   a. Detailed description of the control functions at the local level.
   b. Function of local operator interfaces.
   c. Operation of hardwired field pilot controls:
      1) Pushbuttons.
      2) Selector switches.
      3) Potentiometers.
      4) Pilot lights, indicators, and other displays.
4. Hardwired interlocks:
   a. Explanation of the operation of system interlocks and hardwired permissive conditions.
5. PLC control:
   a. Detailed description of the control functions that are under control of the PLC.
   b. Operator controls and automatic controls.
   c. Setpoints, alarms, etc.:
      1) Include units and ranges for analog values.
      2) Include span and range for analog inputs and outputs.
      3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
   d. Control sequences.
   e. Software interlocks:
      1) Operation of system software interlocks.
6. PCS/LOI/HMI control:
   a. Detailed description of the operator controls.
   b. Setpoints, alarms, etc.
7. Indicators and alarms:
   a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
8. Failure modes:
   a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loop 130, 230 - Well Pump:
   1. References:
      a. N103, N203.
   2. Abstract:
      a. The well pump is rated for average flows of 1,200 gpm at 418 feet TDH. The well pump will discharge to directly into the potable water system where it can also fill the onsite tank. The well pump will be manually controlled at the MCC located in the electrical room, and remotely controlled via SCADA. Operational monitors are provided at the MCC and SCADA level. The well pump motor is equipped with a variable frequency drive (VFD).
      b. In addition to the normal pump operation controls, pump startup and shutdown sequences will require valve control for the pump-to-waste cycle.

c. All timers described in the pump sequence shall be adjustable through SCADA.

3. Hardwired control:
   a. With the LOR switch in LOCAL position, the well pump is controlled by the START and STOP pushbuttons.
      1) When the START pushbutton is pressed the PLC will initiate the well start sequence as follows:
         a) Energize the LOCAL RUN output to start the pump.
         b) Upon receiving a running signal from the well pump circuit, the PLC will start a countdown timer:
            (1) Pump-to-Waste Close Valve Timer (approximately 5 minutes, although can be varied as appropriate)
         c) After the Pump-to-Waste Close Valve Timer expires the PLC will close the pump-to-waste valve. As the pump-to-waste valve closes, the wellhead pressure will increase, causing the system check valve to open and begin conveying groundwater to either the on-site tank or distribution system (depending which manually-set gate valves are opened or closed).
            (1) If the position of the pump-to-waste valve is not proven closed after a setpoint period of time (approximately 3 minutes) the PLC will remove the LOCAL RUN output to the pump run circuit.
      2) When the STOP pushbutton is pressed the PLC will initiate a soft stop where the following sequence will occur:
         a) Upon receiving the SHUTDOWN signal from the well pump circuit, the PLC will open the pump-to-waste valve. As the pump-to-waste valve opens the system hydraulics will cause the check valve to close.
         b) When the pump-to-waste valve is proven open, a backspin timer will start and the PLC will remove the LOCAL RUN output to the pump run circuit. While the backspin timer is active, the LOCAL RUN output is not permitted to energize.
         c) When the backspin timer has expired, the oil feed solenoid will de-energize.
4. Hardwired interlocks:
   a. The well pump is stopped when:
      1) High temperature switch is activated.
      2) Pump motor overload is activated.
5. PLC control:
   a. In PCIS AUTO, the well pump is controlled via the PLC:
      1) When the PCIS HAND/OFF/AUTO software switch is selected for HAND the well pump startup sequence can be manually started and shutdown via the START/STOP software switch. See below for startup and shutdown sequence.
      2) When the PCIS HAND/OFF/AUTO software switch is selected for OFF the well pump will be prohibited from starting from the PLC. See below for startup and shutdown sequence.
      3) When the PCIS HAND/OFF/AUTO software switch is selected for AUTO the well pump startup and shutdown sequence will be initiated via remote control from the tank control system or the distribution system control system. See below for startup and shutdown sequence.

4) Pump Startup Sequence:
   a) Upon initiation from the PCIS system the PLC will start the pre-lube (oil feed solenoid open) cycle timer (initially set at approximately 60 seconds).
   b) When the pre-lube cycle timer expires, energize the RUN output to start the pump.
   c) Upon receiving a running signal from the well pump circuit, the PLC will start a countdown timer:
      (1) Pump-to-Waste Close Valve Timer (approximately 5 minutes, although can be varied as appropriate)
   d) After the Pump-to-Waste Close Valve Timer expires the PLC will close the pump-to-waste valve. As the pump-to-waste valve closes, the wellhead pressure will cause the check valve to open, discharging pumped water to the on-site tank or the distribution system (depending on manually-set gate valves).
      (1) If the pump-to-waste valve position is not proven closed after a setpoint period of time (approximately 3 minutes) the PLC will remove the LOCAL RUN output to the pump run circuit.

5) Pump Shutdown Sequence:
   a) Upon initiation of a shutdown from the PCIS system the PLC will open the pump-to-waste valve. As the pump-to-waste valve opens the system hydraulics will cause the check valve to close.
   b) When the pump-to-waste valve is proven open, the backspin timer will start and the PLC will remove the RUN output and the LOCAL RUN output to the pump run circuit. While the backspin timer is active, the LOCAL RUN and RUN outputs are not permitted to energize.
   c) When the backspin timer has expired, the oil feed solenoid will de-energize.

6. Software interlocks:
   a. Begin pump shutdown sequence when:
      1) Pump to waste valve is not proven open.
      2) The backspin timer is active.
      3) Tank level is greater than 32 ft and tank gate valve is not proven closed AND system gate valve is not proved open.
      4) Pump discharge high pressure switch is activated.
7. HMI control:
   a. As indicated on the Drawings and specified herein.
8. SCADA control:
   a. As indicated on the Drawings and specified herein.
9. Indicators and alarms:
   a. As indicated on the Drawings and specified herein.
10. Failure modes:
   a. As indicated on the Drawings and specified herein.

B. Loop 110, 120 - Booster Pump Station:
   1. References:
      a. N102, N202.
   2. Abstract:
      a. The booster pump station has 2 pumps that operate in a duty/standby configuration with a design capacity of 4,200 gpm at 48 psi. The booster

pump station draws water from the water storage tank and will discharge directly into the potable water system. The booster pump station will be manually controlled at the MCC located in the electrical room, and remotely controlled via SCADA. Operational monitors are provided at the MCC and SCADA level. The booster pump motors are both equipped with VFDs.

b. All timers and pressure settings described in the pump sequence shall be adjustable through SCADA.

3. Hardwired control:
   a. With the LOR switch in LOCAL position, the booster pumps are controlled by the START and STOP pushbuttons and the speed control potentiometer.
4. Hardwired interlocks:
   a. The booster pumps are stopped when:
      1) High temperature switch is activated.
      2) Pump motor overload is activated.
5. PLC control:
   a. The pumps will operate in a 1+1 setup with a fully redundant pump on stand-by at all times. The booster pump station discharges through a magnetic flow meter, a pressure sustaining valve and into the potable water system.
   b. The booster pump station will be called to run at an operator selectable low-low pressure setpoint from pressure transmitter PT-143
   c. While operating the booster pumps will adjust speed to maintain an operator selectable pressure set point from PT-143 triggering a speed step up or step down based on low and high pressure setpoints respectively.
      A step down when the pump is already at minimum speed will shut the pump down.
6. Software interlocks:
   a. The booster pumps will not start when:
      1) Tank Fill valve is open.
      2) Tank level is less than 5 ft.
   b. The booster pumps are stopped when:
      1) Pump discharge high pressure switch is activated.
7. HMI control:
   a. As indicated on the Drawings and specified herein.
8. SCADA control:
   a. As indicated on the Drawings and specified herein.
9. Indicators and alarms:
   a. As indicated on the Drawings and specified herein.
10. Failure modes:
   a. As indicated on the Drawings and specified herein.

C. Loop 151/152, 251/252 - Well Sodium Hypochlorite Feed System:
1. References:
   a. N104, N204.
2. Abstract:
   a. Water from the well will be pumped directly into the potable water system. Sodium hypochlorite pumps are used to inject sodium hypochlorite into the well discharge piping. A sample line running from downstream of the injection point will provide positive feedback of dosing.

3. Hardwired control:
    a. The chemical feed pumps can be operated via the pump interface or through SCADA.
4. Hardwired interlocks:
    a. The chemical feed pumps will not start when:
        1) Chemical storage tank is empty.
        2) Well pump is off
    b. The chemical feed pumps are stopped when:
        1) Pump discharge high pressure switch is activated.
        2) E-STOP pushbutton is pressed.
5. PLC control:
    a. The pumps will operate in a 1+1 setup with a fully redundant pump on stand-by at all times.
    b. The chemical feed pumps will be interlocked to run when the well pump is operating and the well Pump-to-Waste valve is closed.
    c. While operating the chemical feed pumps will adjust stroke frequency to maintain the same operator selectable residual concentration based on the measurement from chlorine analyzer AIT-155.2.
6. Software interlocks:
    a. As indicated on the Drawings and specified herein.
7. HMI control:
    a. As indicated on the Drawings and specified herein.
8. SCADA control:
    a. As indicated on the Drawings and specified herein.
9. Indicators and alarms:
    a. As indicated on the Drawings and specified herein.
10. Failure modes:
    a. As indicated on the Drawings and specified herein.

D. Loop 153/154, 253/254 - Booster Pump Sodium Hypochlorite Feed System:
1. References:
    a. N105.
2. Abstract:
    a. Water from the booster pump station will be pumped directly into the potable water system. Sodium hypochlorite pumps are used to inject sodium hypochlorite into the booster pump station discharge piping. A sample line running from downstream of the injection point will provide positive feedback of dosing.
3. Hardwired control:
    a. The chemical feed pumps can be operated via the pump interface or through SCADA.
4. Hardwired interlocks:
    a. The chemical feed pumps will not start when:
        1) Chemical storage tank is empty.
        2) Booster pumps are off
    b. The chemical feed pumps are stopped when:
        1) Pump discharge high pressure switch is activated.
        2) E-STOP pushbutton is pressed.
5. PLC control:
    a. The pumps will operate in a 1+1 setup with a fully redundant pump on stand-by at all times.

b. The chemical feed pumps will be interlocked to run when the booster pumps are running.
c. While operating the chemical feed pumps will adjust stroke frequency to maintain the same operator selectable residual concentration based on the measurement from chlorine analyzer AIT-155.1.

6. Software interlocks:
   a. As indicated on the Drawings and specified herein.
7. HMI control:
   a. As indicated on the Drawings and specified herein.
8. SCADA control:
   a. As indicated on the Drawings and specified herein.
9. Indicators and alarms:
   a. As indicated on the Drawings and specified herein.
10. Failure modes:
   a. As indicated on the Drawings and specified herein.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 40_61_00.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 40_64_01

CONTROL SYSTEMS: PROGRAMMABLE LOGIC CONTROLLERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Programmable logic controller (PLC) based control systems hardware.
   2. Development software to be used with the specified PLC hardware.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Section 40_61_00.

B. Institute of Electrical and Electronics Engineers (IEEE).

1.03 DEFINITIONS

A. As specified in Section 40_61_00.

B. Specific definitions:
   1. CPU: Central processing unit.
   2. I/O: Input/Output.

C. Specific definitions:
   1. Development operating software: The software provided by the PLC manufacturer for use in programming the PLC.
   2. Application software: The software that is programmed specifically for the Project.

1.04 SYSTEM DESCRIPTION

A. Provide all PLC hardware as indicated on the Drawings and as specified in this Section.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.

B. Product data:
   1. CPU:
      a. Processor type.
      b. Processor speed.
      c. Memory.

d. Internal processor battery backup time.
2. I/O modules:
   a. Type.
   b. Standard wiring diagram.

C. Calculations:
1. Submit calculations or documented estimate to verify that memory requirements of this Section are met, including spare requirements. If possible, use PLC manufacturer's calculation or estimating worksheet.
2. Submit calculations to verify that spare I/O requirements of this Section are met.
3. Submit calculations to verify that PLC power supply requirements of this Section are met.

D. Product data:
1. Programming languages.
2. Operating system requirements.

E. Control logic:
1. Fully annotated copy of programmed PLC logic.
2. Cross-referenced index of all PLC registers or points.

F. Provide application software for the specific Project process requirements.
1. Fully annotated copy of programmed PLC logic in its native format.
2. Cross-referenced index of all PLC registers or points.

1.06 QUALITY ASSURANCE

A. As specified in Section 40_61_00.

B. Provide PLC hardware manufactured at facilities certified to the quality standards of ISO 9001.

C. Additional requirements:
1. Provide PLC system components by a single manufacturer:
   a. Third-party communication modules may be used only for communication or network media functions not provided by the PLC manufacturer.
2. Use PLC manufacturer approved hardware, such as cable, mounting hardware, connectors, enclosures, racks, communication cable, splitters, terminators, and taps.
3. All PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects, and produced by manufacturers regularly engaged in the manufacture of these products.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 40_61_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 40_61_00.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. As specified in Section 40_61_00.

B. In addition to the spare parts requirements specified in Section 40_61_00, furnish the following:
   1. CPU: 1 spare for each type of CPU.
   2. I/O cards: 3 spares for each type of I/O card.
   3. Power supplies: 2 spares..
   4. Network/communications cards: 1 spare for every network or communications card in the system.

C. Installed spare requirements:
   1. I/O points:
      a. Provide total of 25 percent spare I/O capacity for each type of I/O at every PLC and remote inputs and outputs (RIO).
      b. Wire all spare I/O points to field terminal blocks in the same enclosure the PLC resides in.
   2. PLC backplane capacity:
      a. Provide 25-percent or 3 spare backplane slots, whichever is greater, in all racks containing I/O.
   3. PLC memory:
      a. Provide 50-percent spare program volatile memory.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Acceptable manufacturers:
   1. Allen-Bradley no equals or substitutions.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Programmable logic controller:
   1. Construction:
      a. Furnish plug-in modular system.

b. Provide PLCs capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
   1) Temperature: 0 to 60 degrees Celsius.
   2) RFI: 80 to 1,000 MHz.
   3) Vibration: 10 to 500 Hertz.
   4) Humidity: 0 to 95 percent.
c. Provide internal power supplies designed to protect against overvoltage and frequency distortion characteristics frequently encountered with the local power utility.
d. Design the PLC system to function as a standalone unit that performs all of the control functions described herein completely independent from the functions of the SCADA system PC-based operator interfaces:
   1) Failure of the SCADA system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.

2. CPU:
   a. Allen-Bradley.
   b. Configure each CPU so that it contains all the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
   c. Capable of interfacing with all discrete inputs, analog inputs, discrete outputs, analog outputs, and communication cards to meet the specified requirements.
   d. Capable of supporting and implementing closed-loop floating-point math and PID control that is directly integrated into the CPU control program.
3. Memory:
   a. Supply with sufficient memory to implement the specified control functions plus a reserve capacity as specified with the requirements of this Section:
      1) Reserve capacity:
         a) Totally free from any system use.
      2) Programmed in a multi-mode configuration with multiple series or parallel contacts, function blocks, counters, timers, and arithmetic functions.
4. PLC power supply:
   a. Input: 120 VAC.
   b. Mounted in the PLC housing or as indicated on the Drawings.
   c. Sized to power all modules mounted in that housing including an average module load for any empty housing slots plus 50 percent above that total.
5. PLC input/output, I/O modules:
   a. General:
      1) Compatible with all of the PLCs being furnished under the contract and by the same manufacturer as the PLCs.
      2) Provide I/O modules that:
         a) Isolate in accordance with IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.
         b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
         c) Accept dual-ended inputs.
      3) The use of common grounds between I/O points is not acceptable.

4) Provide modules that are removable without having to disconnect wiring terminals:
    a) Utilize a swing-arm or plug-in wiring connector.
5) Provide at each PLC the I/O modules for the following:
    a) Designated future I/O points contained in the I/O Lists and/or shown on the P&IDs, control schematics, or described in the control strategies.
    b) Installed spare capacity in accordance with the requirements of this Section.
    c) Wire all spares provided to the field terminal strip.
6) Condition, filter, and check input signals for instrument limit conditions.
7) Filter, scale, and linearize the raw signal into an engineering-units-based measurement.
8) Alarm measurements for high, low, rate-of-change limits, and alarm trends.
9) Provide external fuses mounted on the field connection terminal block for all discrete input, discrete output, and analog input I/O points.
10) When multiple cards of the same I/O type are provided and parallel equipment, instrumentation, or redundant processes exist, distribute I/O among cards to ensure that a single card failure will not render an entire process unavailable.

b. Discrete input modules:
    1) Allen-Bradley 1769-IQ16.
    2) Defined as contact closure inputs from devices external to the input module.
    3) With LEDs to indicate status of each discrete input.
    4) Input signal level: As indicated in the schematics and as required to interface with the equipment and instruments. It is most desirable to stick with a signal voltage level where possible.
    5) Provide input module points that are individually fused with blown-fuse indicator lights, mounted external of the module on the output terminal strip:
        a) Coordinate external fuse size with the protection located on the module, so that the external fuse opens first under a fault condition.

c. Discrete output modules:
    1) Allen-Bradley 1769-OB8.
    2) Defined as contact closure outputs for ON/OFF operation of devices external to the output module.
    3) Relay output: Form A (SPST).
    4) LEDs to indicate status of each output point.

d. Analog input modules:
    1) Allen-Bradley 1769-IF8.
    2) Signal type: Provide 4-20 mA for most applications; other levels are acceptable to interface to vendor control panels.
    3) Analog-to-digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
    4) The analog-to-digital conversion updated with each scan of the processor.

e. Analog output modules:
   1) Allen-Bradley 1769-OF4.
   2) Signal type: Provide 4-20 mA for most applications; other levels are acceptable to interface to vendor control panels.
   3) Individual isolated output points each rated for loads of up to 1,200 ohms.

6. PLC backplane housing:
   a. Mount the PLC power supply, CPU, communications module, and I/O modules in a suitable standard PLC backplane or housing.
   b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
   c. Provide a blank slot filler module for each spare slot.

B. PLC programming software:
1. Furnish operating software capable of monitoring and/or controlling the PLCs via the PLC data network:
   a. Contain diagnostics to collect troubleshooting and performance data and display it in easy to understand graphs and tables.
   b. Monitor devices at each drop on the PLC data network for proper communications.
   c. Provide the ability to program all PLCs on the PLC data network from the Engineer’s console.
2. PLC programming laptop/desktop operating system:
   a. Microsoft Windows 7.
3. The PLC programming software shall be suitable for the PLCs specified above.
4. PLC programming software for all programming, monitoring, searching, and editing:
   a. Usable both on-line, while connected to the PLC, and off-line.
   b. The operating software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical function blocks.
   c. Capable of disabling/forcing all inputs, outputs, and coils to simulate the elements of the ladder logic; forced elements shall be identifiable by means of color change.
   d. Include a search capability to locate any address or element and its program location.
   e. Display at the EC, PLC status information, such as faults and communication errors and amount of memory remaining.
5. Generate a PLC program printout, which is fully documented, through the PLC programming software:
   a. Fully documented program listings include, as a minimum, appropriate rungs, address, and coils shown with comments to clarify to a reader what that segment of the program accomplishes on an individual line-by-line basis.
   b. Include a sufficient embedded comment for every rung of the program explaining the control function accomplished in said rung.
   c. Use a mnemonic associated with each contact, coil, etc. that describes its function.
   d. Utilize the tag and loop identification as contained in the P&IDs:
      1) If additional internal coils, timers, etc. are used for a loop, they shall contain the loop number.
   e. Provide a cross-reference report of program addresses.

6. Software functions automatically without operator intervention, except as required to establish file names and similar information:
   a. Furnish the operating system software that is the standard uncorrupted product of the PLC manufacturer with the following minimum functions:
      1) Respond to demands from a program request.
      2) Dynamic allocation of the resources available in the PLC. These resources include main memory usage, computation time, peripheral usage, and I/O channel usage.
      3) Allotment of system resources based on task priority levels such that a logical allocation of resources and suitable response times are ensured.
      4) Queuing of requests in order of priority if one or more requested resources are unavailable.
      5) Resolution of contending requests for the same resource in accordance with priority.
      6) Service requests for execution of one program by another.
      7) Transfer data between programs as requested.
      8) Management of all information transfers to and from peripheral devices.
      9) Control and recovery from all program fault conditions.
      10) Diagnose and report real-time hardware device errors.
7. Program execution:
   a. Application software - program execution scheduled on a priority basis:
      1) A multilevel priority interrupt structure is required.
      2) Enter into a list of pending programs a program interrupted by a higher priority program:
         a) Resume its execution once it becomes the currently highest priority program.
      3) Schedule periodic programs.
      4) Base the allocation of resources to a time-scheduled program on its relative priority and the availability of resources.
8. Start-up and restart:
   a. Provide software that initializes and brings a PLC or any microprocessor-based hardware unit from an inactive condition to a state of operational readiness.
   b. Initialization:
      1) Determination of system status before start-up of initializing operating system software and initializing application software.
      2) Loading of all memory-resident software, initializing timers, counters, and queues, and initialization of all dynamic database values.
9. Shutdown:
   a. Where possible, provide orderly shutdown capability for shutdowns resulting from equipment failure, including other PLC processor failures, primary power failure, or a manually entered shutdown command.
   b. Upon loss of primary power, a high-priority hardware interrupt initiates software for an immediate, orderly shutdown.
   c. Hardware is quickly and automatically commanded to a secure state in response to shutdown command or malfunction.
   d. Alarm PLC failure at the operator interface level.

10. Diagnostics:
    a. Furnish diagnostic programs with the PLC software package to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures.
    b. Use the manufacturer's standard diagnostic routines as much as possible.
    c. Furnish diagnostic software and test programs for each significant component in the control system.
    d. As a minimum, provide diagnostic routines to test for power supply, central processing unit, memory, communications, and I/O bus failures.
11. Calendar/time program:
    a. The calendar/time program to update the second, minute, hour, day, month, and year and transfer accurate time and date information to all system-level and application software.
    b. Variations in the number of days in each month and in leap years must be handled automatically by the program.
    c. The operator must be able to set or correct the time and date from any operator interface, only at the highest security level.
12. Algorithms:
    a. Implementation of algorithms for the determinations of control actions and special calculations involving analog and discrete data.
    b. Algorithms must be capable of outputting positional or incremental control outputs or providing the product of calculations.
    c. Algorithms must include alarm checks where appropriate.
    d. Provide, as a minimum, the following types of algorithms:
        1) Performs functions such as summing several variables, raising to a power, roots, dividing, multiplying, and subtracting.
        2) A switch algorithm, which reads the current and value from its input address and stores it as the value of its output address. 2 types of switches shall be accommodated: 2 outputs with 1 input and 1 output with 2 inputs.
        3) A 3-mode proportional-integral-derivative, PID, controller algorithm, with each of the 3 modes independently adjustable, supports both direct and reverse-acting modes.
        4) Lead, lag, dead time, and ratio compensators.
        5) Integration and totalization of analog process variables.
13. Furnish a comprehensive database for the analog inputs, calculated values, control modules, and outputs:
    a. In addition, provide spare database points for future expansion.
14. One integrated database can be utilized for all types of analog points or separate databases for each type; in either case, the database for each point must include all specified aspects.
15. All portions of the database must be available for use by the display, report, and other specified software modules.
16. All of the data fields and functions specified below must be part of the point definition database at the operator interface. Provide the capability to define new database points through the point display specified below as well as modifying defined points through these displays. This point definition and

modification must include all of the features and functions defined below. The analog database software must support the following functions and attributes:

a. Analog input signal types:
   1) Provide software at the remote terminal units (RTUs) and PLCs to read variable voltage/current signals and pulse duration/frequency type analog input signals.
b. Input accuracy:
   1) Inputs must be read with an accuracy of within 0.05-percent full scale or better.
   2) Data conversion errors must be less than 0.05-percent full scale.
   3) Pulse accumulation error less than or equal to 1 count of actual input count at a scan rate of once per minute.
   4) Maintain for a minimum of 1 year the system accuracy stated above without adjustments.
c. Blocking:
   1) Provide mechanisms to inhibit or block the scanning and/or processing of any analog input through the operator interface.
   2) For any input so blocked, the operator may manually enter a value to be used as the input value.
d. Filtering:
   1) For each analog input, provide a first order lag digital filter with an adjustable filter factor.
e. Linearizing:
   1) Where analog inputs require square root extraction or other linearization, provide a mechanism to condition the filtered data before the process of scaling and zero suppression takes place.
f. Calculated values:
   1) Provide means to allow for pseudo-inputs calculated by algebraic and/or Boolean expressions utilizing real inputs, other calculated values, constants, etc.
   2) These values must be handled the same as real inputs in terms of record-keeping, alarming, etc.
g. Scaling and zero suppression:
   1) Provide a conversion program to convert input values into engineering units in a floating-point format.
h. Alarms:
   1) Provide an alarm program to check all analog variables against high-high, high, low, and low-low alarm limits.
   2) When an analog value exceeds a set limit, it must be reported as an alarm based on individually set priority level for each alarm point.
   3) Provide an adjustable hysteresis band in order to prevent excessive alarms when a variable is hovering around an alarm limit.
   4) Must be possible to inhibit alarms based on external events, e.g., lock-out low pump flow alarm when the pump is off.
i. Averages:
   1) Provide a program to calculate and store hourly, daily, and monthly averages of analog variables.
   2) Continuously compute averages, e.g., the average for the current period to the present point in time must be stored in memory and available for use in displays, etc.
   3) Update hourly averages each minute or at the polling interval for the selected variable.

4) Update daily averages at least once each hour and calculate using the results of the hourly averages.
5) Update monthly averages at least once each day and calculate using the results of the daily averages.
6) At the end of each averaging period, store the average values for the period on the hard disk for historical record-keeping and reset the present period average register to the present value of the variable.
7) The active database must include the present period average and previous period average for each variable and averaging period.

j. Totals:
1) Provide a program to calculate and store hourly, daily, and monthly totalization of analog variables.
2) Assign a scaling factor to each variable to convert to the appropriate units based on a 1-minute totalizing interval.
3) Assign a separate factor for each totalizing interval.
4) Variables for which totalization is inappropriate must have scaling factors of zero.
5) At the end of each totalizing period, store the totalized values for the period on the hard disk for historical record-keeping and reset the present period totalization register to zero.
6) The active database must include the present period total and previous period total for each variable and totalizing period.

k. Engineering units:
1) Provide software to allow the system and the operator to convert all the measured analog variables to any desired engineering units.
2) The operator must be able to view displays and generate reports of any measured variable in one or more engineering units such as flow in gpm, mgd, cfs, and acre-feet per day.
3) Pre-program the conversion of the engineering units, and, if not pre-programmed, the operator must be able to program new engineering unit conversions by using simple methods, e.g., multiplication of the database attributes by a constant.
4) The programming method must be at a level and compatible with the specified training of the operator and the Owner's personnel.
5) New conversions must not require the services of a special programmer and/or special, high-level, programming training.

l. Control modules:
1) For each control function configured, whether processed at the RTU, PLC, or operator interface, maintain a file of necessary data including input values, setpoints, constants, intermediate calculated values, output value and limit clamps, etc.
2) Input and output assignments, setpoints, and constants must be adjustable by the operator through the operator interface.
3) Provide control algorithms for manual control with output values adjustable by the operator.

m. Analog outputs:
1) Analog outputs must be maintained as part of the database.
2) These outputs must be adjustable manually by the operator through the operator interface or through automatic control algorithms.

17. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the

ICSC to optimize the location of the various functions between all software packages.

C. General control functions:
   1. Analog control functions:
      a. PID, lead/lag, signal select, alarm, limit, delay, and time base.
      b. Furnish the control system complete with a library of mathematical/calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR, and NXOR functions.
      c. All math utilities must be linkable to process data points or manual inputs via control block configuration.
      d. By linking control blocks to data points, the math library must support system unit conversion and calculation requirements.
   2. Discrete control functions:
      a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays, and time base.
   3. Software support:
      a. Retain in firmware all control and logic functions at each RTU and PLC and in RAM at the operator interface.
      b. Call each function as required by the configured controls to perform the intended function.
   4. Control and status discrepancies:
      a. Generate a discrepancy/fail alarm for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status.
         1) For example, the system commands to start (call), and the pump fails to start (run status report back), within predetermined operator-programmable time delay (time disagree), then a discrepancy (fail) alarm shall be generated.
      b. Involuntary change in the device's status must also generate an alarm:
         1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.
      c. Each command, status, and alarm must cause the color of the symbol to change.
      d. Because many discrete final control elements have a cycle time in excess of the scan interval, provide each control output with an associated delay period selected to be longer than the operating period of the control element:
         1) Delay periods for each final control element must be adjustable at the operator interface.
         2) List all time delays in the final documentation.
   5. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

D. Control configuration:
   1. Provide software to allow control strategies to be developed, and their operation initiated through the operator interface.

2. Provide standardized control point displays for defining the control functions including the function type, input/output addresses, setpoints, tuning constants, etc.
3. Provide a mechanism to link separate control functions together into an integrated control strategy.
4. Provide a mechanism to download operational/control setpoints developed at any operator interface to any PLC or RTU for operational implementation.
5. Provide a mechanism to define and implement operational/control setpoints locally at the PLC or RTU, and to upload them to the operator interface for operational record-keeping.
6. Perform control configurations on-line at the operator interface; the PLC or RTU may be taken off-line when being configured or downloaded.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 40_61_00.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 40_61_00.

B. Utilize personnel to accomplish or supervise the physical installation of all elements, components, accessories, or assemblies:
   1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.

C. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.

D. General:
   1. The control system logic program shall reside at the PLC level.

E. Use the tag and loop identifications found on the P&IDs for all tags used and/or assigned as part of the application software work provided by the ICSC.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Provide a minimum of 4 CD/DVD copies of the following:
   1. Application software:
      a. Finalized fully annotated copy of programmed PLC logic in its native format.
      b. Cross-referenced index of all PLC registers or points.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 40_61_00.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 40_61_00.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 40_61_00.

B. Tailor training specifically for this Project that reflects the entire control system installation and configuration.

C. Perform training by pre-approved and qualified representatives of the ICSC and/or manufacturer of the PLC hardware and programming software:
   1. A representative of the ICSC may perform the PLC hardware training only if the representative has completed the manufacturer’s training course for the PLC hardware.
   2. A representative of the ICSC may perform the PLC programming software training only if the representative has completed the manufacturer’s training course for the PLC programming software.

3.11 PROTECTION

A. As specified in Section 40_61_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 40_64_21

CONTROL SYSTEMS: LOCAL OPERATOR INTERFACE (LOI)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Local Operator Interface (LOI) control systems hardware and software.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Section 40_61_00.

1.03 DEFINITIONS

A. As specified in Section 40_61_00.

1.04 SYSTEM DESCRIPTION

A. Provide all LOI hardware identified in the Contract Documents.

1.05 SUBMITTALS

A. Furnish submittals in accordance with Sections 01_33_00 and 40_61_00.

B. Product data:
   1. Complete manufacturer’s brochures for each item of equipment.
   2. Complete manufacturer’s brochures that identify LOI software and options. Mark up to clearly show options and components to be provided, and cross out any options or components that will not be provided.
   3. Manufacturer’s operation and installation instructions.
   4. Additional requirements:
      a. Display type and size.
      b. Operator input.
      c. Processor type and speed.
      d. Memory size.
      e. Programming protocols.
      f. Communication protocols.
      g. Power requirements.
      h. Operating temperature and humidity ranges. NEMA ratings.

C. Shop drawings:
   1. Furnish the following:
      a. System block diagram showing relationship and connections between devices. Include manufacturer and model information, and address settings.
      b. Mounting drawings with dimensions and elevations for each equipment location, including identification of all components, preparation and finish data, and nameplates.
      c. Electrical connection diagrams.
      d. Complete grounding requirements.
   2. Graphic Screens:
      a. Color printouts of each graphic screen and all control pop-ups.
   3. Furnish data sheets for each component together with a technical product brochure or bulletin:
      a. Manufacturer’s model number.
      b. Project equipment tag.
   4. Complete and detailed bills of materials identified by each cabinet. Include with each bill of material item the following:
      a. Quantity.
      b. Description.
      c. Manufacturer.
      d. Part numbers.

D. Operation and maintenance manuals:
   1. Complete installation, operations, calibration, and testing manuals as described in Section 40_61_00.

E. Record documents:
   1. Electrical connection diagrams revised to reflect any changes made in the field and submitted as record Drawings.

1.06 QUALITY ASSURANCE

A. As specified in Section 40_61_00.

B. Examine the complete set of Contract Documents and verify that the LOI equipment is compatible with the installed conditions.

C. Notify the Engineer if any installation condition does not meet the manufacturer’s recommendations or specifications.

D. Provide LOI hardware manufactured at facilities certified to the quality standards of ISO Standard 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and Servicing.

E. System compatibility:
   1. The software must be the standard operating software system designed specifically for use with the LOI hardware.
   2. The software must be furnished and developed by the manufacturer of the LOI hardware.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00.

1.08 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 40_61_00.
   1. Provide LOI equipment suitable for the installed site conditions including, but not limited to, site altitude, site seismic conditions, humidity, and ambient temperatures.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 40_61_00.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

A. As specified in Section 40_61_00.

B. Provide system upgrades and maintenance fixes for a period of 2 years from substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Acceptable manufacturers:
   1. Allen-Bradley - PanelView Plus 7 Standard no equals or substitutions.

B. Provide the LOI graphic software system manufactured by the LOI hardware manufacturer.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Local Operator Interface:
   1. General:
      a. Provide Local Operator Interface located on the face of the PCM as indicated on the Drawings.

b. NEMA 12 rated.
c. Local Operator Interface consists of graphical display screen with operator input capabilities.
d. Capable of stand-alone operation in conjunction with 1 PLC.
e. Equipped with data network communication capabilities.

2. Display:
   a. Type:
      1) Color TFT LCD screen.
   b. Resolution:
      1) 640 by 480 pixels.
   c. Size: As indicated on the Drawings.
   d. Easy display viewing at any angle in various ambient light conditions.
   e. Operator input:
      1) Configurable touch screen.
   f. Screen update speed: The screen update speed and screen change speed less than 1 second.
   g. Provide following features for outdoor use:
      1) Anti-glare screen overlay.
      2) Luminescence: Minimum 1,000 Nits.
3. Graphic configuration:
   a. Easily configured graphics by:
      1) Portable laptop computer both locally and via the PLC data network.
      2) SCADA Engineer's console via the PLC data network.
   b. As specified in Section.
4. Memory:
   a. Application:
      1) 512 MB Flash EPROM.
5. CPU: Minimum 100 MHz.
6. Communications:
   a. Ethernet.
7. Environment:
   a. Temperature: 0 to 50 degrees Celsius.
   b. Relative humidity: 10 to 90 percent.
8. Electrical:
   a. Power supply:
      1) 120 VAC.

B. Local Operator Interface software:
   1. Provide a complete software package to be used for programming the necessary screens and operator interaction with the LOIs.
   2. Operating system:
      a. Microsoft Windows 7.
   3. Furnish software with preconfigured symbols, objects, graphics, and imported bitmaps for the generation of the displays.
   4. Software must allow bitmaps to be imported or exported to or from other applications.
   5. Capable of generating custom reports, complete with screen prints.
   6. Capable of working with multiple screens concurrently.
   7. Provide dialog boxes for defining object attributes.
   8. Configure objects using fill in dialog boxes.

9. Furnish graphic and text editor that allows custom formatting in order to customize and change the appearance of objects and text:
   a. Allow selection of different fill patterns to define object status.
10. As a minimum, provide the following object capabilities:
    a. Operator inputs:
       1) Momentary pushbutton.
       2) Maintained pushbutton.
       3) Latched pushbutton.
       4) Multistate pushbutton.
       5) Keypad enable button.
       6) Cursor point.
    b. Control list selectors:
       1) Standard control list.
       2) Piloted control list.
    c. Global objects.
    d. Display objects:
       1) Bar graph.
       2) Scale.
       3) Message display.
       4) Multistate indicator.
       5) List indicator.
       6) Numeric data display.
    e. Screen selector objects:
       1) Go to.
       2) Return.
       3) Screen list selector.
    f. Embedded variables:
       1) Time.
       2) Date.
       3) Numeric variable.
    g. Graphics:
       1) Lines.
       2) Shapes.
       3) Freeform drawings.
       4) Imported graphics.
       5) Background text.
       6) Selection table for standard ISA symbols.
       7) PID controller faceplate.
    h. Alarm screens.
11. Documentation:
    a. Provide complete user documentation, including examples of how to operate the various modules within the system.
    b. Provide the documentation in electronic format, HTML based with the ability to search for topics by keyword or search or specific text.
12. On-line help:
    a. Provide an on-line "help" facility, based upon Windows standard Hypertext:
       1) Useful, context-sensitive information on the operation of the package:
          a) That can be invoked on-line through a point-and-click operation.
          b) The "help" facility must also support the ability to perform full text word search, add custom comments, bookmark topics, copy

and pasting into another application, printing, and use of system fonts and colors.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 40_61_00.

PART 3 EXECUTION

3.01 EXAMINATION

A. As specified in Section 40_61_00.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 40_61_00.

B. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.

C. Provide panel support bracing if more than 25 percent of the area has been removed to allow for the mounting of the LOI.

D. All tags used and/or assigned as part of the application programming work are to use the tag and loop identifications found on the P&IDs.

E. Station graphics:
   1. Configure the graphic display for each device both in the facility including but not limited to:
      a. Symbols for:
         1) Pumps.
         2) Valves.
         3) Analytical instruments.
         4) Flowmeters.
         5) Pressure transmitters.
         6) Major equipment.
      b. Alarm symbols including intrusion alarm.
      c. Relevant test and operational data.

d. Status for each controller or controlled device:
   1) Hand-Off-Auto Status.
   2) Local-Off-Remote Status.
   3) Run.
   4) Call.
   5) Fail.
   6) Open.
   7) Close.
   8) Hold.
   9) Modulate.
   10) Running.

e. Depict a change of state of pumps and valves by a change in color.

2. Production and usage bar graph:
   a. Depict the production for each site and/or piece of equipment, as determined during the requisite graphics meeting, within the treatment plant, summarized to type, and total usage, with a bar graph and numeric value for each analog value.
3. System level summary:
   a. Show the level for the plant influent and effluent production, etc, via a display using bar graphs and numbers, as determined during the requisite graphics meeting.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 40_61_00.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 40_61_00.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 40_61_00.

B. Perform the training using pre-approved and qualified representatives of the ICSC and or manufacturer of the LOI software:
   1. A representative of the ICSC may perform the training only if the representative has completed the manufacturer’s training course for the LOI software.

3.11 PROTECTION

A. As specified in Section 40_61_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 40_66_70

CONTROL SYSTEMS: WIRELESS COMMUNICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Radio communication system.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 26_05_00 - Common Work Results for Electrical.
   3. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Section 40_61_00.

1.03 DEFINITIONS

A. As specified in Section 40_61_00.

B. Specific definitions:
   1. CPM: Critical path method.
   2. EIRP: Effective isotropically radiated power.
   3. Fade margin: This is the amount of margin left to allow for the natural variations in radio performance, which will occur due to weather, air density, etc.
   4. FCC: Federal Communications Commission.
   5. ITS: Institute for Telecommunications Science.
   6. RF: Radio frequency.
   7. SIM: Subscriber identity module.

1.04 SYSTEM DESCRIPTION

A. The radio communication system will serve the following sites:
   1. Alpine Vista, J Street remote sites.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.

1.06 QUALITY ASSURANCE

A. As specified in Section 40_61_00.

B. After installation, verify through the use of field collected data, that the installed equipment conforms to reliability benchmark developed as part of the field testing.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 40_61_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 40_61_00.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER’S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. As specified in Section 40_61_00.

B. Furnish all parts, materials, fluids, etc., necessary for maintenance and calibration purposes for 1 year:
   1. Deliver all supplies before Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Wireless radio communication system:
   1. Radio Transceiver:
      a. Accepted Manufacturers.
         1) Xeta 9 - EL no equals or substitution.
   2. Radio Antenna:
      a. Accepted Manufacturers.
         1) Yagi, model: YAG9D9

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Wireless radio communication system:
   1. License-free frequency hopping spread spectrum radio system:
      a. General:
         1) The license-free radio system comprises the following:
            a) Wireless radio(s).
            b) Antennas.
            c) Surge protectors.
            d) Transmission cables.
            e) Software and other accessories as specified in the Accessories article.
         2) Performance requirements:
            a) Frequency: 902-928 MHz.
            b) Ambient temperature range: -20 to 60 degrees Celsius.
            c) Enclosure protection class: IEC IP20.
      b. Unidirectional (one-way) system:
         1) Wireless radio:
            a) Transmitter:
               (1) Transmission capacity: 1 W.
               (2) Inputs:
                  (a) Analog 4 to 20 mA.
                  (b) 120 VAC discrete input.
               (3) Supply voltage: 12 - 30 VDC.
            b) Receiver:
               (1) Outputs:
                  (a) Analog 4 to 20 mA.
                  (b) 120 VAC dry contact.
                  (c) Provide dry contact for radio connection status.
               (2) Supply voltage: 12 - 30 VDC.
   2. Antennas:
      a. Antenna characteristics:
         1) Yagi antenna:
            a) Frequency range: 902-928 MHz.
            b) Nominal impedance: 50 ohm.
            c) Connector: N-Type.
            d) Gain: As specified in the Examination article.
            e) Wind loading: 102.5 mph.
            f) Construction material: All welded aluminum.
            g) Operating temperature:
               (1) Stationary: -40 to 85 degrees Celsius.
               (2) Cyclic: -40 to 55 degrees Celsius.
   3. Surge protector:
      a. Manufacturer: One of the following or equal:
         1) Andrews:
            a) T Series Surge Arrestors.
            b) Gas Tube Surge Arrestors.
         2) Phoenix Contact Trabtech Series.
   4. Transmission cables:
      a. Manufacturer: One of the following or equal:
         1) Andrews:
            a) HELIAX Cable Products.

2) Phoenix Contact Interface Wireless.

b. 1/2-inch, nominal diameter.

c. Continuous section without splices or connectors other than at the radio and antenna.

d. Cable characteristics:

1) Attenuation: Less than 2.2 dB at 960 MHz per 100 feet.

2) Characteristic impedance: 50 ohms.

3) Coaxial shield.

4) Dielectric: Foam.

5. Software:

a. Provide software package for radio diagnostic testing.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

A. As specified in Section 40_61_00.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING

A. Orient directional antennas as required for maximum receive strength signal intensity (RSSI) during startup.

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 40_67_01

CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Design, fabrication and assembly of all instrumentation enclosures, control panels and components provided under this contract, including but not limited to:
      a. Custom built instrumentation and control panels, including all enclosures for hand stations controllers, low voltage power distribution and marshalling panels.
      b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs) and chemical feed panels.
      c. Control components.
      d. Control panel installation.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_81_02 - Seismic Design Criteria.
   3. Section 26_05_00 - Common Work Results for Electrical.
   4. Section 26_05_53 - Identification for Electrical Systems.
   5. Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
   6. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all control panels identified in Contract Documents.

1.02 REFERENCES

A. As specified in Section 40_61_00.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.

C. Underwriters Laboratories Inc. (UL):
   1. 508 - Standard for Industrial Control Equipment.
   2. 508A - Standard for Industrial Control Panel.
   3. 1283 - Standard for Electromagnetic Interference Filters.
   4. 1449 - Standard for Surge Protective Devices.

1.03 DEFINITIONS

A. As specified in Section 40_61_00.

B. Specific definitions:
   1. The term “panel” in this Section is interchangeable with the term “enclosure”.

1.04 SYSTEM DESCRIPTION

A. Panel dimensions:
   1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer’s non-certified information. It is the responsibility of the Contractor or manufacturer to design and size all panels:
      a. Size panels to provide space for all equipment, wiring, terminations, and other items in the panel, including space for future build out.
      b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
      c. Maximum panel depth: 30 inches, unless otherwise indicated.

B. Structural design:
   1. Completed and installed panel work shall safely withstand seismic requirements at the project site as specified in Section 26_05_00. Enclosures and internal equipment shall be braced to prevent damage from specified forces.

1.05 SUBMITTALS

A. Provide submittals as specified in Sections 01_33_00 and 40_61_00.

B. Provide a control panel hardware submittal for each control panel and enclosure being provided on this project, including but not limited to:
   1. Product data:
      a. Enclosure construction details and NEMA type.
      b. Manufacturer's literature and specification data sheets for each type of equipment to be installed within or on the panel or enclosure.
   2. Shop drawings:
      a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
         1) Provide draft for review and approval by Engineer. The Engineer has the authority to substantially alter initial panel layouts.
      b. Complete nameplate engraving schedule.
      c. Structural details of fabricated panels.
   3. Calculations:
      a. Provide installation details based on calculated shear and tension forces:
         1) Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.
      b. For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:
         1) Weight including panel internal components.
         2) Seismic forces and overturning moments.
         3) Shear and tension forces in connections.
      c. Cooling calculations, including but not limited to:
         1) Highest expected ambient temperature for the enclosure's location.
         2) Internal heat load.
         3) Exposure to direct sunlight.

4) Dimensions of the enclosure in inches.
5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

C. Seismic design:
1. Seismic panel construction:
a. Seismic anchorage: Provide seismic design calculations and installation details for anchorage of all panels, enclosures, consoles, etc. to meet seismic requirements in Section 01_81_02:
1) Stamped by a Professional Engineer registered in the state where the project is being constructed.
b. For floor-mounted freestanding panels weighing 200 pounds or more (assembled, including contents), submit calculations, data sheets, and other information to substantiate that panel, base, and framing meet minimum design strength requirements and seismic requirements as specified in Section 01_81_02. Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.

1.06 QUALITY ASSURANCE

A. As specified in Section 40_61_00.

B. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
1. Provide all components and equipment with UL 508 listing.
2. All control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL 508A labeling.
3. Provide fuses for all equipment that is not UL or UR listed.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Project environmental conditions as specified in Section 40_61_00.
1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 40_61_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 40_61_00.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. As listed below in the individual component paragraphs.

B. Provide instruments and other components performing similar functions of the same type, model, or class, and from 1 manufacturer.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
   1. Enclosures shall have the following properties:
      a. NEMA Type 1: Steel.
      b. NEMA Type 4: Steel with gasketed door, raintight.
      c. NEMA Type 4X: Type 316 stainless steel (unless Type 304 is indicated on the Drawings).
      d. NEMA Type 12: Steel with gasketed door, dusttight.

B. Bolting material:
   1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts, and washers, with unified coarse (UNC) threads.
   2. Carriage bolts for attaching end plates.
   3. All other bolted joints shall have S.A.E. standard lock washers.

2.04 MANUFACTURED UNITS

A. Panels/enclosures:
   1. Manufacturer: One of the following or equal:
      a. Rittal.
      b. Pentair (formerly Hoffman Engineering).
      c. Saginaw Control & Engineering.
   2. Panel assembly:
      a. General guidelines for panel fabrication include:
         1) Continuous welds ground smooth.
         2) Exposed surfaces free of burrs and sharp edges.
         3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.

b. Construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	14	14
Up to 57	12	12
57 - 69	12	10
69 - 82	12, except 10 on back	10
82 or more	10	10

1) Use heavier sheet metal to meet seismic requirements at the project site or when required due to equipment requirements.

c. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.

d. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.

e. Door construction:
   1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
   2) Sufficient width to permit door opening without interference with rear projection of flush-mounted instruments.
   3) Heavy-gauge piano-type continuous stainless steel hinges.
   4) For NEMA Type 12, Type 4, and Type 4X, provide oil-resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
   5) Gasket installed to seal against roll lip on the enclosure opening.

f. Latches:
   1) For panels, provide each door with a 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods shall be connected to a common door handle, hold doors securely, and form a compressed seal between door and gasket, at the top, side, and bottom.
      a) Provide padlock for each enclosure with padlock provisions.
   2) Include an oiltight key-locking, 3-point latching mechanism on each door:
      a) Provide 2 keys per panel.
      b) All locks keyed alike.

g. Panel cut-outs:
   1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
   2) Allow a minimum of 3-inch envelope around all displays, controllers, and monitors.

3) Reinforce around cut-outs with steel angles or flat bars for the following:
   a) Large panel cutouts; for example, openings for local operator interfaces.
   b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.

B. Arrangement of components:
1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
2. Arrange panel instruments and control devices in a logical configuration, associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
3. Mount internal control components on an internal back panel. Devices may be mounted on the side panel only by special permission from the Engineer.
4. All control-panel-mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.

C. Overcurrent protection:
1. Main overcurrent device:
   a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange-mounted disconnect handle operating a molded-case circuit breaker and provide a control power transformer for 120-VAC circuits:
      1) Door-mounted disconnect handles are not acceptable.
      2) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
      3) Provide means to defeat the interlock.
      4) Lockable in the off position.
   b. Control panels supplied with 120 VAC:
      1) Provide an internal breaker with the line side terminals covered by a barrier.
      2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
2. Provide circuit breakers as specified in Section 26_28_01.
3. Selection and ratings of protective devices:
   a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
   b. Voltage rating: Not less than the voltage of the application.
   c. Select current rating and trip characteristics to be suitable for:
      1) Maximum normal operating current.
      2) Inrush characteristics.
      3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
4. Provide a separate protective device for each powered electrical device:
   a. An individual circuit breaker for each 120-VAC instrument installed within its respective control panel and clearly identified for function.

b. An individual fuse for each PLC discrete output. Provide with individual blown fuse indication external of the I/O card:
   1) Size external fuse to open before any I/O-card-mounted fuses.
   2) Individual discrete inputs shall use a 0.5-ampre fuse.
c. Control loops can use individual 5-ampere fuse for the loop.
d. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.

5. Fuses for 4 to 20 milliamperes signals:
   a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
      1) Label shall not cover or interfere with equipment manufacturer's instructions.
   b. An individual 1/2-ampere fuse for each 4 to 20 milliamperes analog loop powered from the control panel.
   c. Provide fuses rated for the voltage and available short-circuit current at which they are applied.
   d. Manufacturer: One of the following or equal:
      1) Ferraz Shawmut.
      2) Littelfuse.
      3) Bussmann.
6. Fuse holders:
   a. Modular type:
      1) DIN rail mounting on 35-millimeter rail.
      2) Touch-safe design: All connection terminals to be protected against accidental touch.
      3) Incorporates blown-fuse indicator.
      4) Plug-in style fuse teminals and fuse plugs are not acceptable.
   b. Provide nameplate identifying each fuse:
      1) As specified in Section 26_05_53.
   c. Manufacturer: One of the following or equal:
      1) Phoenix Contact.
      2) Allen-Bradley 1492-FB Series B.
7. Control circuit breakers:
   a. DIN rail mounting on 35-millimeter rail.
   b. Manual OPEN-CLOSE toggle switch.
   c. Rated for 250 VAC.
   d. Interrupting rating: 10 kiloampere (kA) or available fault current at the line terminal, whichever is higher.
   e. Current ratings: As indicated on the Drawings or as required for the application.
   f. Provide nameplate identifying each circuit breaker:
      1) As specified in Section 26_05_53.
   g. Manufacturer: One of the following or equal:
      1) Phoenix Contact.
      2) ABB.
      3) Allen-Bradley.
      4) Square D.

D. Conductors and cables:
   1. Power and control wiring:
      a. Materials: Stranded, soft annealed copper.
      b. Insulation: 600 volts type MTW.

c. Minimum sizes:
   1) Primary power distribution: 12 AWG.
   2) Secondary power distribution: 14 AWG.
   3) Control: 16 AWG.
d. Color:
   1) AC power (line and load): Black.
   2) AC power (neutral): White.
   3) AC control: Red.
   4) AC control: Orange for foreign voltages.
   5) DC power and control (ungrounded): Blue.
   6) DC power and control (grounded): White with Blue stripe.
   7) Ground: Green.

2. Signal cables:
   a. Materials: Stranded, soft annealed copper.
   b. Insulation: 600 volts, PVC outer jacket.
   c. Minimum size: 18 AWG paired triad.
   d. Overall aluminum shield (tape).
   e. Copper drain wire.
   f. Color:
      1) 2-Conductor:
         a) Positive (+): Black.
         b) Negative (-): White and red.
      2) 3-Conductor:
         a) Positive (+): Black.
         b) Negative (-): Red.
         c) Signal: White.
   g. Insulate the foil shielding and exposed drain wire for each signal cable with heat-shrink tubing.

E. Conductor identification:
   1. Identify each conductor and cable with unique wire numbers as specified in Section 26_05_53.
   2. Readily identified without twisting the conductor.

F. General wiring requirements:
   1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
   2. Install all components in accordance with the manufacturer’s instructions included in the listing and labeling.
   3. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
   4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
   5. Provide power surge protection for all control panels.
   6. Provide signal surge protection within control panels for each analog I/O, discrete I/O, and data line (Copper Ethernet, Coax, Fieldbus signals) that originates from outdoor devices.
   7. Provide non-metallic ducts for routing and organization of conductors and cables:
      a. Provide wiring separation plan.

b. Size ducts for ultimate build-out of the panel, or for 20-percent spare, whichever is greater.
c. Provide separate ducts for signal and low-voltage wiring from power and 120-VAC control wiring:
1) 120 VAC: Grey colored ducts.
2) 24 VDC: White colored ducts.

8. Cables shall be fastened with cable-mounting clamps or with cable ties supported by any of the following methods:
a. Screw-on cable tie mounts.
b. Hammer-on cable-tie mounting clips.
c. Fingers of the nonmetallic duct.

9. Wire Ties:
a. No wire ties inside wire duct.
b. Use Panduit Cable tie installation tool, with tension control/cutoff.
c. Verify cut ends are cut flush filed smooth after installed.

10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
11. Support panel conductors where necessary to keep them in place.
12. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
13. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
a. Factory-applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.

14. The control panel shall be the source of power for all 120-VAC devices interconnected with the control panel including, but not limited to:
a. Solenoid valves.
b. Instruments both mounted in the control panel and remotely connected to the control panel.

G. Provide power circuits for all Contractor and Vendor-furnished PLC cabinets in accordance with the PLC and Instrument Power wiring diagrams Indicated on the Drawings or as specified.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Panel meters:
1. Digital process indicators:
a. General:
1) Integral provisions for scaling.
2) Scale to process engineering units.
3) Switch-programmable decimal points.
4) NEMA Type 4/IP65 sealed front bezel.

b. Current and voltage indicators:
1) 3-1/2-digit minimum.
2) Minimum character height: 0.5 inches.
3) Accuracy:
a) AC/DC volts: Within 0.1 percent of reading plus 2 digits.
b) DC current: 4 to 20 milliamperes; within 0.1 percent of reading plus 1 digit.

c) DC voltage: 0 to 10 volts; within 0.1 percent of reading plus 1 digit.

c. Operating voltage: 120 VAC.

d. Operating temperature: 0 to 60 degrees Celsius.

1) Manufacturer: One of the following or equal:

a) Red Lion.

b) Action Instruments Visipak.

B. Pilot devices:

1. General:

a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.

b. Size:

1) 30.5 millimeters.

c. Heavy duty.

d. Pushbuttons:

1) Contacts rated:

a) NEMA Type A600.

2) Furnish 1 spare normally open contact and normally closed contact with each switch.

e. Selector switches:

1) Contacts rated:

a) NEMA Type A600.

b) Knob type.

2) Furnish 1 spare normally open contact and normally closed contact with each switch.

3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.

f. Pilot lights:

1) Type:

a) LED for interior installations.

2) Push to test.

3) Lamp color:

a) On/Running/Start: Red.

b) Off/Stop: Green.

c) Power: White.

d) Alarm: Amber.

e) Status or normal condition: White.

f) Opened: Red.

g) Closed: Green.

h) Failure: Red.

2. Indoor and outdoor areas:

a. NEMA Type 4/13.

b. Manufacturer: One of the following or equal:

1) Allen-Bradley Type 800T.

2) Square D Class 9001, Type K.

3) General Electric Type CR104P.

4) IDEC TWTD Series.

C. Signal isolators and converters:
 1. Furnish signal isolators that provide complete isolation of input, output, and power input:
  a. Minimum isolation level: 1.5 kilovolts AC/50 Hertz for at least 1 minute.
  b. Adjustable span and zero.
  c. Accuracy: Within 1.0 percent of span.
  d. Ambient temperature range: -20 to +65 degrees Celsius.
 2. Manufacturer: One of the following or equal:
  a. Phoenix Contact MCR Series.
  b. Acromag 1500, 600T, 800T, Flat Pack, or ACR Series.
  c. Action Instruments Q500 Series or Ultra SlimPakII.
  d. AGM Electronics Model TA-4000.

D. Relays:
 1. General:
  a. For all types of 120-VAC relays, provide surge protection across the coil of each relay.
  b. For all types of 24-VDC relays, provide a free-wheeling diode across the coil of each relay.
 2. General purpose:
  a. Magnetic control relays.
  b. NEMA Type A300 rated:
   1) 300 volts.
   2) 8 Amps continuous (minimum).
   3) 7,200 volt-amperes make.
   4) 720 volt-amperes break.
  c. Plug-in type.
  d. LED indication for energization status.
  e. Coil voltages: As required for the application.
  f. Minimum poles: DPDT.
  g. Touch-safe design: All connection terminals to be protected against accidental touch.
  h. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
  i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
  j. Relays with screw-type socket terminals.
  k. Provide additional (slave/interposing) relays when the following occurs:
   1) The number or type of contacts shown exceeds the contact capacity of the specified relays.
   2) Higher contact rating is required in order to interface with starter circuits or other equipment.
  l. DIN rail mounting on 35-millimeter rail.
  m. Ice-cube-type relays with retainer clips to secure relay in socket.
  n. Integrated label holder for device labeling.
  o. Manufacturer: One of the following or equal:
   1) Phoenix Contact PLC Series.
   2) Potter and Brumfield Type KRP or KUP.
   3) IDEC R* Series (* = H, J, R, S, U).
   4) Allen-Bradley Type 700 HC.
   5) Square D Type K.
 3. Latching:
  a. Magnetic-latching control relays.

b. NEMA Type B300 rated:
   1) 300 volts.
   2) 10 Amps continuous.
   3) 3,600 volt-amperes make.
   4) 320 volt-amperes break.
c. Plug-in type.
d. DIN rail mounting on 35-millimeter rail.
e. Coil voltage: As required for the application.
f. Minimum poles: 2 PDT; as required for the application. Plus 1 spare pole.
g. Touch-safe design: All connection terminals to be protected against accidental touch.
h. Clear cover for visual inspection.
i. Provide retainer clip to secure relay in socket.
j. Manufacturer: One of the following or equal:
   1) Square D 8501, Type K.
   2) IDEC TWTD Series.

4. Time delay:
   a. Provide time-delay relays to control contact transition time.
   b. Contact rating:
      1) 240 volts.
      2) 10 Amps continuous.
      3) 3,600 volt-amperes make.
      4) 360 volt-amperes break.
   c. Coil voltage: As required for the application.
   d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off-delay:
      1) For off-delay, use true power-off time-delay relays. Where the required timing range exceeds capability of the off-delay relay use, signal off-delay where power loss will not cause undesirable operation or pneumatic time-delay relays.
   e. Minimum poles: 2 PDT.
   f. Units include adjustable dial with graduated scale covering the time range in each case.
   g. Minimum timing range: 0.1 seconds to 10 minutes, or as required for the application.
   h. Manufacturer: One of the following or equal:
      1) IDEC RTE Series.
      2) Agastat Series 7000 (pneumatic).
      3) Allen-Bradley Type 700-HR.

E. Terminal blocks:
   1. DIN rail mounting on 35-millimeter rail.
   2. Suitable for specified AWG wire.
   3. Rated for 15 amperes at 600 volts.
   4. Screw terminal type.
   5. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
   6. Finger-safe protection for all terminals for conductors.
   7. Construction: Polyamide insulation material capable of withstanding temperature extremes from - 40 to 105 degrees Celsius.

8. Terminals: Plainly identified to correspond with markings on the diagrams:
    a. Permanent machine-printed terminal identification.
9. Disconnect-type field signal conductor terminals with socket/screw for testing.
10. Identify terminals suitable for use with more than 1 conductor.
11. Position:
    a. So that the internal and external wiring does not cross.
    b. To provide unobstructed access to the terminals and their conductors.
12. Provide minimum 25-percent spare terminals.
13. Manufacturer: One of the following or equal:
    a. Phoenix Contact UK5 Series.
    b. Allen-Bradley 1492 Series.

F. Wire duct:
1. Provide flame retardant plastic wiring duct, slotted with dust cover.
2. Type:
    a. Wide slot.
    b. Narrow slot.
    c. Round hole.
3. Manufacturer: The following or equal:
    a. Panduit.

G. Din Rail:
1. Perforated Steel.
2. 35mm width.
3. 15mm deep.
4. Provide 2 inch offset using one of the following:
    a. Offset brackets.
    b. Preformed standoff Din Rail Channel.

H. Surge protection devices:
1. Control panel power:
    a. 120-volt control power source: Non-UPS powered:
        1) Provide surge protection device (SPD) for panel power entrances:
            a) Nominal 120-VAC with a nominal clamping voltage of 200 volts.
            b) Non-faulting and non-interrupting design.
            c) A response time of not more than 5 nanoseconds.
        2) Control panel power system level protection, non-UPS powered:
            a) Designed to withstand a maximum 10-kA test current of a 8/20 µs waveform according to IEEE C62.41.1 Category C Area.
            b) For panels receiving power at 120 VAC, provide surge protection at secondary of main circuit breaker.
            c) Provide both normal mode noise protection (line to neutral) and common mode (neutral to ground) surge protection.
            d) DIN rail mounting.
            e) Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:
                (1) Gastight connections.
                (2) The terminal block: Fabricated of non-ferrous, non-corrosive materials.
            f) Visual status indication of MOV status on the input and output circuits.

g) Dry contact rated for at least 250 VAC, 1 Amp for remote status indication.
h) Meeting the following requirements:
(1) Response time: Less than or equal to 100 ns.
(2) Attenuation: Greater than or equal to -40 dB at 100 kilovolt-Hertz as determined by a standard 50-ohm insertion test.
(3) Safety approvals:
(a) UL 1283 (EMI/RFI Filter).
(b) UL 1449 2nd Edition.
i) Manufacturer: One of the following or equal:
(1) Phoenix Contact Type SFP TVSS/Filter.
(2) Liebert Accuvar Series.
(3) Islatrol.

b. 120-volt control power source: UPS powered.
1) Provide surge protection on the control power source at each panel containing power supplies, or electronic components including PLCs, I/O, HMI, and digital meters.
2) Location:
a) For panels with a UPS, install surge protection ahead of UPS and maintenance bypass switch.
(1) Surge protection is not required for 120-VAC circuits that are only used for panel lights and receptacles.
b) For panels receiving power at 480 VAC, provide surge protection on the 120-VAC control power transformer secondary.
3) MCOV: 150 VAC.
4) Surge capability (8/20 µs wave): 10 kA.
5) Peak let-through: 620V L-N, 850V L-G.
6) Manufacturer: One of the following or equal:
a) Phoenix Contact Plugtrab PT Series.
b) MTL Surge Technologies MA15 Series.

2. Instrument, data, and signal line protectors (traditional I/O) – panel mounted:
a. Surge protection minimum requirements: Withstand a 10-kA test current of a 8/20 µs waveform in accordance with IEEE C62.41.1 Category C Area.
b. DIN rail mounting on 35-millimeter rail (except field-mounted SPDs).
c. SPDs consisting of 2 parts:
1) A base terminal block.
2) A plug protection module:
a) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
b) Base and plug coded to accept only the correct voltage plug.
d. SPD manufacturer: One of the following or equal:
1) Phoenix Contact Plugtrab Series.
2) Bournes Series 1800.

3. Instrument, data, and signal line protectors (traditional I/O) – field mounted:
a. Surge protection minimum requirements: Withstand a minimum 10-kA test current of a 8/20 µs waveform in accordance with IEEE C62.41.1 Category C Area.
b. Manufacturer: One of the following or equal:
1) Plugtrab PT Series.

2) MTL TP48 Series.

I. Power supplies:
1. Design power supply systems so that either the primary or backup supply can be removed, repaired, and returned to service without disrupting the system operation.
2. Convert 120 VAC to 24 volt DC or other DC voltages required or as required for the application.
3. Provide backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.
4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure:
    a. Provide automatic switchover upon module failure.
    b. Alarm contacts monitored by the PLC.
5. Sized to provide 40-percent excess rated capacity.
6. UL 508C listed to allow full rated output without de-rating.
7. Provide fuse or short-circuit protection.
8. Provide a minimum of 1 set of dry contacts configured to change state on failure for monitoring and signaling purposes.
9. Output regulation: Within 0.05 percent for a 10-percent line change or a 50-percent load change:
    a. With remote voltage sensing.
10. Operating temperature range: 0 to 50 degrees Celsius.
11. Touch-safe design: All connection terminals to be protected against accidental touch.
12. DIN rail mounting on 35-millimeter rail.
13. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
14. Manufacturer: One of the following or equal:
    a. Fully redundant:
        1) Phoenix Contact Quint Power Supply with SFB technology.
            a) Phoenix Contact Quint - O-ring redundancy module.
        2) IDEC PS5R Series:
            a) Wit redundancy Diode.
    b. Sola.
    c. Acopian.
    d. PULS.

J. Limit switches:
1. NEMA Type 4X.
2. AC contact rating 120 volts, 10 A.
3. DC contact rating 125 volts, 0.4 A.
4. Provide robust actuation mechanism not prone to degradation.
5. Provide complete actuator mechanism with all required hardware.
6. Allows for contact opening even during contact weld condition.
7. UL approved.
8. Operating temperature range: -18 to +110 degrees Celsius (0 to 230 degrees Fahrenheit).
9. Manufacturer: One of the following or equal:
    a. Allen-Bradley 802 Series.
    b. Honeywell HDLS Series.
    c. Omron D4 Series.

d. Eaton E47, E49, E50.
e. ABB.

2.07 ACCESSORIES

A. As specified in Section 40_61_00.

B. Provide panels with an inside protective pocket to hold the panel drawings. Ship panels with 1 copy of accepted Shop Drawings including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.

C. Provide 15-inch floor stands or legs where needed or as indicated on the Drawings.

D. Provide a folding shelf for enclosures that contain programmable controllers. The shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.

E. Provide nameplate to each panel as indicated on the Drawings:
1. Provide as specified in Section 26_05_53 on all internal and external instruments and devices.
2. Provide a nameplate with the following markings that is plainly visible after installation:
a. Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
b. Supply voltage, phase, frequency, and full-load current.
c. Power source or circuit ID.
d. Short-circuit current rating of the panel based on one of the following:
1) Short-circuit current rating of a listed and labeled assembly.
2) Short-circuit current rating established utilizing an approved method.

F. Lighting:
1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
a. Covered or guarded.
b. Provide On-Off door-activated switches where indicated on the Drawings.
c. 120-volt, single-phase, 15-amp style plug.
d. Provide 4,000 K, 900 Lumens – LED fixture.
1) Provide additional fixtures for every 36 inches of width.

G. Receptacles:
1. Provide 1 duplex receptacle located every 4 feet of enclosure width, spaced evenly along the back mounting panels.
2. GFCI, 120-volt, single-phase, 15-amp style plug.
3. Provide circuit breaker or fuse to limit receptacle draw to 5 amperes.

H. Grounding:
1. Provide the following:
a. Grounding strap between enclosure doors and the enclosure.
b. Equipment grounding conductor terminals.
c. Provide equipment ground bus with lugs for connection of all equipment grounding wires.

d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding bus.
2. Identify equipment grounding conductor terminals with the word “GROUND,” the letters “GND,” the letter “G,” or the color green.
3. Signal (24 VDC) grounding: Terminate each drain wire of a signal (shielded) cable to a unique grounding terminal block, or common ground bus at the end of the cable as shown on the Loop Drawings.
4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
5. Design so that removing a device does not interrupt the continuity of the equipment-grounding circuit.
6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
8. Connect all exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment-grounding circuit.
9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.
10. Bond together all remote and local control panels, processor racks, and conductive enclosures of power supplies and connect to the equipment-grounding circuit to provide a common ground reference.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finishes:
1. Metallic (non-stainless):
a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer’s recommendations to achieve a smooth, well-finished surface.
b. Scratches or blemishes shall be filled before finishing. One coat of zinc phosphate shall be applied per the manufacturer’s recommended dry-film thickness and allowed to dry before applying the finish coat.
c. Finish coat shall be a baked polyester-urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
d. Exterior of enclosures located outdoors shall be UV-resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
2. Stainless steel:
a. Stainless enclosures shall be provided with a Number 4 brushed finish - not painted.

B. Colors:
1. Exterior color of panels mounted indoors shall be manufacturer’s standard light gray.
2. Panel interiors shall be manufacturer’s standard white.

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 40_61_00.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install enclosures so that their surfaces are plumb and level within 1/8 inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to drywall is not permitted.

B. Install the enclosure per guidelines and submitted installation instructions to meet the seismic requirements at the project site.

C. Provide floor stand kits for wall-mounted enclosures larger than 48 inches high.

D. Provide 3-1/2-inch high concrete housekeeping pads for freestanding enclosures.

E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
   1. Undercoat floor-mounted panels.

F. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

G. All holes for field conduits, etc. shall be cut in the field. There shall be no additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or mis-cut holes shall require that the entire enclosure be replaced.

H. Provide individually fused analog input module points with blown-fuse indicator lights, mounted external of the module on the output terminal strip.

I. Side Panels:
   1. Side panels shall be kept free off all control equipment and devices. Any deviation must be sent to the engineer in writing asking for a deviation.

3.04 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

3.05 REPAIRS/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 40_61_00.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 40_61_00.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 40_61_00.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 40_67_26

CONTROL SYSTEMS: UNINTERRUPTIBLE POWER SUPPLIES 10 KVA AND BELOW

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Single-phase double conversion uninterruptible power supplies rated 10 kilovolt-amperes and below.
   2. Uninterruptible power supplies rated 10 kilovolt-amperes and below.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 26_05_00 - Common Work Results for Electrical.
   3. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Sections 26_05_00 and 40_61_00.

B. Federal Communications Commission (FCC):
   1. FCC Part 15, Class A.
   2. FCC Part 15, Class B.

C. Institute of Electrical and Electronic Engineers (IEEE):
   1. 519 - IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
   2. 1184 - IEEE Guide for Batteries for Uninterruptible Power Supply Systems.
   3. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.

D. Underwriters Laboratories, Inc. (UL):
   1. UL 1778 - Standard for Uninterruptible Power Supply Systems and Equipment.

1.03 DEFINITIONS

A. As specified in Sections 26_05_00 and 40_61_00.

B. Specific definitions:
   1. Critical load: Load supplied by the UPS.
   2. MOV: Metal oxide varistor.

1.04 SYSTEM DESCRIPTION

A. Provide complete, factory-assembled, wired, and tested, true on-line double conversion UPS equipment including, but not limited to, rectifier, DC bus, inverter, battery charger, batteries, automatic bypass, and ancillary components as specified herein and as indicated on the Drawings.

B. UPS loads as indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.

B. Product data:
1. Manufacturer and model number.
2. Catalog data.
3. Dimensions:
   a. Height.
   b. Width.
   c. Depth.
   d. Weight.
4. Ratings:
   a. Input voltage.
   b. Output voltage.
   c. Input/output power factor.
   d. Efficiency.
   e. Harmonic distortion.
   f. Runtime.
5. Noise specifications.
6. Heat dissipation.
7. Warranties and maintenance contracts:
8. All communications requirements such as software, cards, etc.
9. Alarms and status available for remote monitoring and system health.

C. Shop drawings:
1. Power distribution block diagrams.
2. Front and rear views of equipment enclosures:
   a. Front elevation including all control and indicating devices.
3. Support points and weight of overall equipment.
4. Schematic and control wiring diagrams including, but not limited to:
   a. Line and load terminals.
   b. Alarm and status terminals.
   c. Manual maintenance bypass switch terminals.
   d. External Battery or Step-down/Step-up Transformers if any.
   e. External wiring requirements for all communication signals.
5. Switching and overcurrent protective devices.

D. Calculations:
1. Include derating for temperature and elevation as necessary.
2. UPS sizing computation:
   a. Apply safety factors as specified in this Section.
   b. Provide itemized list of critical loads, including individual VA and watt ratings.
3. Battery time calculation based on specified runtime for total load with the safety factor multiplied to it. Table/graph for back-up time calculation.
4. Load calculation shall include power for all shown in the power distribution drawing, which include but not limited to PLC power supply, field instruments (120VAC and 24VDC), Instrument power, Ethernet switches, and I/O modules. Refer to Network Drawings for additional information and notes.

5. Total battery recharge time as a function of capacity utilized.

E. Design data:
   1. Design mounting and anchorage for seismic design criteria specified in Section 01_81_02:
      a. Provide seismic kits as required to meet design criteria.

F. Record documents:
   1. Provide Record Drawings of installed unit(s) including layout and wiring.

G. Manufacturer's field reports.

H. Operation and maintenance manuals:
   1. System instruction manuals that describe troubleshooting, installation, operations, and safety procedures.
   2. Recommendations for maintenance procedures and intervals.
   3. Battery data/replacement information.
   4. Parts list.

1.06 QUALITY ASSURANCE

A. Manufacturer qualifications:
   1. A minimum of 10 years' experience in the design, manufacture, and testing of solid-state UPS systems.
   2. ISO 9001 certified.

B. Regulatory requirements for complete UPS system:
   1. UL listed per UL Standard 1778
   2. IEEE C62.41, Categories A & B.
   3. FCC 15:
      a. Greater than 2,000 VA - Class A.
      b. Less than 2,000 VA - Class B.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 40_61_00.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 40_61_00.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Double-conversion true-online UPS manufacturers, one of the following or equal:
   1. Free-standing UPS, 700-3,000 VA:
      a. Allen-Bradley, model: 1609-D & 1609 -ENET no equal or substitutes.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Double conversion true on-line UPS system requirements:
   1. System characteristics:
      a. Provide rack-mount or free-standing UPS as specified and as indicated on the Drawings.
      b. The minimum VA rating of the UPS shall be greater than or equal to the safety factor (as indicated in the UPS schedule) times the connected load or 700 VA, whichever is greater.
      c. Battery runtime at full load and site ambient temperature as indicated in the UPS schedule.
      d. Efficiency greater than 85 percent AC-AC, all modes.
      e. Acoustical noise:
         1) Less than 55 dBA at 5 feet.
      f. Output connections:
         1) Receptacles:
            a) 700-2,500 VA units:
               (1) Provide a minimum of four NEMA Type 5-15R or Type 5-20R receptacles.
            b) 3,000 VA units:
               (1) Provide a minimum of four NEMA Type 5-20R receptacles.
               (2) Provide at least one NEMA Type L5-30R receptacle.
            c) Greater than 3,000 VA units:
               (1) Provide a minimum of four NEMA Type 5-20R receptacles.
               (2) Provide at least one NEMA Type L14-30R receptacle.
         2) Provide hardwired connections as indicated on the Drawings.
      g. Protection:
         1) Undervoltage:
            a) Operate on battery power if incoming source voltage goes below UPS system limits of operation.
         2) Overvoltage:
            a) Operate on battery power if incoming source voltage exceeds UPS system limits of operation.
         3) Overcurrent:
            a) Provide input and output current-limiting protection to ensure adequate overcurrent protection for UPS.

4) Surge protection:
   a) MOV-based.

2. Electrical characteristics:
   a. AC input:
      1) Single phase.
      2) Voltage as indicated in the UPS schedule.
         a) Fully functional within +10 percent, -15 percent of nominal voltage at full load without depleting battery.
         b) 120 V input:
            (1) 2-wire plus ground.
         c) 208/120 V or 240/120 input:
            (1) 3-wire plus ground.
      3) Current:
         a) Reflected total harmonic distortion (THD) less than 25 percent at rated load.
      4) Frequency range of operation:
         a) 57-63 hertz.
      5) Power factor:
         a) Not less than 0.95 lagging at rated load.
   b. AC output:
      1) Single phase.
      2) Voltage:
         a) Regulation:
            (1) Within 3 percent for 3,000 VA rating and below.
            (2) Within 5 percent for greater than 3,000 VA rating - static load.
            (3) Within 10 percent for greater than 3,000 VA rating - dynamic load.
         b) Total harmonic distortion (THD) when operating on incoming power:
            (1) Not more than 3 percent for linear loads with a crest factor of 3:1.
            (2) Not more than 5 percent for non-linear loads with a crest factor of 3:1.
         c) Transient response:
            (1) Within 7 percent for a 20-100 percent step load.
            (2) Transient recovery time to nominal voltage within 166 milliseconds.
      3) Load power factor:
         a) UPS shall be capable of supporting the critical loads for all power factors experienced for their full range of operation.
      4) Frequency regulation:
         a) Within 3.5 hertz when on utility power.
         b) Within 1.0 hertz when on UPS power.
3. Environmental requirements:
   a. Operating ambient temperature:
      1) UPS module: 50 degrees Fahrenheit to 104 degrees Fahrenheit (10 degrees Celsius to 40 degrees Celsius).
      2) Battery: 68 degrees Fahrenheit to 86 degrees Fahrenheit (20 degrees Celsius to 30 degrees Celsius).

b. Operating altitude:
    1) Project site conditions as specified in Sections 26_05_00 and 40_61_00.

4. System components:
    a. Surge protective devices:
        1) MOV-supplied protection.
    b. Inverter:
        1) Pulse-width modulated AC output signal.
        2) Overload withstand minimum time without transferring to bypass:
            a) 101 to 110 percent for 2 minutes.
            b) 111 to 125 percent for 10 seconds.
            c) 126 to 150 percent for 1 second.
            d) Greater than 150 percent for 96 milliseconds.
        3) Transfer load to bypass when overload capacity is exceeded.
    c. Battery rectifier/charger:
        1) Recharge batteries to 90 percent in 6 hours or less.
    d. Batteries:
        1) VRLA (valve regulated lead acid), sealed, maintenance free.
        2) Minimum 3-year float service life at 25 degrees Celsius.
        3) Integral to UPS enclosure or housed in a matching enclosure.
        4) Less than and including 6,000 VA: Hot-swappable.
        5) Automatically perform routine battery health monitoring and provide visual, audible, and/or serial warnings if abnormal battery conditions exist.
    e. Automatic bypass switch:
        1) Integral to UPS system.
        2) Sense UPS overload, inverter failure, or overtemperature, and automatically transfer loads to source power.
        3) Maximum detect and transfer time of 4-6 milliseconds.
        4) Automatic re-transfer without power interruption to critical load.
        5) Input shall match output in phase, voltage, frequency, and grounding.
        6) Rated to carry the full input current of the UPS.
        7) Provide ability for manual operation.
    f. UPS chassis:
        1) Electrically isolate from AC output neutral.
        2) Include an equipment ground terminal.
    g. Cooling:
        1) Forced air cooled.
    h. Locally displayed system indicators:
        1) Audible alarms during abnormal conditions:
            a) UPS fault or overload condition.
            b) Battery on.
            c) Low battery.
            d) Automatic bypass on/off.
            e) Input power on.
            f) Battery testing mode.
    i. Controls:
        1) Front-panel pushbuttons:
            a) UPS start-up, shutdown, and manual bypass (for automatic bypass).
            b) Testing.
            c) Visual/audible alarms reset.

2) Applicable controls as specified in Communications Requirements.

j. Alarm contacts:
   1) Provide relay interface card and required interposing relays for 120 VAC discrete input status signals:
      a) Low battery.
      b) UPS alarm.
      c) On UPS power.

k. Communications requirements:
   1) RS-232.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions.

B. Do not utilize extension cords, adapters, or other electrical connectors for UPS input.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIRS/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Perform inspections and test procedures before UPS startup:
   1. Inspect equipment for signs of damage.
   2. Verify installation as indicated on the Drawings and specified in the Specifications.
   3. Inspect cabinets for foreign objects.
   4. Verify neutral and ground conductors are properly sized and terminated.
   5. Inspect battery cases.

6. Inspect batteries for proper polarity.
7. Check power and control wiring for tightness.
8. Check terminal connectors for tightness.
9. Assure connection and voltage of the battery string(s).

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 40_61_00.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 40_61_00.

3.12 SCHEDULES

TAG	MINIMUM RUNTIME	INPUT VOLTAGE / CONNECTION	SAFETY FACTOR	NOTES
Alpine Vista	30 minutes	120 VAC, 1 phase		
J Street	30 minutes	120 VAC, 1 phase		

END OF SECTION

SECTION 40_71_15

FLOW MEASUREMENT: MAGNETIC FLOWMETERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Full-body magnetic flowmeters.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in the Contract Drawings.

1.02 REFERENCES

A. As specified in Section 40_61_00.

B. International Organization for Standardization (ISO):
   1. 9000 - Quality management systems -- Fundamentals and vocabulary.
   2. 17025 - General requirements for the competence of testing and calibration laboratories.

C. National Institute of Standards and Technology (NIST).

D. NSF International (NSF).

1.03 DEFINITIONS

A. As specified in Section 40_61_00.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.

1.05 QUALITY ASSURANCE

A. As specified in Section 40_61_00.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 40_61_00.

1.08 WARRANTY

A. As specified in Section 40_61_00.

1.09 MAINTENANCE

A. As specified in Section 40_61_00.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Endress+Hauser:
      a. L or W 400, Promag H100.
      b. Promag 53.
   2. Rosemount: 8750W.
   3. Krohne: IFC.
   4. Yokogawa: AXF.
   5. ABB: Watermaster.

2.02 MANUFACTURED UNITS

A. Magnetic flowmeter:
   1. General:
      a. Magnetic flowmeters obtain the flow velocity by measuring the changes of induced voltage of the conductive fluid passing across a controlled magnetic field.
      b. Complete zero stability shall be an inherent characteristic of the flowmeter system.
      c. Include for each magnetic flow metering system:
         1) A metering tube with electrodes (sensor).
         2) Signal cable.
         3) Transmitter integral or remote as indicated on the Drawings.
         4) Flowmeter grounding rings.
   2. Performance requirements:
      a. Accuracy:
         1) 0.25 percent of flow rate from 10 to 100 percent of full scale for velocities ranging between 1.9 to 10 feet persecond.
      b. Repeatability:
         1) 0.25 percent of rate.

3. Element:
   a. Metering tube:
      1) Constructed of carbon steel or Type 304 stainless steel (unless specifically noted otherwise in the instrument data sheets) with flanged connections to match with piping material.
      2) Liner material in conformance with:
         a) Manufacturer's recommendations for the intended service.
         b) NSF certified for all drinking water applications.
      3) Electrodes type and material in conformance with:
         a) Manufacturer's recommendations for the intended service.
         b) Utilize a minimum of 2, self-cleaning electrodes.
      4) Meter terminal housing NEMA Type 4X unless specifically noted otherwise in the instrument data sheets.
      5) Meter coating consisting of epoxy painted finish.
      6) Components:
         a) 2 grounding rings:
            (1) Which are in conformance with the manufacturer's bore and material recommendation for the meter's intended service.
            (2) Designed to protect and shield from abrasion of the liner's edge interface at the meter's end.
4. Transmitter:
   a. Power supply:
      1) 120 VAC.
      2) Power consumption: 60 VA maximum.
   b. Outputs:
      1) As noted in the instrument data sheets.
      2) For all instruments with 4 to 20 mA HART or digital bus protocol, provide a Device Type Manager (DTM) certification by FDT group.
   c. Microprocessor-based signal converter/transmitter.
   d. Utilize DC pulse technique to drive flux-producing coils.
   e. Contain a 6-digit display for flow rate, percent of span, and totalizer.
   f. Operator keypad interface.
   g. Integral zero return to provide consistent zero output signals in response to an external dry contact closure.
   h. Integral low flow cut-off zero return.
   i. Programmable parameters including:
      1) Meter size.
      2) Full-scale flow rate.
      3) Magnetic field frequency.
      4) Time constant.
   j. Data retention for a minimum of 5 years without auxiliary main or battery power.
   k. Self-diagnostics and automatic data checking.
   l. Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
   m. Ambient operating temperature limits of -5 to 140 degrees Fahrenheit (-20 to 60 degrees Celsius).

2.03 ACCESSORIES

A. Stainless steel tag labeled as specified in the Contract Documents.

B. Provide sunshades for all transmitters located outdoors.

C. Provide galvanic isolation gaskets, nylon/Teflon flange bolt insulation bushings and nylon washers on all meters installed on pipes with cathodic protection.

D. Furnish 1 spool piece for every size of magnetic flow tube being provided.

E. Electronic tester for calibration verification and diagnostics.
   1. Transmitter shall have continuous internal meter verification method comparing current meter system values to base line value.
   2. Should variance in readings be determined exceeding a preset limit the transmitter will provide a alarm condition via a configurable discrete output.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 40_61_00.

B. Factory calibrate each flow metering system at a facility that is traceable to the NIST. ISO-17025 accredited test facility with certified accuracy traceable to NIST

C. Evidence of accreditation shall originate from a national verification agency such as A2LA.

D. A real-time computer generated printout of the actual calibration date indication actual velocities and as read values of the flow tube.
   1. Flow calibration report of the manufacturers flow lab calibration procedure shall be shipped with the meter system.
   2. Minimum calibration shall be a 3 point calibration including 1, 3, and 10 feet per second velocities for every meter and transmitter system.
   3. Manufacturer shall archive all calibration reports for future reference.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 40_61_00.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 40_61_00.

B. Provide manufacturer’s services to perform installation inspection.

3.05 ADJUSTING

A. Field Verification:
   1. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions:

2. The transmitter and sensor to include a method to verify flow meter performance to the original manufacturer specifications.
3. Verification should be traceable to factory calibration using a third party, attested onboard system pursuant to ISO standards.
4. The verification report should be compliant to common quality systems such as ISO 9000 to prove reliability of the meter specified accuracy.
5. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 40_61_00.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.08 PROTECTION

A. As specified in Section 40_61_00.

3.09 SCHEDULES

A. Instrument Data Sheets included in this Section.

B. The provided information does not necessarily include all required instruments.

C. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:	Carollo Engineers	MAGNETIC FLOWMETERS				INSTRUMENT DATA SHEETS	
						Spec. No.	Rev.
Contractor:		No	By	Date	Revision	40_71_15	
Project:	Water Storage Tank Improvements project					Contract	Date
Customer:	**City of Tulare**						
Plant:	**Water Storage Tank**					Req.	P.O.
Location:	**J Street**						
BOM No.:						By / Chk / App	
File:							

	No.		Item	FIT-100	FIT-141	FIT-140
	1		Instrument Tag No.	**FIT-100**	**FIT-141**	**FIT-140**
	2		Service	Potable water	Potable water	Potable water
	3		P&ID	N101	N102	N103
	4	C	Line Size / Schedule	12"	12"	10"
	5	O	Line Material			
	6	N	Connection Type/ Pressure Rating			
	7	N	Connection Materials			
	8		Tube Size			
E	9		Tube Material			
L	10		Liner Material			
E	11	M	Electrode Type	Mfg Standard	Mfg Standard	Mfg Standard
M	12	E	Electrode Material			
E	13	T	Meter Casing			
N	14	E	Power Spply / Phase	120 VAC / 1P	120 VAC / 1P	120 VAC / 1P
T	15	R	Grounding Type & Matl.			
	16		Enclosure Class	NEMA 4X	NEMA 4X	NEMA 4X
	17		Other			
	18		Fluid	Potable water	Potable water	Potable water
	19	F	Max Flow	5600 gpm	5600 gpm	1500 gpm
	20	L	Min Velocity			
	21	U	Min Flow / Norm Flow	0 gpm /	0 gpm /	0 gpm /
	22	I	Min Temp / Max Temp			
	23	D	Min Press / Max Press			
	24		Vacuum Possibility			
	25		Conductivity			
T	26		Function			
R	27		Mounting	Integral	Integral	Integral
A	28		Enclosure Class	NEMA 4X	NEMA 4X	NEMA 4X
N	29		Length Signal Cable			
S	30		Type Span Adjustment			
M	31		Power Supply			
I	32		Transmitter Output	4-20 mA HART	4-20 mA HART	4-20 mA HART
			Relay Outputs	Form C	Form C	Form C
T	33		Accuracy	0.25%	0.25%	0.25%
T	34		Calibrated Range			
E	35		Empty Pipe Detection			
R	36		Bi-Directional Flow			
	37		Display Scale Size / Range			
	38		Alarm Contact No. / Form			
	39		Manufacturer			
	40		Element (Meter) Model No.			
	41		Transmitter (Inst.) Model No.			

Notes:

A/E:	**Carollo Engineers**	**MAGNETIC FLOWMETERS**				**INSTRUMENT DATA SHEETS**		
						Spec. No.	**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	40_71_15		
Project:	Water Storage Tank Improvements project					**Contract**	**Date**	
Customer:	**City of Tulare**							
Plant:	**Water Storage Tank**					**Req.**	**P.O.**	
Location:	**J Street**							
BOM No.:						**By**	**Chk**	**App**
File:								

	1		**Instrument Tag No.**		**FIT-133**					
	2		**Service**		Potable water					
	3		**P&ID**		N103					
	4	**C**	**Line Size / Schedule**		8"					
	5	**O**	**Line Material**							
	6	**N**	**Connection Type/ Pressure Rating**							
	7	**N**	**Connection Materials**							
	8		**Tube Size**							
E	**9**		**Tube Material**							
L	**10**		**Liner Material**							
E	**11**	**M**	**Electrode Type**		Mfg Standard					
M	**12**	**E**	**Electrode Material**							
E	**13**	**T**	**Meter Casing**							
N	**14**	**E**	**Power Spply**	**Phase**	120 VAC	1P				
T	**15**	**R**	**Grounding Type & Matl.**							
	16		**Enclosure Class**		NEMA 4X					
	17		**Other**							
	18		**Fluid**		Potable water					
	19	**F**	**Max Flow**		1500 gpm					
	20	**L**	**Min Velocity**							
	21	**U**	**Min Flow**	**Norm Flow**	0 gpm					
	22	**I**	**Min Temp**	**Max Temp**						
	23	**D**	**Min Press**	**Max Press**						
	24		**Vacuum Possibility**							
	25		**Conductivity**							
T	**26**		**Function**							
R	**27**		**Mounting**		Integral					
A	**28**		**Enclosure Class**		NEMA 4X					
N	**29**		**Length Signal Cable**							
S	**30**		**Type Span Adjustment**							
M	**31**		**Power Supply**							
I	**32**		**Transmitter Output**		4-20 mA HART					
			Relay Outputs		Form C					
T	**33**		**Accuracy**		0.25%					
T	**34**		**Calibrated Range**							
E	**35**		**Empty Pipe Detection**							
R	**36**		**Bi-Directional Flow**							
	37		**Display Scale Size**	**Range**						
	38		**Alarm Contact No.**	**Form**						
	39		**Manufacturer**							
	40		**Element (Meter) Model No.**							
	41		**Transmitter (Inst.) Model No.**							

Notes:

A/E:	Carollo Engineers	MAGNETIC FLOWMETERS				INSTRUMENT DATA SHEETS		
						Spec. No.		Rev.
Contractor:		No	By	Date	Revision	40_71_15		
Project:	Water Storage Tank Improvements project					Contract		Date
Customer:	**City of Tulare**							
Plant:	**Water Storage Tank**					Req.		P.O.
Location:	**Alpine Vista**							
BOM No.:						By	Chk	App
File:								

	1		**Instrument Tag No.**		**FIT-200**		**FIT-241**		**FIT-140**	
	2		**Service**		Potable water		Potable water		Potable water	
	3		**P&ID**		N201		N202		N103	
	4	C	**Line Size / Schedule**		12"		10"			
	5	O	**Line Material**							
	6	N	**Connection Type/ Pressure Rating**							
	7	N	**Connection Materials**							
	8		**Tube Size**							
E	9		**Tube Material**							
L	10		**Liner Material**							
E	11	M	**Electrode Type**		Mfg Standard		Mfg Standard		Mfg Standard	
M	12	E	**Electrode Material**							
E	13	T	**Meter Casing**							
N	14	E	**Power Spply**	**Phase**	120 VAC	1P	120 VAC	1P	120 VAC	1P
T	15	R	**Grounding Type & Matl.**							
	16		**Enclosure Class**		NEMA 4X		NEMA 4X		NEMA 4X	
	17		**Other**							
	18		**Fluid**		Potable water		Potable water		Potable water	
	19	F	**Max Flow**		5600 gpm		1500 gpm		1500 gpm	
	20	L	**Min Velocity**							
	21	U	**Min Flow**	**Norm Flow**	0 gpm		0 gpm		0 gpm	
	22	I	**Min Temp**	**Max Temp**						
	23	D	**Min Press**	**Max Press**						
	24		**Vacuum Possibility**							
	25		**Conductivity**							
T	26		**Function**							
R	27		**Mounting**		Integral		Integral		Integral	
A	28		**Enclosure Class**		NEMA 4X		NEMA 4X		NEMA 4X	
N	29		**Length Signal Cable**							
S	30		**Type Span Adjustment**							
M	31		**Power Supply**							
I	32		**Transmitter Output**		4-20 mA HART		4-20 mA HART		4-20 mA HART	
			Relay Outputs		Form C		Form C		Form C	
T	33		**Accuracy**		0.25%		0.25%		0.25%	
T	34		**Calibrated Range**							
E	35		**Empty Pipe Detection**							
R	36		**Bi-Directional Flow**							
	37		**Display Scale Size**	**Range**						
	38		**Alarm Contact No.**	**Form**						
	39		**Manufacturer**							
	40		**Element (Meter) Model No.**							
	41		**Transmitter (Inst.) Model No.**							

Notes:

A/E:	Carollo Engineers	MAGNETIC FLOWMETERS				INSTRUMENT DATA SHEETS	
						Spec. No.	Rev.
Contractor:		No	By	Date	Revision	40_71_15	
Project:	Water Storage Tank Improvements project					Contract	Date
Customer:	City of Tulare						
Plant:	Water Storage Tank					Req.	P.O.
Location:	Alpine Vista						
BOM No.:						By / Chk / App	
File:							

	1		Instrument Tag No.	**FIT-233**		
	2		Service	Potable water		
	3		P&ID	N203		
	4	C	Line Size / Schedule	8"		
	5	O	Line Material			
	6	N	Connection Type/ Pressure Rating			
	7	N	Connection Materials			
	8		Tube Size			
E	9		Tube Material			
L	10		Liner Material			
E	11	M	Electrode Type	Mfg Standard		
M	12	E	Electrode Material			
E	13	T	Meter Casing			
N	14	E	Power Spply / Phase	120 VAC / 1P		
T	15	R	Grounding Type & Matl.			
	16		Enclosure Class	NEMA 4X		
	17		Other			
	18		Fluid	Potable water		
	19	F	Max Flow	1500 gpm		
	20	L	Min Velocity			
	21	U	Min Flow / Norm Flow	0 gpm /		
	22	I	Min Temp / Max Temp			
	23	D	Min Press / Max Press			
	24		Vacuum Possibility			
	25		Conductivity			
T	26		Function			
R	27		Mounting	Integral		
A	28		Enclosure Class	NEMA 4X		
N	29		Length Signal Cable			
S	30		Type Span Adjustment			
M	31		Power Supply			
I	32		Transmitter Output	4-20 mA HART		
			Relay Outputs	Form C		
T	33		Accuracy	0.25%		
T	34		Calibrated Range			
E	35		Empty Pipe Detection			
R	36		Bi-Directional Flow			
	37		Display Scale Size / Range			
	38		Alarm Contact No. / Form			
	39		Manufacturer			
	40		Element (Meter) Model No.			
	41		Transmitter (Inst.) Model No.			

Notes:

SECTION 40_72_13

LEVEL MEASUREMENT: ULTRASONIC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Ultrasonic level instruments.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 40_61_00.

1.03 DEFINITIONS

A. As specified in Section 40_61_00.

B. Specific definitions:
   1. FDT: Field Device Tool.
   2. DTM: Device Type Manager.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 40_61_00.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 40_61_00.
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 40_61_00.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Ultrasonic level sensor with 4-wire remote transmitter:
      a. Ametek Drexelbrook: USonic-R Series.
      b. Endress+Hauser: Prosonic S FDU Series Sensor with FMU Series Transmitter.
      c. Magnetrol: Echomaster 384 Series Sensor with Echotel 344 Series Transmitter.
      d. Siemens: Echomax Series sensor with HydroRanger 200 Series Transmitter.
      e. Pulsar dB Series Sensor with Ultra 3 transmitter.

2.02 MANUFACTURED UNITS

A. Ultrasonic level measurement with 4-wire remote transmitter:
   1. General:
      a. Continuous non-contact level measurement device with remote transmitter using ultrasonic echo sensing. The transducer generates an ultrasonic pulse in the range of 12 to 50 kHz and measures the time required for the pulse to travel to the process surface and return. The

distance is calculated from the send and receive times. Each 4-wire level transmitter system includes, but is not limited to:

1) Ultrasonic transducer.
2) Signal cable.
3) Transmitter.

2. Performance requirements:
   a. Accuracy:
      1) 0.25 percent of range.
   b. Repeatability:
      1) 0.1 percent of range.
3. Ultrasonic transducer:
   a. Encapsulated in chemical- and corrosion-resistant material as indicated on the Instrument Data Sheet or Instrument Index.
   b. Class I Division 1 for transducer only.
   c. Operating temperature range: -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius).
   d. Operating relative humidity range: 5 to 95 percent.
   e. Functions:
      1) Temperature compensation.
   f. Mounting: As indicated in the Contract Documents.
4. Transmitter:
   a. Level-indicating transmitter:
      1) Indicator: Liquid crystal display with approximately 0.50-inch display scaled to read in engineering units.
      2) Sensitivity: Able to ignore momentary level spikes or momentary loss of echo and indicate loss of echo condition on indicating transmitter unit.
      3) Ability to allow for signal profiles and echo mapping:
         a) Provide manufacturer’s software for re-mapping the signal.
   b. Functions:
      1) Level measurement.
      2) Tank volume.
      3) Flow measurement.
   c. Power supply:
      1) 120 VAC.
      2) Power consumption: 36 VA maximum.
   d. Outputs:
      1) Isolated 4 to 20 milliamperes DC.
      2) Relay outputs:
         a) 3 Form A or Form C contacts.
         b) Rated 5 amps at 250 VAC.
         c) Programmable.
      3) Enclosure: NEMA Type 4X.
      4) Mounting: As indicated in the Contract Documents.
      5) Operating temperature range from -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius); relative humidity of 10 to 100 percent.

2.03 ACCESSORIES

A. Mounting brackets: As indicated on the Drawings.

B. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 40_61_00.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to manufacturer's standard at a facility that is traceable to NIST.
   1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 40_61_00.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 40_61_00.

3.05 ADJUSTING

A. As specified in Section 40_80_01.

B. Turn on turbulent surface software feature for all installations measuring surfaces lacking a placid surface. This would include but not be limited to level measurements in mixed media filters and potentially wet wells.

3.06 CLEANING

A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 40_61_00.

3.08 PROTECTION

A. As specified in Section 40_61_00.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:

1. Instruments may be as indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:	Carollo Engineers	ULTRASONIC LEVEL INSTRUMENTS						
						Spec. No.		Rev.
Contractor:		No	By	Date	Revision	40_72_13		
Project:	Water Storage Tank Improvements project					Contract		Date
Customer:	City of Tulare							
Plant:	Water Storage Tank					Req.		P.O.
Location:	J Street							
BOM No.:						By	Chk	App
File:								

G	1	Instrument Tag Number	LE/LIT-102		
E	2	Service	Water Storage Tank		
N	3	P&ID	N101		
	4	Other			
	5	Type	Ultrasonic		
P	6	Housing Material			
R	7	Measurement Range			
O	8	Op. Temp. Range			
B	9	Manufacturer			
E	10	Model			
	11	Model Number			
C	12	Style	Mfg. Std		
A	13	Length			
B	14	Other			
L	15	Other			
E	16	Other			
	17	Type			
T	18	Operating Mode			
R	19	Enclosure	NEMA 4X		
A	20	Mounting	Remote		
N	21	Temperature Range			
S	22	Voltage Requirements	115 VAC, 60 Hz		
M	23	Power			
I	24	Accuracy			
T	25	Display			
T	26	Output	4-20 mA		
E	27	Calibration			
R	28	Status Relay			
	29	Manufacturer			
	30	Model No.			
	31	Elect. Entry			
	32	Other			
O	33				
P	34				
T	35				
S	36				

Notes:

A/E:	Carollo Engineers	ULTRASONIC LEVEL INSTRUMENTS					
						Spec. No.	Rev.
Contractor:		No	By	Date	Revision	40_72_13	
Project:	Water Storage Tank Improvements project					Contract	Date
Customer:	City of Tulare						
Plant:	Water Storage Tank					Req.	P.O.
Location:	Alpine Vista						
BOM No.:						By / Chk / App	
File:							

G	1	Instrument Tag Number	LE/LIT-202		
E	2	Service	Water Storage Tank		
N	3	P&ID	N201		
	4	Other			
	5	Type	Ultrasonic		
P	6	Housing Material			
R	7	Measurement Range			
O	8	Op. Temp. Range			
B	9	Manufacturer			
E	10	Model			
	11	Model Number			
C	12	Style	Mfg. Std		
A	13	Length			
B	14	Other			
L	15	Other			
E	16	Other			
	17	Type			
T	18	Operating Mode			
R	19	Enclosure	NEMA 4X		
A	20	Mounting	Remote		
N	21	Temperature Range			
S	22	Voltage Requirements	115 VAC, 60 Hz		
M	23	Power			
I	24	Accuracy			
T	25	Display			
T	26	Output	4-20 mA		
E	27	Calibration			
R	28	Status Relay			
	29	Manufacturer			
	30	Model No.			
	31	Elect. Entry			
	32	Other			
O	33				
P	34				
T	35				
S	36				

Notes:

SECTION 40_73_13

PRESSURE/VACUUM MEASUREMENT: GAUGES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
  1. Pressure/vacuum gauges.

B. Related sections:
  1. Section 01_33_00 - Submittal Procedures.
  2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
  3. Section 40_73_63 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals.
  4. Section 40_73_64 - Pressure/Vacuum Measurement: Instrument Valves.

C. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 40_61_00.

B. American Society of Mechanical Engineers (ASME):
  1. B40.100 - Pressure Gauges and Gauge Attachments.

1.03 DEFINITIONS

A. As specified in Section 40_61_00.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.

B. Additional requirements:
  1. Product data:
    a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

A. As specified in Section 40_61_00.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
  1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  2. Physical conditions:
    a. Installation and mounting requirements.
    b. Location within the process.

c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 40_61_00.

1.08 WARRANTY

A. As specified in Section 40_61_00.

1.09 MAINTENANCE

A. As specified in Section 40_61_00.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: One of the following or equal:
1. Ashcroft:
2. Wika.
3. Ametek U.S. Gauge.

2.02 MANUFACTURED UNITS

A. General:
1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.

B. Performance requirements:
1. Pressure range:
   a. As specified in the Contract Documents.
2. Accuracy:
   a. Grade 2A, as defined by ASME B40.100.
   b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
   c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.
3. Element:
   a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon tube.
   b. Socket tips for bellows and Bourdon tube:
      1) Materials: Type 316 stainless steel.

c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
d. Wetted materials: Type 316 stainless steel.
4. Dial gauge:
a. Dial size: 4-1/2 inches.
b. Dial case material:
c. Maximum pressure less than 10 pounds per square inch:
1) Phenolic.
d. Maximum pressure greater than or equal to 10 pounds per square inch:
1) Phenolic.
e. Provide safety gauge with safety blow out through the back or top of the unit.
f. Dial face: Gasketed shatterproof glass or polycarbonate.
g. Provide gauge locks on all pressure gauges directly connected to diaphragm seals.
h. Provide gauge locks where possible.
i. Connection and mounting:
1) Direct mounted and suitable for outdoor installation.
2) 1/2 inch NPT.
3) Connection material: Stainless steel.
j. Pointer: Externally adjustable.

2.03 ACCESSORIES

A. Pulsation dampeners and snubbers:
1. Provide pulsation dampener or snubber with each pressure gauge installed on discharge of positive displacement type pump.
2. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
3. Materials: Type 316 stainless steel.
4. Mount pulsation dampener or snubber integrally to the pressure gauge.
5. Connection: 1/2-inch NPT.

B. Provide diaphragm seals as specified in the Contract Documents and in Section 40_73_63:
1. Diaphragm seal and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

C. Provide means for gauge isolation as specified in Section 40_73_64:
1. Mount valve manifold integrally to the gauge.
2. Valve manifold and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 40_61_00.

B. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 40_61_00.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 40_61_00.

3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 40_61_00.

3.08 PROTECTION

A. As specified in Section 40_61_00.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

A/E:	**Carollo Engineers**	**PRESSURE GAUGES**					
						Spec. No.	**Rev.**
Contractor:		**No**	**By**	**Date**	**Revision**	40_73_13	
Project:	Water Storage Tank Improvements project					**Contract**	**Date**
Customer:	**City of Tulare**						
Plant:	**Water Storage Tank**					**Req.**	**P.O.**
Location:	**J Street**						
BOM No.:						**By** / **Chk** / **App**	
File:							

1	**Type**	Direct Rdg.: √	Receiver:	Other:		
2	**Mounting**	Surface: Local:		Flush:		
3	**Dial**	Diameter: 4.5”	Color:			
4	**Case**	**Cast Iron:**	**Aluminum:**	**Phenolic: √**	**Polished SS**	**Other:**
5	**Ring**	Screwed:	Hinged:	Slip:	Std:	Other:
6	**Blowout Protection**	None:	Disc:	Front:	Other:	Mfr. Std.
7	**Lens**	Glass: √	Plastic:			
8	**Options**	Siphon: N/A	Material:			
9	**Other**	Snubber:				
10	**Other**	Pressure Limit Valve: N/A				
11	**Other**	Movement Damping: N/A				
12	**Nominal Accuracy Required**					
13	**Pressure Element**	Bourdon: √	Bellows:	Other:		
14	**Element Material**	Bronze:	Steel:	Type SS: 316 √	Other:	
15	**Socket Material**	Bronze:	Steel:	SS: 316	Other:	
16	**Connection**	¼ in.:	½ in.: √	Bottom:	Other:	
17	**Movement**	Dampened:	Standard: √	Other:		
18	**Diaphragm Seal**	Mfr.:	Wetted Part Mat’l:	Type:		
19	**Other**	Other Mat’l:	Fill Fluid:	Model:		
20	**Manufacturer**					
21	**Model No.**					

Rev	**Tag Number**	**Range**	**P&ID**	**Service**	**Notes**
	PI-143	**0-100 PSIG**	**N102**	**POTABLE WATER**	
	PI-132	**0-100 PSIG**	**N103**	**POTABLE WATER**	

Notes:
Refer to Section 40_73_64 for additional instrument valve requirements.

A/E:	Carollo Engineers	PRESSURE GAUGES						
						Spec. No.	Rev.	
Contractor:		No	By	Date	Revision	40_73_13		
Project:	Water Storage Tank Improvements project					Contract	Date	
Customer:	**City of Tulare**							
Plant:	**Water Storage Tank**					Req.	P.O.	
Location:	**Alpine Vista**							
BOM No.:						By	Chk	App
File:								

1	**Type**	Direct Rdg.: √	Receiver:		Other:	
2	**Mounting**	Surface: Local:			Flush:	
3	**Dial**	Diameter: 4.5”		Color:		
4	**Case**	**Cast Iron:**	**Aluminum:**	**Phenolic: √**	**Polished SS**	**Other:**
5	**Ring**	Screwed:	Hinged:	Slip:	Std:	Other:
6	**Blowout Protection**	None:	Disc:	Front:	Other:	Mfr. Std.
7	**Lens**	Glass: √		Plastic:		
8	**Options**	Siphon: N/A		Material:		
9	**Other**	Snubber:				
10	**Other**	Pressure Limit Valve: N/A				
11	**Other**	Movement Damping: N/A				
12	**Nominal Accuracy Required**					
13	**Pressure Element**	Bourdon: √	Bellows:		Other:	
14	**Element Material**	Bronze:	Steel:	Type SS: 316 √	Other:	
15	**Socket Material**	Bronze:	Steel:	SS: 316	Other:	
16	**Connection**	¼ in.:	½ in.: √	Bottom:	Other:	
17	**Movement**	Dampened:	Standard: √	Other:		
18	**Diaphragm Seal**	Mfr.:	Wetted Part Mat’l:		Type:	
19	**Other**	Other Mat’l:	Fill Fluid:		Model:	
20	**Manufacturer**					
21	**Model No.**					

Rev	Tag Number	Range	P&ID	Service	Notes
	PI-243	**0-100 PSIG**	**N202**	**POTABLE WATER**	
	PI-232	**0-100 PSIG**	**N203**	**POTABLE WATER**	

Notes:
Refer to Section 40_73_64 for additional instrument valve requirements.

SECTION 40_73_23

PRESSURE/VACUUM MEASUREMENT: DIRECT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure transmitters and indicators.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
   3. Section 40_73_63 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals.
   4. Section 40_73_64 - Pressure/Vacuum Measurement: Instrument Valves.
   5. Section 40_80_01 - Testing, Calibration, and Commissioning.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 40_61_00.

1.03 DEFINITIONS

A. As specified in Section 40_61_00.

B. Specific definitions:
   1. Lower range value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.
   2. Upper range value (URV): Highest pressure that the pressure transmitter is capable of measuring.
   3. Calibrated range: The range that the pressure transmitter is configured to measure. The low end of the calibrated range must be greater than the LRV of the transmitter. The high end of the calibrated range must be less than or equal to the URV. The calibrated range corresponds to the flow signal sent from the transmitter.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 40_61_00.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 40_61_00.

B. Project environmental conditions as specified in Section 40_61_00.
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 40_61_00.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Rosemount: 3051 Series.

2.02 MANUFACTURED UNITS

A. Pressure transmitters – direct:
   1. General:
      a. Pressure transmitter assembly shall include a diaphragm type pressure transducer and microprocessor based transmitter for measurement of gauge, vacuum, or absolute pressure.

2. Performance requirements:
   a. Maximum ratio of total instrument range to calibrated span: 10 to 1.
   b. Accuracy:
      1) Reference accuracy: Plus or minus 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.
      2) Total performance accuracy: Plus or minus 0.30 percent of calibrated span, including reference accuracy effects, static pressure and ambient temperature effects.
      3) Stability: Plus or minus 0.15 percent of upper range limit over 5 years.
3. Element:
   a. Diaphragm type transducer integral to pressure transmitter.
   b. Diaphragm material: Stainless steel or ceramic.
   c. Process material compatibility:
      1) Verify all material compatibilities with the instrument manufacturer.
   d. Process connection: As specified in the Instrument Data Sheets.
4. Transmitter:
   a. Power supply:
      1) 24 VDC - 2 wire loop powered.
      2) Power consumption: 3 VA maximum.
   b. Outputs:
      1) Isolated 4-20mA DC with HART communication protocol.
   c. Provided with electronic microprocessor.
   d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
   e. Local display:
      1) 5-digit LCD.
      2) Scaled in engineering units.
   f. Enclosure:
      1) NEMA Type 4X.
   g. Over range protection: To maximum process line pressure.
   h. Conduit: 1/2 inch male NPT.
5. Components:
   a. Transmitter mounting:
      1) As specified in the Instrument Data Sheets.
      2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

A. Provide valve manifolds as specified in Section 40_73_64:
   1. Mount valve manifold integrally to the transmitter.
   2. Valve manifold and transmitter shall be assembled by Manufacturer and shipped as an assembly.
   3. Provide remote or integral diaphragm seals as specified in the Instrument Data Sheets and in Section 40_73_63.

B. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 40_61_00.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
   1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 40_61_00.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 40_61_00.

3.05 ADJUSTING

A. As specified in Section 40_80_01.

3.06 CLEANING

A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 40_61_00.

3.08 PROTECTION

A. As specified in Section 40_61_00.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:	**Carollo Engineers**	**PRESSURE TRANSMITTERS**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	40_73_23			
Project:	Water Storage Tank Improvements project					**Contract**		**Date**	
Customer:	**City of Tulare**								
Plant:	**Water Storage Tank**					**Req.**		**P.O.**	
Location:	**J Street**								
BOM No.:						**By**	**Chk**	**App**	
File:									

GENERAL	**1**	**Instrument Tag No.**	PT-143	PIT-132
	2	**Service**	Water	Water
	3	**P&ID**	**N102**	**N103**
SERVICE	**4**	**Pressure**		
	5	**Process Temperature**	35-70 deg F	35-70 deg F
	6	**Ambient Temperature**		
TRANSMITTER	**7**	**Manufacture**		
	8	**Model No.**		
	9	**Pressure Transmitter Type**	Direct	Direct
	10	**Calibrated Span**	0 - 100 psig	0 - 100 psig
	11	**Accuracy**		
	12	**Adjustable Range**		
	13	**Output Signal**	4-20 Ma HART	4-20 Ma HART
	14	**Body Rating**		
BODY	**15**	**Process Flange Type**	Threaded	Threaded
	16	**Drain/Vent**	None	None
	17	**Process Flange**	MNPT	MNPT
	18	**Adapters**		
	19	**Wetted O-Ring**		
	20	**Housing**		
	21	**Bolts**		
	22	**Mounting Brackets**		
	23	**Conduit Entry Size**		
ELEMENT	**24**	**Isolating Diaphragm**	Required	Not Required
	25	**Fill Fluid**	Not Required	Not Required
OPTIONS	**26**	**Certification / Approval Type**		
	27	**Meter**		
	28	**Zero Span & Adjustment**		
	29	**Surge Protection**		
	30	**Custom Configuration**		
MANIFOLD	**31**	**Manufacturer**		
	32	**Model Number**		
	33	**Manifold Style**	Reference Details	Reference Details
	34	**Manifold Type**	Block and Bleed	Block and Bleed

Notes:
Refer to Section 40_73_64 for additional instrument valve requirements.

A/E:	**Carollo Engineers**	**PRESSURE TRANSMITTERS**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	40_73_23			
Project:	Water Storage Tank Improvements project					**Contract**		**Date**	
Customer:	**City of Tulare**								
Plant:	**Water Storage Tank**					**Req.**		**P.O.**	
Location:	**Alpine Vista**								
BOM No.:						**By**	**Chk**	**App**	
File:									

GENERAL	**1**	**Instrument Tag No.**	PT-243	PIT-232
	2	**Service**	Water	Water
	3	**P&ID**	**N202**	**N203**
SERVICE	**4**	**Pressure**		
	5	**Process Temperature**	35-70 deg F	35-70 deg F
	6	**Ambient Temperature**		
TRANSMITTER	**7**	**Manufacture**		
	8	**Model No.**		
	9	**Pressure Transmitter Type**	Direct	Direct
	10	**Calibrated Span**	0 - 100 psig	0 - 100 psig
	11	**Accuracy**		
	12	**Adjustable Range**		
	13	**Output Signal**	4-20 Ma HART	4-20 Ma HART
	14	**Body Rating**		
BODY	**15**	**Process Flange Type**	Threaded	Threaded
	16	**Drain/Vent**	None	None
	17	**Process Flange**	MNPT	MNPT
	18	**Adapters**		
	19	**Wetted O-Ring**		
	20	**Housing**		
	21	**Bolts**		
	22	**Mounting Brackets**		
	23	**Conduit Entry Size**		
ELEMENT	**24**	**Isolating Diaphragm**	Required	Not Required
	25	**Fill Fluid**	Not Required	Not Required
OPTIONS	**26**	**Certification / Approval Type**		
	27	**Meter**		
	28	**Zero Span & Adjustment**		
	29	**Surge Protection**		
	30	**Custom Configuration**		
MANIFOLD	**31**	**Manufacturer**		
	32	**Model Number**		
	33	**Manifold Style**	Reference Details	Reference Details
	34	**Manifold Type**	Block and Bleed	Block and Bleed

Notes:
Refer to Section 40_73_64 for additional instrument valve requirements.

SECTION 40_73_36

PRESSURE/VACUUM MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure/vacuum switches.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
   3. Section 40_73_63 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals.
   4. Section 40_73_64 - Pressure/Vacuum Measurement: Instrument Valves.

C. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 40_61_00.

1.03 DEFINITIONS

A. As specified in Section 40_61_00.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.

B. Additional requirements:
   1. Product data:
      a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

A. As specified in Section 40_61_00.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 40_61_00.
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 40_61_00.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Mechanical type pressure switch: One of the following or equal:
   1. Ashcroft B Series Type.
   2. United Electric Controls.
   3. ASCO S-Series.

2.02 MANUFACTURED UNITS

A. Mechanical type pressure switches:
   1. General:
      a. Pressure switch shall be diaphragm or diaphragm-sealed piston type.
   2. Performance requirements:
      a. Pressure range:
         1) As specified in data sheets following this Section.
      b. Accuracy:
         1) Within 1.0 percent of range.
      c. Repeatability:
         1) Within 1.0 percent of range.
   3. Element:
      a. Type: Diaphragm, diaphragm-sealed piston, or bourdon tube.
      b. Overpressure:
         1) Minimum 130 percent of maximum range pressure without damage to switch or sensing element.
         2) Minimum 400 percent of nominal range without leakage or rupture.
      c. Sensing element shall not require ambient temperature compensation.

d. Wetted materials: Stainless steel.
e. Setpoint:
   1) Single.
   2) Switch shall activate at setpoint on increasing pressure for high-pressure alarm applications and on decreasing pressure for low-pressure alarm applications.
f. Adjustable deadband.
g. Switch elements:
   1) Snap acting.
   2) 2 single pole-double throw (SPDT).
   3) Rated at 5 A, 125/250 VAC.
   4) Automatic reset type.
h. Enclosure: Epoxy coated:
   1) NEMA Type 4.
i. Switch mounting:
   1) Process connection: 1/2-inch NPT.

4. Components:
   a. Provide all necessary hardware for pressure switch mounting.

2.03 ACCESSORIES

A. Pulsation dampeners and snubbers:
   1. Provide pulsation dampener or snubber with each pressure switch installed on discharge of positive displacement type pump.
   2. Materials: Stainless steel.
   3. Mount pulsation dampener or snubber integrally to the pressure switch.
   4. Connection: 1/2-inch NPT.

B. Provide diaphragm seals as specified in data sheets or as indicated on the Drawings and as specified in Section 40_73_63:
   1. Diaphragm seal and pressure switch shall be assembled by manufacturer and shipped as an assembly.

C. Furnish gauge valves as specified in Section 40_73_64.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 40_61_00.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer’s standard at a facility that is traceable to the NIST.
   1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 40_61_00.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 40_61_00.

3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 40_61_00.

3.08 PROTECTION

A. As specified in Section 40_61_00.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments specified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

A/E:	**Carollo Engineers**	**PRESSURE/VACUUM SWITCHES**					
						Spec. No.	**Rev.**
Contractor:		**No**	**By**	**Date**	**Revision**	40_73_36	
Project:	Water Storage Tank Improvements project					**Contract**	**Date**
Customer:	**City of Tulare**						
Plant:	**Water Storage Tank**					**Req.**	**P.O.**
Location:	**J Street**						
BOM No.:						**By** / **Chk** / **App**	
File:							

	1	**Type**	Press: Vacuum: Comp.: Diff.Press: Other
D	**2**	**Setting**	Set in Field: Factory Set: Internal: External: Dial:
E	**3**	**Dead Band**	**Fixed: Adj.: Min.: Other:**
V	**4**	**Mtl : Body / Seat / Tube**	
I	**5**	**Element Type**	Diaphragm: Bourdon: Bellows: Other
C	**6**	**Material**	Bronze: SS: Alloy St.: Other
E	**7**	**Connection**	½ in NPT √ Bottom: Back:
	8	**Mounting**	Local: Surface: Flush:
	9	**Accuracy**	
	10	**Other**	
	11	**Type**	Mercury: Snap: Other
	12	**Quantity**	Single: Dual: Other
S	**13**	**Form**	SPST: SPDT: DPDT: Other
W	**14**	**Rating: Amps / Volts / Hertz**	10 / 120 / 60
I	**15**	**Other**	
T	**16**	**Load**	Inductive: Non-Inductive: √
C	**17**	**Enclosure**	General Purpose: Weatherproof: None: Explosion proof:
H	**18**	**Enclosure Class**	
	19	**Conduit Connection**	MFR STD: Other
	20	**Other**	
	21	**Manufacturer**	
	22	**Model No.**	

Rev	**Tag Number**	**Adj. Range**	**SP Process**	**Signal SP**	**Op. Temp.**	**P&ID**	**Service**	**Notes**
	PSH-132	**0-100 PSIG**				**N103**	**Portable water**	

Notes:
Refer to Section 40_73_63 for additional diaphragm seal requirements.
Refer to Section 40_73_64 for additional instrument valve requirements.

A/E:	Carollo Engineers	PRESSURE/VACUUM SWITCHES					
						Spec. No.	Rev.
Contractor:		No	By	Date	Revision	40_73_36	
Project:	Water Storage Tank Improvements project					Contract	Date
Customer:	**City of Tulare**						
Plant:	**Water Storage Tank**					Req.	P.O.
Location:	**Alpine Street**						
BOM No.:						By / Chk / App	
File:							

D	1	Type	Press: Vacuum: Comp.: Diff.Press: Other
E	2	Setting	Set in Field: Factory Set: Internal: External: Dial:
V	3	Dead Band	**Fixed: Adj.: Min.: Other:**
I	4	Mtl : Body / Seat / Tube	
C	5	Element Type	Diaphragm: Bourdon: Bellows: Other
E	6	Material	Bronze: SS: Alloy St.: Other
	7	Connection	½ in NPT √ Bottom: Back:
	8	Mounting	Local: Surface: Flush:
	9	Accuracy	
	10	Other	
	11	Type	Mercury: Snap: Other
	12	Quantity	Single: Dual: Other
S	13	Form	SPST: SPDT: DPDT: Other
W	14	Rating: Amps / Volts / Hertz	10 / 120 / 60
I	15	Other	
T	16	Load	Inductive: Non-Inductive: √
C	17	Enclosure	General Purpose: Weatherproof: None: Explosion proof:
H	18	Enclosure Class	
	19	Conduit Connection	MFR STD: Other
	20	Other	
	21	Manufacturer	
	22	Model No.	

Rev	Tag Number	Adj. Range	SP Process	Signal SP	Op. Temp.	P&ID	Service	Notes
	PSH-232	**0-100 PSIG**				**N203**	**Portable water**	

Notes:
Refer to Section 40_73_63 for additional diaphragm seal requirements.
Refer to Section 40_73_64 for additional instrument valve requirements.

SECTION 40_73_63

PRESSURE/VACUUM MEASUREMENT: DIAPHRAGM AND ANNULAR SEALS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Diaphragm seals.
   2. Annular seals.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all seals identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 40_61_00.

1.03 DEFINITIONS

A. As specified in Section 40_61_00.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.

B. Additional requirements:
   1. Product data:
      a. Manufacturer’s installation instructions.
      b. Seal type.
      c. Body materials.
      d. Diaphragm material.
      e. Fill fluid type.
      f. Seal size.
      g. Options.
      h. Process connection.

1.05 QUALITY ASSURANCE

A. As specified in Section 40_61_00.

B. Examine the complete set of Contract Documents and verify the compatibility with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.

b. Location within the process.
c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 40_61_00.

1.08 WARRANTY

A. As specified in Section 40_61_00.

1.09 MAINTENANCE

A. As specified in Section 40_61_00.

B. Provide spare annular seal for every size indicated in the project.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Diaphragm seals:
1. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch gauge: One of the following or equal:
    a. Ashcroft:
        1) Flushing connection: Type 741.
        2) Without flushing connection: Type 740.
    b. Mansfield and Green:
        1) Flushing connection: Type SGT.
        2) Without flushing connection: Type SBT.
    c. Wika, Type L990.40.
    d. Rosemount.
2. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures greater than or equal to 15 pounds per square inch gauge: One of the following or equal:
    a. Ashcroft:
        1) Flushing connection: Type 201.
        2) Without flushing connection: Type 200.
    b. Mansfield and Green:
        1) Flushing connection: Type SG.
        2) Without flushing connection: Type SB.
    c. Wika:
        1) Type L990.10.

2) Saddle mount: L910.ZA.

d. Rosemount.

B. Annular seals:

1. One of the following or equal:

a. Ashcroft Iso-Ring.

b. Onyx Valve.

2.02 MANUFACTURED UNITS

A. Diaphragm seals:

1. General:

a. Diaphragm seal and pressure instrument shall be assembled by pressure instrument manufacturer and shipped as an assembly.

2. Requirements:

a. Seal type:

1) Metallic diaphragm: Welded to upper housing.

2) Elastomer diaphragm: Bonded to upper housing.

b. Process connection: 1 inch NPT.

c. Instrument connection: 1/2 inch NPT.

d. Material Construction: Type 316 Stainless Steel.

e. Provide fill/bleed connection.

f. Mounting: As indicated in the Contract Documents.

g. Provide Type 316 stainless steel armored capillary for all remote installations.

h. Nuts and bolts: Type 316 stainless steel.

i. Materials of construction:

1) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch:

a) Diaphragm: Type 316 stainless steel.

b) Lower housing: Type 316 stainless steel.

c) Upper housing: Manufacturer’s standard.

d) Fill fluid: Silicon oil.

2) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures greater than 15 pounds per square inch:

a) Diaphragm: Type 316 stainless steel.

b) Lower housing: Type 316 stainless steel.

c) Upper housing: Manufacturer’s standard.

d) Fill fluid: Silicon oil.

3) Engineer’s approval.

2.03 ACCESSORIES (NOT USED)

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 40_61_00.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 40_61_00.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

C. Do not use Teflon thread seal tape on pressure instruments with silicon oil fill fluid.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 40_61_00.

3.05 ADJUSTING (NOT USED)

3.06 CLEANING

A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 40_61_00.

3.08 PROTECTION

A. As specified in Section 40_61_00.

3.09 SCHEDULES (NOT USED)

END OF SECTION

SECTION 40_73_64

PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Valve manifolds and instrument valves.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all valves identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 40_61_00.

1.03 DEFINITIONS

A. As specified in Section 40_61_00.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.

B. Additional requirements:
   1. Product data:
      a. Valve type.
      b. Body material.
      c. Size.
      d. Options.
   2. Shop drawings:
      a. Mounting details for all manifold valves.

1.05 QUALITY ASSURANCE

A. As specified in Section 40_61_00.

B. Examine the complete set of Contract Documents and verify that the valves are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the valve manufacturer's recommendations or specifications.

D. Provide valves manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00.

B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 40_61_00.
   1. Provide valves suitable for the installed site conditions including, but not limited to, material compatibility, process, and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 40_61_00.

1.09 MAINTENANCE

A. As specified in Section 40_61_00.

B. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Valve manifold manufacturers: One of the following or equal:
   1. Anderson Greenwood.
   2. Hex Valve.
   3. Noshok.
   4. Rosemount.

B. Block and bleed valve manufacturers: One of the following or equal:
   1. Anderson Greenwood.
   2. Hex Valve.

C. Gauge valve manufacturers: One of the following or equal:
   1. Anderson Greenwood.
   2. Hex Valve.

D. Level sensor isolation valve manufacturers: One of the following or equal:
   1. Indu-Tech Level Sensor Isolation Valve.
   2. DeZURIK Level Sensor Isolation Valve.

3. Tyco Rovalve Isolation Knife Gate Valve.

2.02 MANUFACTURED UNITS

A. Valve manifolds:
   1. General:
      a. Provide 2-valve, 3-valve, blowdown type 5-valve, or metering type 5-valve manifolds as indicated on the Drawings.
      b. Valve manifolds shall have one piece bonnet with a metal to metal seal to the valve body below the bonnet threads.
   2. Requirements:
      a. Bonnet lock pin to prevent accidental loosening.
      b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
      c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
      d. Manifold valves shall have straight through portion for bi-directional flow and easy roddable cleaning.
      e. Manifold valves shall allow for direct or remote instrument mounting.
      f. Shall be able to withstand pressures up to 6,000 psi for soft seat valves and 10,000 psi for hard seat valves at maximum 200 degrees Fahrenheit.
      g. Materials of construction:
         1) Body material: Type 316 stainless steel.
         2) O-Ring: Teflon.
      h. 2-Valve manifolds:
         1) 1 isolation valve and 1 drain/vent and calibration valve.
      i. 3-Valve manifolds:
         1) 2 isolation valves and 1 equalizing valve for differential pressure applications.
         2) Plugged vent connections used for vent/drain or calibration.
      j. Blowdown 5-valve manifold:
         1) 2 isolation valves, 1 equalizing valve, 2 blowdown valves for differential pressure applications.
      k. Metering 5-valve manifold:
         1) 2 isolation valves, 2 equalizing valves, 1 vent/drain and calibration valve for differential pressure applications.

B. Block and bleed valves:
   1. General:
      a. Valve shall provide process isolation and venting/draining capabilities.
      b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
      c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
      d. Valve shall not be used with fluids with high solids content, such as raw wastewater or sludge.
   2. Requirements:
      a. Materials of construction:
         1) Body material: Type 316 stainless steel.
         2) O-Ring: Teflon.

C. Gauge valves:
   1. General:
      a. Valve shall provide process isolation from pressure instrument.
      b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
      c. Gas leak tested soft seat design with replaceable seat for soft seat valves.

2. Requirements:
   a. Materials of construction:
      1) Body material: Type 316 stainless steel.
      2) O-Ring: Teflon.

D. Level sensor isolation valves:
   1. General:
      a. Valve shall provide process isolation from level diaphragm.
      b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
      c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
   2. Requirements:
      a. Materials of construction:
         1) Body material: Type 316 stainless steel.
         2) Flange diameter size: 3 inches.

2.03 ACCESSORIES

A. Provide tube fitting, female NPT, or pipe butt weld connections if necessary.

B. Provide stainless steel concentric or eccentric pipe nipples when necessary.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 40_61_00.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location and verify it will work properly when installed.
   1. Notify the Engineer promptly if any installation condition does not meet the manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 40_61_00.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of all valves.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 40_61_00.

3.05 ADJUSTING

A. As specified in Section 40_80_01.

3.06 CLEANING

A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 40_61_00.

B. Demonstrate performance of all valves to the Engineer before commissioning.

3.08 PROTECTION

A. As specified in Section 40_61_00.

3.09 SCHEDULES (NOT USED)

END OF SECTION

SECTION 40_73_65

PRESSURE MEASUREMENT: SUBMERSIBLE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Submersible pressure transmitters.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
   3. Section 40_80_01 - Testing, Calibration, and Commissioning.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 40_61_00.

1.03 DEFINITIONS

A. As specified in Section 40_61_00.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00, and 40_61_00.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 40_61_00.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 40_61_00.
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 40_61_00.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Submersible level measurement with 2-wire integral transmitter:
   1. One of the following or equal:
      a. Endress+Hauser, Waterpilot FMX21.
      b. GE Druck, PTX-1830.
      c. Siemens, A1000i.
      d. Measurement Specialties KPSI 700 Series.

2.02 MANUFACTURED UNITS

A. Submersible level measurement with 2-wire integral transmitter:
   1. General:
      a. Pressure is measured through a diaphragm-type measuring cell and converted to linear pressure measurement.
      b. Each submersible pressure transmitter system shall include:
         1) Signal cable, including pressure compensation tube.
         2) Transducer probe with integral transmitter.
         3) Transmitter cable termination box.
   2. Performance requirements:
      a. Accuracy:
         1) 0.3 percent of range.
      b. Repeatability:
         1) 0.25 percent of full scale.
      c. Rangeability:
         1) 3:1.

d. Range:
   1) As indicated on the contract documents.

3. Element:
   a. Sensor housing shall be Type 316L stainless steel or titanium with ceramic, teflon-coated, or titanium diaphragm.
   b. Protective cap shall be manufacturer's recommended material, chemically resistant to process fluid.
   c. Slip resistant extension cable with pressure compensation tube with Teflon filter.
   d. Enclosure for probe and transmitter assembly shall be NEMA Type 4X.
4. Transmitter:
   a. Power supply:
      1) 24 VDC: 2 wire loop powered.
      2) Power consumption: 18 VA maximum.
   b. Outputs:
      1) Isolated 4 to 20 milliamperes DC.
   c. Without display.
   d. Ambient operating temperature limits of -10 to 70 degrees Celsius (-14 to 158 degrees Fahrenheit).
   e. Transmitter shall be integral to probe housing.
5. Transmitter cable termination box:
   a. NEMA Type 4X.
   b. Equipped with filter or desiccant chamber to eliminate moisture from the pressure compensation tube.
   c. Termination for signal wires and pressure compensation tube.

2.03 ACCESSORIES

A. Type 316L stainless steel mounting clamp with Type 304 stainless steel mounting screws.

B. Provide cable clamp and strain relief.

C. Provide sunshade for outdoor installations.

D. Provide integral surge protection.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 40_61_00.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
   1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 40_61_00.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 40_61_00.

3.05 ADJUSTING

A. As specified in Section 40_80_01.

3.06 CLEANING

A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 40_61_00.

3.08 PROTECTION

A. As specified in Section 40_61_00.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:	Carollo Engineers	SUBMERSIBLE PRESSURE INSTRUMENTS						
						Spec. No.	Rev.	
Contractor:		No	By	Date	Revision	40_73_65		
Project:	Water Storage Tank Improvements project					Contract	Date	
Customer:	City of Tulare							
Plant:	Water Storage Tank					Req.	P.O.	
Location:	J Street							
BOM No.:						By	Chk	App
File:								

	1	Instrument Tag Number	LT-130		
G	2	Service	Potable Water - Well		
E	3	P&ID	N103		
N	4	Fluid Type	Water		
	5	Fluid Specific Gravity	1.0		
	6	Type	Submersible		
P	7	Measuring Cell Material	Diaphragm		
R	8	Probe Body Material			
O	9	Op. Temp. Range	40-80 deg F		
B	10	Op. Pressure Range	0- 100 PSIG		
E	11	Other			
	12	Other			
C	13	Style	Mfg. Std		
A	14	Signal Cable Length	As Required		
B	15	Other			
L	16	Other			
E	17	Other			
	18	Type			
T	19	Operating Mode	Continuous		
R	20	Enclosure			
A	21	Mounting			
N	22	Temperature Range			
S	23	Measurement Range			
M	24	Power Supply	24 VDC		
I	25	Accuracy	0.3 % of range		
T	26	Display			
T	27	Output	4-20 mA		
E	28	Calibration			
R	29	Status Relay			
	30	Manufacturer			
	31	Model No.			
	32	Elect. Entry			
	33	Other			
O	33				
P	34				
T	35				
S	36				

Notes:

A/E:	Carollo Engineers	SUBMERSIBLE PRESSURE INSTRUMENTS						
						Spec. No.	Rev.	
Contractor:		No	By	Date	Revision	40_73_65		
Project:	Water Storage Tank Improvements project					Contract	Date	
Customer:	City of Tulare							
Plant:	Water Storage Tank					Req.	P.O.	
Location:	Alpine Street							
BOM No.:						By	Chk	App
File:								

	1	Instrument Tag Number	LT-230		
G	2	Service	Potable Water - Well		
E	3	P&ID	N203		
N	4	Fluid Type	Water		
	5	Fluid Specific Gravity	1.0		
	6	Type	Submersible		
P	7	Measuring Cell Material	Diaphragm		
R	8	Probe Body Material			
O	9	Op. Temp. Range	40-80 deg F		
B	10	Op. Pressure Range	0- 100 PSIG		
E	11	Other			
	12	Other			
C	13	Style	Mfg. Std		
A	14	Signal Cable Length	As Required		
B	15	Other			
L	16	Other			
E	17	Other			
	18	Type			
T	19	Operating Mode	Continuous		
R	20	Enclosure			
A	21	Mounting			
N	22	Temperature Range			
S	23	Measurement Range			
M	24	Power Supply	24 VDC		
I	25	Accuracy	0.3 % of range		
T	26	Display			
T	27	Output	4-20 mA		
E	28	Calibration			
R	29	Status Relay			
	30	Manufacturer			
	31	Model No.			
	32	Elect. Entry			
	33	Other			
O	33				
P	34				
T	35				
S	36				

Notes:

SECTION 40_75_23

ANALYZERS: RESIDUAL CHLORINE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Residual chlorine analyzers.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 40_61_00.

1.03 DEFINITIONS

A. As specified in Section 40_61_00.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 40_61_00.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 40_61_00.
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 40_61_00.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Colorimetric residual analyzers:
   1. The following or equal:
      a. HACH CL17.

2.02 MANUFACTURED UNITS

A. Amperometric residual analyzers:
   1. General:
      a. Residual chlorine analyzer utilizing amperometric technology for continuous monitoring of the free chlorine residual in solution.
   2. Performance requirements:
      a. Continuous on-line analysis for free or total chlorine residual.
      b. Minimum detection: 0.040 milligrams per liters.
      c. Accuracy:
         1) Within 5 percent of reading or within 0.035 milligrams per liters.
      d. Range:
         1) 0 to 5 milligrams per liters free or total residual.
      e. Repeatability:
         1) Within 5 percent or 0.005 milligrams per liters.
   3. Components:
      a. Flow through sensors, including flow rate control, multiple probes.
   4. Transmitter:
      a. Power supply:
         1) 120 VAC.
         2) Power consumption: 95 VA maximum.

b. Outputs:
   1) 4 to 20 milliamperes isolated output with span programmable over any portion of the chlorine residual range.
   2) As indicated in the instrument datasheets.
   3) Relay outputs:
      a) SPST relay contacts: 2.
      b) Selectable to activate on the following conditions:
         (1) High or low sample concentration.
         (2) Analyzer system warning.
         (3) Analyzer system shutdown.
   4) Components:
      a) Manufacturer’s cables.
c. Microprocessor-based signal converter/transmitter.
d. Display:
   1) LCD, 2-line minimum.
e. Enclosure:
   1) NEMA Type 4X.

2.03 ACCESSORIES

A. Provide sun shades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 40_61_00.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer’s standard at a facility that is traceable to the NIST.
   1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 40_61_00.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 40_61_00.

B. Provide manufacturer’s services to perform installation inspection, start-up, and calibration/verification.

3.05 ADJUSTING

A. As specified in Section 40_80_01.

3.06 CLEANING

A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 40_61_00.

3.08 PROTECTION

A. As specified in Section 40_61_00.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:	Carollo Engineers	CHLORINE RESIDUAL ANALYZERS						
						Spec. No.		Rev.
Contractor:		No	By	Date	Revision	40_75_23		
Project:	Water Storage Tank Improvements project					Contract		Date
Customer:	City of Tulare							
Plant:	Water Storage Tank					Req.		P.O.
Location:	J Street							
BOM No.:						By	Chk	App
File:								

G	1	Tag No. | Sample Unit | Transmitter		AE/AIT-155.1	AE/AIT-155.2
E	2	Service		Residual Chlorine	Residual Chlorine
N	3	P&ID		N105	N104
S	4	Type		Amperometric	Amperometric
M	5	Enclosure		NEMA 4X	NEMA 4X
P	6	Sampling Method		Slip Stream	Slip Stream
L	7	Operating Temperature Range		35-120 degrees F	35-120 degrees F
	8	Sample Temperature Range		40-80 degrees F	40-80 degrees F
U	9	Sample Flow Required		200 - 500 mL/min	200 - 500 mL/min
N	10	Manufacturer			
I	11	Model No.			
T	12	Other			
C	13	Style		N/A	
A	14	Length			
B	15	Model No.			
L	16	Other			
E	17	Other			
	18	Type		Control Unit and Display	Control Unit and Display
T	19	Enclosure		NEMA 4X	NEMA 4X
R	20	Mounting			
A	21	Accuracy		+/- 5%	+/- 5%
N	22	Range		0-500 mg	0-500 mg
S	23	Power Requirements		115 VAC, 60 HZ	115 VAC, 60 HZ
M	24	Display		LCD	LCD
I	25	Resolution			
T	26	Output		4-20 mA	4-20 mA
T	27	Calibration			
E	28	Manufacturer			
R	29	Model No.			
	30	Other			
	31	Other			
	32	Other			
	33				
O	34				
P	35				
T	36				
S	37				
	38				

Notes:

A/E:	**Carollo Engineers**	**CHLORINE RESIDUAL ANALYZERS**						
						Spec. No.		**Rev.**
Contractor:		**No**	**By**	**Date**	**Revision**	40_75_23		
Project:	Water Storage Tank Improvements project					**Contract**		**Date**
Customer:	**City of Tulare**							
Plant:	**Water Storage Tank**					**Req.**		**P.O.**
Location:	**Alpine Street**							
BOM No.:						**By**	**Chk**	**App**
File:								

G	**1**	**Tag No. / Sample Unit / Transmitter**	**AE/AIT-255.1**	**AE/AIT-255.2**
E	**2**	**Service**	Residual Chlorine	Residual Chlorine
N	**3**	**P&ID**	N205	N204
S	**4**	**Type**	Amperometric	Amperometric
M	**5**	**Enclosure**	NEMA 4X	NEMA 4X
P	**6**	**Sampling Method**	Slip Stream	Slip Stream
L	**7**	**Operating Temperature Range**	35-120 degrees F	35-120 degrees F
	8	**Sample Temperature Range**	40-80 degrees F	40-80 degrees F
U	**9**	**Sample Flow Required**	200 - 500 mL/min	200 - 500 mL/min
N	**10**	**Manufacturer**		
I	**11**	**Model No.**		
T	**12**	**Other**		
C	**13**	**Style**	N/A	
A	**14**	**Length**		
B	**15**	**Model No.**		
L	**16**	**Other**		
E	**17**	**Other**		
	18	**Type**	Control Unit and Display	Control Unit and Display
T	**19**	**Enclosure**	NEMA 4X	NEMA 4X
R	**20**	**Mounting**		
A	**21**	**Accuracy**	+/- 5%	+/- 5%
N	**22**	**Range**	0-500 mg	0-500 mg
S	**23**	**Power Requirements**	115 VAC, 60 HZ	115 VAC, 60 HZ
M	**24**	**Display**	LCD	LCD
I	**25**	**Resolution**		
T	**26**	**Output**	4-20 mA	4-20 mA
T	**27**	**Calibration**		
E	**28**	**Manufacturer**		
R	**29**	**Model No.**		
	30	**Other**		
	31	**Other**		
	32	**Other**		
	33			
O	**34**			
P	**35**			
T	**36**			
S	**37**			
	38			

Notes:

SECTION 40_80_01

TESTING, CALIBRATION, AND COMMISSIONING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Testing requirements that apply to process control and instrumentation systems for the entire Project.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor’s Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01_33_00 - Submittal Procedures.
      b. Section 01_75_17 - Commissioning and Process Start-Up.
      c. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 40_61_16 - Specific Control Strategies.
      e. Section 40_67_01 - Control Systems - Panels, Enclosures, and Panel Components.

1.02 REFERENCES

A. As specified in Section 40_61_00.

B. Electronics Industries Alliance (EIA).

C. Telecommunications Industry Association (TIA).

1.03 DEFINITIONS

A. As specified in Sections 01_75_17 and 40_61_00.

B. Specific definitions:
   1. PTO: Profibus Trade Organization.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01_33_00.

B. General:
1. Reference additional detailed test submittal scheduling and prerequisite requirements as specified in the Sequencing article of Section 40_61_00.

C. Overall test plan:
1. Develop the PCIS system test submittals in consultation and cooperation with all applicable subcontractors.
2. Develop and submit an overall testing plan for the PCIS. The overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.
3. Describe the test phases as they apply specifically to this Project and each process system.
4. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
5. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
6. Provide examples of proposed forms and checklists.

D. Test procedures:
1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
2. Provide a statement of test objectives for each test.
3. Prepare specific procedures for each process system.
4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
6. Describe the expected role of the Engineer, as well as any requirements for assistance from Owner’s staff.
7. Provide the forms and checklists to be used.

E. Test forms:
1. Provide test and calibration forms and checklists for each of the following:
   a. Calibration.
   b. Factory acceptance tests (FAT).
   c. Loop validation tests.
   d. Installation tests.
   e. Functional tests.
   f. Instrumentation and Controls Performance test.
   g. Communication Testing including all digital bus and all forms of Ethernet.
2. Test forms shall include the detailed test procedures, or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
3. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for

witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.

4. Some sample test forms are included at the end of this Section. These test forms show the minimum required test form content. They are not complete, and have not been customized for this Project. The Contractor is to develop and submit test forms customized for the Project and meeting all of the specified test and submittal requirements.

F. Testing binders:
   1. Sub-system to be tested, provide and submit a test binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
   2. Fill out in advance headings and all other information known before the test.
   3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
   4. Include or list reference material and provide separately at the time of the test.
   5. Record test results and verify that all test requirements and conditions have been met.

G. FAT procedure additional minimal requirements:
   1. Prepare and submit a FAT procedure which includes:
      a. Control system testing block diagram.
      b. Estimated test duration.
      c. Details on the simulator construction, components, and operation.

H. Test reports:
   1. At the conclusion of each test, submit a complete test report, including all test results and certifications.
   2. Include all completed test binders, forms, and checklists.
   3. Submission, review, and acceptance of each test report is required before the start of the sub-system.

1.06 QUALITY ASSURANCE

A. Test personnel:
   1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. As specified in Section 40_61_00.

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 40_61_00.

B. Installation supervision:
   1. Provide as specified in Section 40_61_00.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING AND PROCESS START-UP

A. Source Testing:

1. Provide manufacturer services as specified in the table below.

Section Number	Section Title	Source Testing (Witnessed or Non-Witnessed)
40_61_16	Specific Control Strategies	Non-Witnessed
40_67_01	Control Systems - Panels, Enclosures, and Panel Components	Witnessed
40_80_01	Testing, Calibration, and Commissioning	Witnessed

2. FAT - general:
   a. Performed during the Commissioning Phase, source testing activity.
   b. Before shipment to the Project Site, the complete PCIS system including all operator stations, servers, network equipment, printers, PCMs, PLCs, RTUs, LCPs, CCS, peripherals, communications equipment, and other SCADA equipment, shall be assembled, connected, and all software loaded for a fully functional FAT of the integrated system.
   c. Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
   d. Additional factory tests are specified in other sections of the Instrumentation and Control Specifications.
   e. For systems that contain RTUs or remote communications with other devices, the complete communications system must be factory tested, including actual interfacing with the actual radios used for radio based telemetry systems.
   f. The FAT will be witnessed.
   g. Right of observation: The Owner retains the right to observe all factory test activities including any and all subsystem preparation, pretests, troubleshooting, retests, warm-up, and software modification and/or update.
   h. The Owner reserves the right to test any specified function, whether or not explicitly stated in the test submittal.
   i. Correction of deficiencies: Any deficiencies observed during the test shall be corrected and retested before completion of the test.
   j. Any changes and/or corrections shall be noted on the test forms. Engineer shall witness the revisions and/or corrections prior to leaving the test site.
   k. If the corrections and/or revisions are too extensive to be made while the Engineer is scheduled to be at the FAT test site, the FAT shall be, at the Engineer’s sole discretion, considered failed, and the test shall be restarted at a later date. All costs for the re-test shall be borne by the Contractor.
3. Testing simulation:
   a. The FAT shall make use of hardware simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the SCADA system. All inputs and outputs shall be simulated and proper control and system operation shall be validated.

b. The use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator shall not be allowed.
c. The hardware simulator may consist of a PLC, operating under a SCADA software package, or other approved software that has its I/O points wired to PLC's I/O points. Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.

4. Preliminary FAT:
   a. A complete preliminary FAT (pre-FAT) shall be conducted utilizing test procedures approved by the Engineer. The pre-FAT test procedure shall be a subset of the full FAT.
   b. The purpose of the pre-FAT is to provide assurance to the Engineer that the SCADA system is ready for the full, witnessed FAT, in terms of both stability and functionality. Debugging of software and troubleshooting of hardware shall occur during and before the pre-FAT, not during the FAT. The Contractor shall fully test the SCADA system and fix all deficiencies found before the full FAT.
   c. The Owner shall have the right to witness any or all of the pre-FAT testing and shall be notified in writing 20 days before the start of the pre-FAT.
   d. The pre-FAT test results submittal shall include a letter, signed by the Contractor's project manager or company officer, certifying that the system is complete, has been tested successfully, and is fully ready for the full, witnessed FAT. The submittal shall include completed pre-FAT test forms, signed by the Contractor's staff, and shall be submitted for review before the start of the FAT.
5. Panel inspections:
   a. The Engineer will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the accepted shop drawings.
   b. Provide panel inspection forms as part of the FAT procedures submittal.
   c. Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.
   d. A sample FAT control panel form has been provided at the end of this Section.
6. I/O test:
   a. Verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including all operator interface devices.
   b. Test methodology:
      1) Use the submitted and approved system simulator for this test.
      2) Discrete inputs: Apply appropriate input from simulator at panel terminal, observe input card indicator, observe data value at each indicated data address, observe data received on all operator interface displays (SCADA workstations and local operator interface (LOI) displays).
      3) Discrete outputs: Issue commands from operator interface screen, verify output card indicator light and measure response on simulator.
      4) Analog inputs: Apply appropriate analog input signal at panel terminals on simulator, observe data value at each indicated data

address, and observe data properly received at each operator screen. Check each point at 0 percent, 50 percent, and 100 percent of scale.

5) Analog outputs: Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response on simulator.

c. Test forms to include, but not be limited to:
   1) PLC and panel number.
   2) I/O type.
   3) I/O tag name.
   4) Panel terminal block numbers.
   5) Rack/slot/number of I/O point.
   6) Check-off for correct response for each I/O point.
   7) Space for comments.
   8) Initials of individual performing test.
   9) Date test was performed.
   10) Witness' signature lines.

7. System configuration test:
   a. Demonstrate and test the setup and configuration of all operator stations, servers, development stations, and peripherals.
   b. Demonstrate all utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
   c. Demonstrate the proper operation of all peripheral hardware.
   d. Demonstrate all general SCADA functions.
   e. Demonstrate proper operation of log-on and other access security functions.
   f. Demonstrate the proper operation of all historical data storage, trend, display, backup, and report functions.
   g. Test automatic fail over of redundant equipment.
   h. Demonstrate the proper operation of the alarm display and acknowledgement functions.
   i. Test forms:
      1) For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.
      2) List the specific tests and steps to be conducted.
      3) For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
         a) Include signature and date lines.

8. Control logic test:
   a. The purpose of this test is to verify that all software functions and logic work as specified, along with any hardwired logic or functions in the tested control panels.
   b. Testing requirements:
      1) Demonstrate in detail how each function operates under a variety of operating scenarios. Test to verify the application of each general control strategy function to each specific control strategy or loop description.
      2) Demonstrate the proper operation of the programming and configuration for each control strategy or loop description. Test each strategy or loop description on a sentence by sentence and function by function basis. Loops with similar or identical logic must each be tested individually.

3) Demonstrate the proper operation of all digital communication links and networks. Verify each digital communication I/O point.
4) Failure testing: In addition to demonstrating correct operation of all specified features, special effort shall be made to demonstrate how the system responds to and recovers from abnormal conditions including, but not limited to: equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to SCADA hardware), process equipment failure, and high system loading conditions.

c. Test forms:
1) Include the fully revised and approved control strategy for the loop being tested.
2) Identify the cause and effect as each I/O point is toggled through the simulator. Check boxes shall be provided to track proper and/or improper operation of the loop.
3) Any deficiencies or operational changes shall be noted on the forms for correction and documentation:
a) Include signature and date lines.

B. Owner Training:
1. Complete Owner training as specified in Section 40_61_00.

C. Installation Testing:
1. General:
a. The Owner reserves the right to test any specified function, whether or not explicitly stated in the test submittals.
b. Failure testing:
1) In addition to demonstrating correct operation of all specified features, demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
a) Equipment failure.
b) Operator error.
c) Communications sub-system error.
d) Power failure.
e) Process equipment failure.
f) High system loading conditions.
c. Conduct testing Monday through Friday during normal working hours for no more than 8 hours per day.
1) Testing at other times requires approval of the Engineer.
2. Sequencing:
a. See additional requirements specified in the Sequencing article of Section 40_61_00.
3. Calibration:
a. After installation but before starting other tests, calibrate and adjust all instruments, devices, valves, and systems, in conformance with the component manufacturer's instructions and as specified in these Contract Documents.
b. Components having adjustable features are to be set carefully for the specific conditions and applications of this installation. Test and verify that components and/or systems are within the specified limits of accuracy.

c. Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
d. Calibration points:
   1) Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to NIST.
e. Field verify calibration of instruments that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
f. Analyzer calibration:
   1) Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical representatives.
g. Complete instrument calibration sheets for every field instrument and analyzer.
h. Calibration tags:
   1) Attach a calibration and testing tag to each instrument, piece of equipment, or system.
   2) Sign the tag when calibration is complete.

4. Ultrasonic and radar check out:
   a. Check response under all operating conditions.
   b. Track all responses through trend charts in the SCADA system.
   c. Provide Echo Transmission and signal quality on all level transmitters including guided and unguided units.
      1) Provide printout of the actual transmission and all parameters.
5. Loop check/validation:
   a. Check all control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the SCADA system. Issue commands from the SCADA system and verify proper responses of field devices. Use actual process inputs wherever available.
   b. Provide “end-to-end” tests:
      1) Test SCADA system inputs from field device to SCADA system operator workstations.
      2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.
      3) Observe and record responses at all intermediate devices.
      4) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
      5) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
   c. Retest any loop following any necessary corrections.
   d. Specified accuracy tolerances for each analog network are defined as the square-root of the sum of the squares of individual component accuracy.
   e. Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements, and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.

f. Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
g. Apply provisional settings on controllers and alarm setpoints.
h. Record all analog loop test data on test forms.
i. Exercise each field device requiring an analog command signal, through the SCADA system. Vary, during the validation process, the output from the PLC SCADA system and measure the end device position, speed, etc. to confirm the proper operation of the device for the supplied analog signal. Manually set the output from the SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
j. Exercise each field device providing a discrete input to the SCADA system in the field and observe the proper operation shall be observed at the operator workstation:
    1) Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
    2) Exercise starters, relay contacts, switch contacts, and observe proper operation.
    3) Calibrate and test instruments supplying discrete inputs, and observe proper operation.
k. Test each device accepting a discrete output signal from the SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:
    1) Stroke valves through outputs from the SCADA system, and confirm proper directional operation. Confirm travel limits and any feedback signals to the SCADA system.
    2) Exercise motors starters from the SCADA system and verify proper operation through direct field observation.
    3) Exercise solenoids and other field devices from the SCADA system and verify proper operation through direct field observation.
l. Include in the test forms:
    1) Analog input devices:
        a) Calibration range.
        b) Calibration data: Input, output, and error at each test value.
        c) Analog input associated PLC register address.
        d) Value in PLC register at each test point.
        e) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).
    2) Analog output devices:
        a) Calibration range.
        b) Test value at each test point.
        c) Analog output associated PLC register address.
        d) Control variable value at field device at each test point.
        e) Physical device response at each test point:
            (1) Response to be actual valve position, or motor speed, etc.
    3) Discrete instrument input devices:
        a) Switch setting, contact action, and dead band.
        b) Valve position switches:
            (1) Response in the PLC as the valve is stroked from the PLC.
            (2) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.

c) Operator interface switches (control stations and other pilot devices) and associated response.
d) Starter and drive auxiliary device contact response.
e) Response of all other discrete inputs to the PLC.

4) Discrete output devices:
a) Observed response of field device to the discrete output from the PLC.
b) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.

5) Test equipment used and associated serial numbers.

D. Functional Testing:
1. General:
a. Commence Functional tests after completion of all loop check/validation tests:
1) As specified in Section 40_61_00, Sequencing and Scheduling article.
b. Functional to demonstrate proper operation of all systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
c. Additional tests are specified in other Instrumentation and Control Sections.
d. Follow approved detailed test procedures and check lists for Functional Test activities.
2. Control logic operational validation:
a. The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the SCADA system, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.
b. Demonstrate all control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, Electrical Specifications, and Mechanical Equipment Specifications.
c. Test in detail on a function-by-function and sentence-by-sentence basis.
d. Thoroughly test all hardware and software functions:
1) Including all hardwired and software control circuit interlocks and alarms.
e. Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify all logic and control is achieved.
f. Control logic validation tests to include, but not limited to: a repeat of all control logic tests from the FAT, modified and expanded to include all field instruments, control panels, circuits, and equipment.
3. Loop tuning:
a. Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
b. Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations

and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates. As a minimum, achieve 1/4 wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.

c. If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.

4. Functional validation sheets:
   a. Document each Functional test on an approved test form.
   b. Document loop tuning with a report for each loop, including two-pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by Contractor and Engineer.
   c. Include on the form, functions which can be demonstrated on a loop-by-loop basis:
      1) Loop number and P&ID number.
      2) Control strategy, or reference to specification tested.
      3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the Functional test. Otherwise, create new forms.
   d. For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
      1) Specification page and paragraph of function demonstrated.
      2) Description of function and/or text from specification.
      3) Test procedures: use the FAT loop test checklist forms modified to meet the specific testing conditions of the Functional test.
5. Functional certification:
   a. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01_75_17.
      1) Including all test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that all Functional test requirements have been satisfied.

E. Instrumentation and Controls Performance Testing:
1. After the Process Operational Period, test PCIS system for additional 60 days as specified in this Section to identify issues and make corrections, as needed.
2. General:
   a. The performance test is part of the Work that must be completed as a condition of substantial completion and final completion for the entire Project.
   b. The complete PLC control and SCADA system must run continuously for the duration of the performance test.
   c. Test and use the entire process control system under standard operating conditions.
   d. Exercise all system functions.

e. Log failure, any system interruption and accompanying component, subsystem, or program failure including time of occurrence, duration of each failure, failure classification, and cause.
    1) Provide a competently trained technician or programmer on call for the Project Site during all normal working days and hours from the start of the performance test until final acceptance of the system.
        a) Response time to the Project Site: 24 hours or less, for a major failure.

3. SCADA system testing:
    a. Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates "normal" system operation.
    b. Failure of the SCADA system during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications.
        1) Corrective action is required before restarting the performance test.
4. Failures:
    a. Classify failures as either major or minor.
        1) Minor failure:
            a) A small and non-critical component failure or software problem that can be corrected by the Owner's operators.
            b) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
            c) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
            d) Failure of one printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator station, and repairs can be made and equipment returned to service within 3 working days.
        2) Major failure:
            a) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
            b) Cause termination of the performance test.
            c) Start a new acceptance test when the causes of a major failure have been corrected.
            d) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.
5. Technician report:
    a. Each time a technician is required to respond to a system malfunction, they must complete a report, which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
    b. If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
    c. If a technician has performed work but no report is written, then a major failure is considered to have occurred.

d. Each report shall be submitted within 24 hours to the Engineer and the Owner, or its representative.

3.08 FIELD QUALITY CONTROL (NOT USED)

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES

A. Example test forms:
  1. Example test forms are attached at the end of this Section. They may be used as a starting point for the development of Project-specific test forms for this Project.
  2. The example test forms are not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

END OF SECTION

FACTORY ACCEPTANCE TEST – CONTROL PANELS

1. GENERAL INSPECTION

A. Structural Inspection

- ☐ Verify Lifting Lugs Installed
- ☐ Verity enclosure has lock and lock is functional
- ☐ Confirm that seismic bracing components are provided per manufacturer's installation instructions

B. Exterior Inspection

- ☐ Cabinet exterior is clean, scratch, and dent free
- ☐ Inspect externally for corrosion and damage
- ☐ Verify enclosure door opens and closes easily
- ☐ Verify enclosure has a 3-point latch
- ☐ Verify enclosure has a flange mounted disconnect (where voltages greater than 120 VAC enter the cabinet)
- ☐ Verify enclosure has the appropriate NEMA rating (1, 1G, 12, 3R, 4, 4X, etc)
- ☐ Verify enclosure is the appropriate size (not grossly larger than design, and will still fit in the plant)

Nameplates

- ☐ Cabinet has identification nameplate
- ☐ All door labels are straight, spelled correctly, and match the tagging defined in the Contract
- ☐ Cabinet has a nameplate that includes the following:
  - ☐ Power source(s)
  - ☐ Integrator's Logo
  - ☐ Circuit ID(s)
  - ☐ Short Circuit KAIC ratings
- ☐ If labels are screwed to door, silicone was utilized to cover screw holes (Labels screwed to the door of a NEMA 4/4X panel technically violates the NEMA rating.)

Door Devices

- ☐ All devices penetrating the outside of panel have gaskets, silicone or both
- ☐ All door devices are installed (HMIs, Pilot Devices, etc)
- ☐ Door mounted equipment is mounted straight and square
- ☐ All exterior or door mounted equipment present and accounted for, installed and securely fastened
- ☐ NEMA classification has not been violated due to penetrations
- ☐ Door mounted equipment has the same NEMA rating as the panel
- ☐ All door mounted equipment installed at the correct height
- ☐ All door mounted equipment installed in the correct positions and order (layout of door mounted equipment is grouped properly and in a logical manner)
- ☐ Doors with multiple penetrations have adequate bracing (if needed)
- ☐ Visually check condition of indicators , controllers and annunciators
- ☐ Check that pilot lights illuminate correctly
- ☐ Check the Push-To-Test function
- ☐ Ensure correct pilot light color

Peripheral Devices

- ☐ Horn / Beacon is installed (where required)
- ☐ Silence and Reset pushbutton

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1. GENERAL INSPECTION (continued)

C. Interior Inspection

- ☐ Cabinet is cleaned of marks and dirt.
- ☐ Inspect internally for corrosion and damage.
- ☐ Back panel is clean of marks and dirt.
- ☐ Interior of panel vacuumed and shall be free of all debris.
- ☐ Check that the panel roof is clean and clear of foreign materials.
- ☐ Bottom of panel has been cut out (where bottom entry is required), with angle iron welded around the bottom perimeter. Re-painting has been performed.
- ☐ If internal light door limit switch is provided, ensure the light automatically turns "on" when the doors are open.
- ☐ Intrusion alarms (where required).

Interior Labeling

- ☐ All panel mounted equipment has identification labeling, by using either a Brothers or Phenolic type tags.
- ☐ Verify that door mounted components are mounted square and symmetrical.
- ☐ Verify that nameplates are straight, legible, and spelled correctly.
- ☐ All terminal blocks are identified/labeled with permanent labels including tight end blocks and caps.
- ☐ All wiring shrink labeled and or phased correctly to the specifications.
- ☐ All wire labels shrunk completely rotated and aligned alike for easy identification.
- ☐ All fuses and circuit breakers are labeled with ID and current rating.
- ☐ System Integrator’s label or labels installed on door.
- ☐ Panel manufacturer model/serial number tag is present.
- ☐ All required safety/warning tags installed and straight.
- ☐ Correct UL (typically UL 508) or cUL tag installed and registered and all other associated tags installed and straight (the UL tag might not be installed in the panel at the factory test. If the panel is modified due to changes during the factory test or a punch list generated from the factory test, the UL labeling would need to be re-applied. Some UL shops do not apply the UL label until the panel is released to be shipped.).

Wireways

- ☐ Plastic wire way covers installed properly.
- ☐ Plastic wireways have no sharp edges.
- ☐ No wire Ties inside the wireways.
- ☐ No sharp edges on wire ties.
- ☐ Separation: White duct is used for DC voltages, Gray duct is used for AC voltages.
- ☐ Ensure wiring duct is not over-full, includes provision for 20% more wiring and the cover may easily be installed. Panduit recommends 50% duct fill, but 40% is a better practice.

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1. GENERAL INSPECTION (continued)

C. Interior Inspection (continued)

Wiring

- ☐ Visually check terminals and condition of internal wirings
- ☐ Verify that the control panel has been assembled and wired as designed
- ☐ Verify that all components are operational and perform the functions intended
- ☐ Verify that all components are sized appropriately for the application
- ☐ Verify that equipment control circuits function as intended
- ☐ Back of door wiring is labeled and neatly formed
- ☐ Back panel to door wiring has sufficient bending radius with spiral wrap
- ☐ Wire connection has been verified wired to correct points within the panel
- ☐ Individual wires have been given a pull test to verify a good terminal connection
- ☐ Wire and cable minimum bending radius have not been violated
- ☐ All equipment installed straight and square to back panel
- ☐ Wire colors are correct:
  - ☐ Black and White > AC hot and neutral, respectively
  - ☐ Red > AC control signals
  - ☐ Blue > DC power and control (Blue w/White stripe for DC ground)
  - ☐ Yellow > Foreign voltages (those still present when panel power is disconnected)
  - ☐ Green > AC equipment ground
  - ☐ Black > TSP (+)
  - ☐ White> TSP(-)
- ☐ Analog wiring shields are continuous (connected by a dedicated terminal block for such shields)
- ☐ Analog shield wires are grounded within the panel, where not otherwise grounded at the transmitter itself
- ☐ Discrete inputs are separately fused or protected by a circuit breaker on a “per loop” basis
- ☐ Intrinsic Safety Wiring
  - ☐ Ensure wiring associated with intrinsic safety circuits or intrinsic safety barriers is kept away from all other wiring by UL minimum distances or by a physical (grounded metal) barrier preventing non-intrinsically safe wiring from coming in contact with intrinsically safe circuits or wiring
- ☐ Verify all spare terminals are installed according to the percentage listed in the specifications

Grounding

- ☐ Equipped with “Blackburn” or other grounding type lug
- ☐ Lug is securely fastened to the panel structure
- ☐ Verify Grounding bar is installed
- ☐ Verify Isolated ground bar is installed

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2. POWER TEST

A. AC Power

- ☐ AC Power is routed correctly within the panel, and is isolated from DC and network wiring .
- ☐ All fuses are installed and sized properly.
- ☐ All breakers are installed and sized properly .
- ☐ 24 VDC Power Supplies are functional.
- ☐ 24 VDC Power fail contacts are functional.
- ☐ 24 VDC power supplies are redundant, and have diode modules enabling the hot swap-over between supplies.
  - ☐ 24 VDC supplies are equipped with dry contact failure alarms, wired as PLC inputs to signal failure of any DC power supply. Such alarm inputs to the PLC have been tested as being functional.
- ☐ Dedicated receptacle is wired to receive a dedicated AC supply .
- ☐ Verify continuity for all DC commons, ground and AC neutrals.
- ☐ Verify that the CP temporary input power is connected correctly and is the correct voltage.
- ☐ Close the CP main circuit breaker(s).
- ☐ Verify that voltages at subsequent circuit breakers are correct.
- ☐ Close circuit breakers.
- ☐ Verify that power feeding interruptible and uninterruptible power supplies is correct.
- ☐ Turn on power supplies if they are not already on.
- ☐ Verify that voltages at distribution terminals are correct.
- ☐ Energize any remaining hardware such as the PLC.

B. Uninterruptible Power Supply (UPS)

- ☐ Mounted appropriately within the cabinet, on a dedicated shelf, or rear of a swing-out sub panel.
- ☐ Is equipped with maintenance bypass switch (or at least plug/receptacle means for bypassing the unit).
- ☐ Test all UPS alarms (on inverter, failure, battery failure etc)
- ☐ Turn off the AC power supply and verify that the UPS will be switched on to supply the designated vital loads in the control panel.

3. CONTROLS & AUXILIARY DEVICES TEST

- ☐ Verify all interposing and auxiliary relays are functioning.
- ☐ Verify panel lights are functioning.

Ventilation and Heating

- ☐ If ventilation fans are fitted , check the fans operate correctly any associated air filters are clean and not blocked.
- ☐ Verify components are installed in the correct orientation for proper air flow.

4. HARDWIRED INTERLOCK AND SAFETY TEST

- ☐ Verify that hardwired interlocks through the control panel as shown on schematic drawings are functioning. For example, outlet high pressure switch interlock to a pump.
- ☐ Verify that all hardwired safety devices through the control panel is functioning. For example, the pull cord emergency stops of conveyors.

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5. PLC TEST

A. Components

☐ PLC interior High Temperature alarm is installed, wired to the PLC, and is shown to be functional.

☐ Relays have transient suppression across their coils. This is particularly important for DC coil relays, where diodes in reverse polarity are often used.

☐ TVSS is installed across the main incoming 120 VAC.

PLC and PLC Rack

- ☐ Verify all cards are securely seated.
- ☐ Ensure clearance around PLC rack has been met, such that convective heat transfer is not impeded by devices erroneously mounted in the “no encroachment” area. Confirm with manufacturer clearance recommendations.

B. PLC I/O Test

☐ Furnish **I/O test forms** and test all the listed input and output points as follows:

- ☐ Discrete Inputs: Simulate a field contact closure by “shorting” across the appropriate terminal blocks. Observe the transition between a logical “0” and “1” in the PLC software.
- ☐ Discrete Outputs: Force the output bit to toggle between logical “0” and logical “1” using the PLC software. Measure contact resistance at the wired terminal blocks using a digital meter selected for the “ohms” setting.
- ☐ Analog Inputs: Connect a signal generator to the appropriate terminal blocks. Tailor the connection depending on whether a 2-wire or 4-wire simulation is required. Modulate the 4-20mA signal. Observe the associated PLC internal memory register to transition between 0-65535 or if scaled in engineering units, between 0 and the maximum scaled engineering unit. The latter method is preferred.
- ☐ Analog Outputs: Force the output register to a value between 0-65535 or 0-100%, if the scaling block can be manipulated. Observe the measured 4-20mA value increment and decrement using a digital ammeter.

C. Redundant Controllers (where required) Test

☐ Remove Communication cable from PLC-1 to verify switching to PLC-1A

☐ Remove Communication cable from PLC-1A to verify switching back to PLC-1

☐ Remove Power from PLC-1 to verify switching to PLC-1A

☐ Remove Power from PLC-1A to verify switching to PLC-1

☐ Remove Communication cable from PLC-1 to I/O rack and verify switching to PLC-1A

☐ Remove Communication cable from PLC -1A to I/O rack and verify switching to PLC-1

D. PLC Control Logic Verification

☐ The PLC control strategy is verified by following the Control Logic Verification Form based on the specifications. Each control strategy will be verified by simulating the process and checking the state or value of PLC outputs. The results of equipment status and alarms and process instrument values and trends shall also be verified on the Plant SCADA graphic screens stored in a temporary SCADA computer. Since all PLC input and output wiring has been verified and some field devices are not available during Factory Acceptance Testing, certain inputs will be simulated either by means of additional hardware and/or software as described below.

- ☐ DI states are either simulated by hardwired switches or forced inputs using a programming terminal.
- ☐ For example, when starters and drives are not provided as part of the contract, jumpers may be installed from the output call relays to the running confirmation inputs to simulate the running state of the motors.
- ☐ AI values are either simulated by an external source or within software using a programming terminal.
- ☐ For example, when a level transducer is not provided as part of the contract the level transducer loop current may be simulated with a loop powered potentiometer and adjusted manually for the level input.

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5. PLC TEST (continued)

D. PLC Control Logic Verification (continued)

Typical Fault Logic

- ☐ If the fault input is high and the disable (if applicable) for the fault is not high and the common disable (if applicable) is not high begin timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output. If the fault alarm is a shutdown alarm stop the associated motor and latch the alarm so that it remains present even if the condition clears.
- ☐ The fault condition must return to normal and the alarm must be reset for a latched alarm to clear.

Typical Fail to Start Logic

- ☐ If the motor is called to run (call output high) and no running feedback is received (running input is low) and the fail to start and common alarm disables (if applicable) are not high start timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output, stop calling the motor and latch the alarm.

6. HMI OR OIT TEST

HMI / OIT Functionality

- ☐ Communication with PLC
- ☐ Screen Layouts
- ☐ Screen Navigation
- ☐ Set Point Entry
- ☐ Animation
- ☐ Color Correctness (Green=Run, Red=Off, Amber=Alarm, or the agreed upon convention)
- ☐ Alarms
- ☐ Acknowledge and Reset
- ☐ Security / Access Levels / Passwords

7. NETWORK COMMUNICATION TEST

A. Network Components

- ☐ Fiber optic cabling terminates in a patch panel
- ☐ Media converters are installed and functional
- ☐ Terminating resistors have been installed for trunk/tap topologies or where required
- ☐ Wire and cable bending limitations have not been violated

B. Networking Functions

- ☐ Verify data transfer via the network to different PLCs as shown on the Network Block Diagrams
- ☐ Verify network traffic rate and error margin is acceptable

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8. FAT DOCUMENTATION AND RECORD

Panel Documentation

- ☐ As-built panel drawings showing actual panel construction and devices arrangement and c/w Bill of Material.
- ☐ Panel schematic and interconnection drawings.
- ☐ P&ID drawings and schematic drawings for the process area controlled by the panel that is to be tested.
- ☐ I/O list test forms of the process area to be tested.
- ☐ FAT procedure of the process area to be tested.
- ☐ Test record forms of the process area to be tested. Forms shall include area for signature of responsible test personnel.
- ☐ Hard copy of the PLC application program of the process area to be tested.
- ☐ Hard copy of the HMI/OIT graphic screens of the process area to be tested.

9. FAT TOOLS AND SOFTWARE

- ☐ Simulation software if required
- ☐ Digital volt meter Fluke 87
- ☐ Process meter Fluke 787
- ☐ Laptop computer with PLC application program
- ☐ Temporary SCADA computer with HMI software and applicable graphic screens
- ☐ Jumper wires

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WITNESSED BY: ____________________ SIGNATURE: ____________

	INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	

INSTRUMENT LOOP NO. ____________________

SERVICE DESCRIPTION ____________________

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

REMARKS: ____________________

CHECKED BY (COMPANY) ____________________ ACCEPTED BY (COMPANY) ____________________

SIGNATURE ____________________ SIGNATURE ____________________

DATE ____________________ DATE ____________________

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP NO. ____________________

SERVICE DESCRIPTION ____________________

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. ____________________
- ☐ VERIFIED PER P&ID NO. ____________________
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. ____________________
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. ____________________
- ☐ INSTALLATION CORRECT PER DETAIL NO. ____________________
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

FIELD CALIBRATION CHECK

CONTACT NO.	FUNCTION	FOR SIGNAL	CONTACT IS TO	AT SPECIFIED VALUE FOR		ACTUAL TRIP POINT WAS	
1	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
2	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
3	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
4	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	

NOTE: PERM IS ABBREVIATION FOR PERMISSIVE

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

REMARKS: ______________________________

CHECKED BY (COMPANY) ______________________ ACCEPTED BY (COMPANY) ______________________

SIGNATURE ______________________ SIGNATURE ______________________

DATE ______________________ DATE ______________________

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

	☐ No	☐ Yes
INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?	No	Yes

INSTRUMENT TYPE ☐ TRANSMITTER ☐ CONTROLLER ☐ INDICATOR

☐ OTHER DESCRIPTION ______________________

INSTRUMENT TAG NO. ______________________ SERIAL NO. ______________________

SERVICE DESCRIPTION ______________________

BENCH CALIBRATION CHECK				
INPUT RANGE = ______			OUTPUT RANGE = ______	
HEAD CORRECTION = ______			☐ LINEAR	
CALIBRATED SPAN = ______			☐ SQUARE ROOT	
% CALIB SPAN	**DESIRED VALUE**	**ACTUAL VALUE**	**EXPECTED VALUE**	**ACTUAL VALUE**
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. ______________________

☐ VERIFIED PER P&ID NO. ______________________

☐ CORRESPONDS TO SPECIFICATION SHEET NO. ______________________

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. ______________________

☐ INSTALLATION CORRECT PER DETAIL NO. ______________________

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

FIELD CALIBRATION CHECK				
INPUT RANGE = ______			OUTPUT RANGE = ______	
% CALIB SPAN	**DESIRED VALUE**	**ACTUAL VALUE**	**EXPECTED VALUE**	**ACTUAL VALUE**
0				
50				
100				

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ DIRECT ☐ REVERSE

☐ ACTION VERIFIED AT 50% SPAN

☐ ACTION VERIFIED AT ___________ SPAN

CONTROLLER SETTINGS								
SETTING	**GAIN**	**PB**	**RESET (INTEGRAL)**	**DERIV. (RATE)**	**HIGH LIMIT**	**LOW LIMIT**	**ELEV. ZERO**	**ZERO SUPP**
PRE-TUNE								
POST-TUNE								

PRE-TUNE SETTINGS					
	GAIN	**PB**	**RESET (REPEAT/MIN)**	**RESET (MIN/REPEAT)**	**DERIVATION (MINUTES)**
FLOW	1.0	100	10	0.1	N/A
LEVEL	1.0	100	MIN.	MAX.	N/A
PRESSURE	2.0	50	2.0	0.5	N/A
TEMP.	4.0	25	0.1	10	OFF

REMARKS ____

____

____

____

____

____

____

____

CHECKED BY (COMPANY) ______________________ ACCEPTED BY (COMPANY) ______________________

SIGNATURE ______________________ SIGNATURE ______________________

DATE ______________________ DATE ______________________

	ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST	

☐ No ☐ Yes

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? No Yes

TYPE OF INSTRUMENT ______________________________

INSTRUMENT TAG NO. ______________ SERIAL NO. ______________

SERVICE DESCRIPTION ______________________________

CHECK BELOW, IF TRUE

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. ______________

☐ VERIFIED PER P&ID NO. ______________

☐ CORRESPONDS TO SPECIFICATION SHEET NO. ______________

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. ______________

☐ INSTALLATION CORRECT PER DETAIL NO. ______________

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS ______________________________

CHECKED BY (COMPANY) ______________ ACCEPTED BY (COMPANY) ______________

SIGNATURE ______________ SIGNATURE ______________

DATE ______________ DATE ______________

	CONTROL VALVES **INSTALLATION AND CALIBRATION CHECKLIST**	

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

☐ VALVE TAG NO. ______________________ SERIAL NO. ______________________

☐ TRANSDUCER TAG NO. ______________________ SERIAL NO. ______________________

☐ SOLENOID TAG NO. ______________________ SERIAL NO. ______________________

☐ VOLUME BOOSTER TAG NO. ______________________ SERIAL NO. ______________________

☐ POSITIONER ______________________ SERIAL NO. ______________________

SERVICE DESCRIPTION ______________________

TRANSDUCER CHECK					
INPUT RANGE =			OUTPUT RANGE =		
CALIBRATED SPAN =			CALIBRATED SPAN =		
BENCH					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		
FIELD					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		

CHECK BELOW, IF TRUE:

☐ BENCH CALIBRATED PER ABOVE ______________________

☐ VERIFIED PER P&ID NO. ______________________

☐ CORRESPONDS TO SPECIFICATION SHEET NO. ______________________

- ☐ VALVE SPECIFICATION NO. ______________________
- ☐ TRANSDUCER SPECIFICATION NO. ______________________
- ☐ SOLENOID SPECIFICATION NO. ______________________

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. ______________________

☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS ______________________

- ☐ VALVE DETAIL NO. ______________________
- ☐ TRANSDUCER DETAIL NO. ______________________
- ☐ SOLENOID DETAIL NO. ______________________

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

VALVE CHECK			
FLOW CHECK	☐ PROCESS FLOW DIRECTION THROUGH THE VALVE IS CORRECT		
SAFETY CHECK	ON LOSS OF AIR VALVE FAILS ☐ OPEN ☐ CLOSE	ON LOSS OF POWER SOLENOID FAILS ☐ TO VENT ☐ TO VALVE	
TRAVEL CHECK	FULL OPEN AT _______ PSI	FULL CLOSED AT _______ PSI	MEASURED TRAVEL _______ INCHES
SEATING CHECK	☐ ON BENCH ☐ IN-LINE	RESULTS	ACTUATOR BENCH SET

POSITIONER CHECK
VALVE FULL OPEN AT _______________ PSI TO POSITIONER
VALVE FULL CLOSED AT _______________ PSI TO POSITIONER

VOLUME BOOSTER CHECK
BYPASS VALVE (GAIN) ADJUSTING SCREW BACKED OUT _______ TURNS FROM CLOSED TO ENSURE QUICK BUT STABLE OPERATION (TYPICALLY 1-1/2 TO 2 TURNS)

REMARKS ____

CHECKED BY (COMPANY) _______________ ACCEPTED BY (COMPANY) _______________

SIGNATURE _______________ SIGNATURE _______________

DATE _______________ DATE _______________

Network Power Supplies

Power Supply Equipment	Supply Source (120 VAC)	Network Power Tap (24 VDC)
☐ ODVA compliant	☐ Overcurrent protection	☐ Overcurrent protection
☐ Quantity and ratings	☐ Conductor size	☐ Conductor size

Comments: ______________________________

____

____

CHECKED BY (COMPANY) ______________________________ ACCEPTED BY (COMPANY) ______________________________

SIGNATURE ______________________________ SIGNATURE ______________________________

DATE ______________________________ DATE ______________________________

PROFIBUS
INSTALLATION QUALIFICATION AND TESTING

Media Inspection

CABLING	DP NETWORK	PA NETWORK SEGMENTS			
PI COMPLIANT	☐	☐	☐	☐	☐
LABELING COMPLETE	☐	☐	☐	☐	☐
GROUNDING	☐	☐	☐	☐	☐
CABLE AND CONDUCTOR TERMINATIONS	☐	☐	☐	☐	☐
NO STUB LINES (DP ONLY)	☐	☐	☐	☐	☐
TERMINATING RESISTORS (IN PLACE)	☐	☐	☐	☐	☐
DEDICATED DIAGNOSTICS BUS	☐	☐	☐	☐	☐
INSTALLATION					
NO EVIDENCE OF PHYSICAL DAMAGE	☐	☐	☐	☐	☐
INSTALLATION IN PROTECTIVE RACEWAY	☐	☐	☐	☐	☐
CLEARANCES FROM HIGH TEMPERATURE SOURCES	☐	☐	☐	☐	☐
CLEARANCES FROM HIGH VOLTAGE SOURCES	☐	☐	☐	☐	☐
BEND RADIUS	☐	☐	☐	☐	☐
NO INSTALLATION SUBJECT TO VIBRATION, SHOCK, HIGH FLEX, CHEMICALS, OR MOISTURE	☐	☐	☐	☐	☐
TERMINATING RESISTORS TURNED ON AT CORRECT LOCATION	☐	☐	☐	☐	☐

COMMENTS *(Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)*

Device Inspection

DEVICE QUANTITY/TYPE	INSTALLATION
☐ TOTAL SLAVE COUNT	☐ NO EVIDENCE OF PHYSICAL DAMAGE
☐ MOST UPDATED DEVICE DRIVER INSTALLED?	☐ ACCESSIBLE FOR INSPECTION AND MAINTENANCE
☐ INSTALLED DEVICES COMPLY WITH DRAWINGS AND SPECIFICATIONS	☐ FDT COMPLIANT DEVICES
☐ PI COMPLIANCE DEVICES	
☐ DIAGNOSTICS MODULE INSTALLED	

COMMENTS *(Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)*

Power Supplies

ACTIVE TERMINATIONS	COUPLERS	REPEATERS
☐ SOURCE LOCATION	☐ SOURCE LOCATION	☐ SOURCE LOCATION
☐ OVERCURRENT PROTECTION	☐ OVERCURRENT PROTECTION	☐ OVERCURRENT PROTECTION
☐ CONDUCTOR SIZE	☐ CONDUCTOR SIZE	☐ CONDUCTOR SIZE
☐ GROUNDING	☐ GROUNDING	☐ GROUNDING

COMMENTS *(Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)*

PROJECT NAME: ______________________ TEST DATE: __________

FACILITY NAME: ______________________ TESTED BY: __________

PROCESS AREA: ______________________ COMPANY: __________

NETWORK ID: ______________________ PAGE: __________

WITNESSED BY: ______________________ SIGNATURE: __________

PROFIBUS
INSTALLATION QUALIFICATION AND TESTING

DP Network Media Testing

DESCRIPTION	SEGMENT ID											
TRUNK LENGTH (feet)												
ALLOWABLE TRUNK LENGTH AT SPECIFIED DATA RATE:												
MEASURED TRUNK LENGTH:												
SPARE TRUNK LENGTH												
RESISTANCE MEASUREMENTS (ohms)												
NETWORK CABLE: NO TERMINATIONS												
ONE TERMINATION												
TWO TERMINATIONS												
POWER SUPPLY VOLTAGE (volts DC)												
ACTIVE TERMINATOR												
REPEATER CP1100-RPT1												
REPEATER CP1000-RPT1												
REPEATER CP1000-RPT2												
REPEATER CP2700-RPT1												
CABLE TEXTS	**PASS**	**FAIL**	**PASS**	**FAIL**	**PASS**	**FAIL**	**PASS**	**FAIL**	**PASS**	**FAIL**	**PASS**	**FAIL**
TESTED FOR SHORT CIRCUIT BETWEEN SIGNAL LINES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR SHORT CIRCUIT BETWEEN SIGNAL LINES AND SHIELD	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR SHIELD CONTINUITY	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR OPEN SIGNAL LINES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR CROSSED SIGNAL LINES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR CORRECT TERMINATOR POSITION	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
CORRECT CABLE TYPE AND LENGTH	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR SECURE AND TIGHT CONNECTORS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

COMMENTS *(Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)*

PROJECT NAME: ____________________ TEST DATE: ____________________

FACILITY NAME: ____________________ TESTED BY: ____________________

PROCESS AREA: ____________________ COMPANY: ____________________

NETWORK ID: PAGE:

WITNESSED BY: SIGNATURE:

SECTION 43_23_21.30

AXIALLY-SPLIT CENTRIFUGAL PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Split-case centrifugal pumps with drivers and components. There are 4 pumps total, 2 with left hand rotation and 2 with right hand rotation.

B. Tag numbers: As specified in Pump Schedule.

C. Related sections:
1. Section 01_33_00 - Submittal Procedures.
2. Section 01_60_00 - Product Requirements.
3. Section 01_75_17 - Commissioning.
4. Section 01_78_23 - Operation and Maintenance Data.
5. Section 01_78_36 - Warranties and Bonds.
6. Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
7. Section 09_96_01 - High-Performance Coatings.
8. Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
9. Section 46_05_10 - Common Work Results for Mechanical Equipment.
10. Section 46_05_94 - Mechanical Equipment Testing.

1.02 REFERENCES

A. American Bearing Manufacturers’ Association (ABMA):
1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. American Society of Mechanical Engineers (ASME):
1. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 250.
2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

C. ASTM International (ASTM):
1. A48 - Standard Specification for Gray Iron Castings.
2. A108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
4. A283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
5. A582 - Standard Specification for Free-Machining Stainless Steel Bars.
6. B505 - Standard Specification for Copper Alloy Continuous Castings.
7. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
8. E10 - Standard Test Method for Brinell Hardness of Metallic Materials.

D. Hydraulic Institute (HI):
1. 1.1-1.2 - Rotodynamic (Centrifugal) Pumps for Nomenclature and Definitions.
2. 1.3 - Rotodynamic (Centrifugal) Pumps for Design and Application.

3. 9.1-9.5 - Pumps - General Guidelines for Types, Definitions, Application, Sound Measurement and Decontamination.
4. 9.6.4 - Rotodynamic Pumps for Vibration Measurement and Allowable Values.
5. 14.6 – Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.

E. NSF International (NSF):
1. Standard 61 - Drinking Water System Components - Health Effects.
2. Standard 372 - Drinking Water System Components - Lead Content.

F. National Electrical Manufacturers Association (NEMA):
1. 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).

1.03 DEFINITIONS

A. NEMA: Type 4X enclosure in accordance with NEMA 250.

B. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net-positive suction head available (NPSHa), and net-positive suction head required (NPSHr): As defined in HI 1.1-1.2, 1.3, 9.1-9.5, 9.6.4, and 14.6 and as modified in the Specifications.

C. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; average when using multiple suction pressure taps, regardless of variation in individual taps.

1.04 SYSTEM DESCRIPTION

A. Split-case centrifugal pumps with components: Pump, driver, motors, and drive arrangements as scheduled with seals or packing, couplings, base plates, guards, supports, anchor bolts, necessary valves, gauges, taps, lifting eyes, stands, and other items as specified and as required for a complete and operational system.

B. Pumps suitable for intermittent or continuous service with up to 10 milligrams per liter residual chlorine concentration.

C. Design requirements:
1. Pump performance characteristics:
   a. As specified in the Pump Schedule.
   b. Performance tolerances shall be the same as the test tolerances specified in Section 46_05_94.
2. Motor characteristics: As specified in the Pump Schedule.

D. Product requirements as specified in Section 01_60_00 and Section 46_05_10.

1.05 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 46_05_10:
1. For pumps in contact with Drinking Water submit one of the following:
   a. Pump certification per Section 01_60_00.
   b. Weighted average lead calculations Section 01_60_00.

C. Shop drawings: As specified in Section 46_05_10.

D. Calculations: As specified in Section 46_05_10.

E. Vendor operation and maintenance manuals: As specified in Section 01_78_23.

F. Commissioning submittals:
   1. Provide Certificate of Source Testing as specified in Section 01_75_17.
   2. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01_75_17.

1.06 WARRANTY

A. As specified in Section 01_78_36.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Pump: One of the following or equal:
   1. Aurora, Series 410 as scheduled.
   2. Fairbanks Nijhuis, Series 2800, or 5800 as scheduled.
   3. Peerless Pump, Type A, AE or similar to model scheduled.

2.02 MATERIALS

A. General:
   1. Materials in the Pump Schedule shall be the type and grade as specified in this Section.

B. Cast iron: In accordance with ASTM A48, Class 30 minimum.

C. Low Lead Bronze: :
   1. In accordance with ASTM B584
      a. UNS Alloy C89833 or,
      b. UNS Alloy C89520.
   2. As required for Drinking Water service meeting the requirements of Section 46_05_10.

D. Bronze: In accordance with ASTM B584, UNS Alloy C83600.

E. Zincless bronze: In accordance with ASTM B584, UNS Alloy C93700.

F. Stainless steel:
   1. In accordance with ASTM A276, Type 316 stainless steel.
   2. Impellers and casing: ASTM A276, CF8M stainless steel.
   3. In accordance with ASTM A582, Type 416 stainless steel.

G. Steel: ASTM A108, Grade as scheduled.

2.03 PUMP CASINGS

A. Type: Axially split case; allow removal of rotating element without disturbing piping connections or alignment; mounted horizontally or vertically as scheduled.

B. Material: As scheduled.

C. Construction: Of sufficient strength, weight, and thickness to provide accurate alignment and prevent excessive deflection.

D. Design working pressure: Minimum 1.10 times maximum shutoff total dynamic head with maximum installable impeller diameter at maximum operating speed plus maximum suction static head.

E. Hydrostatic test: 5-minute hydrostatic test minimum 1.5 times design working pressure.

F. Casing assembly: Lifting eye bolts for removable half and doweling to facilitate alignment of bolted halves.

G. Suction and discharge: Single or dual suction as scheduled; piping connections in lower half of casing with side entry and exit unless otherwise indicated on the Drawings.

H. Suction and discharge piping connections: Flanged, meeting ASME B16.1, Class 125, or ASME B16.5, Class 150, or higher pressure class as required to meet design working pressure.

I. Vent and taps:
   1. Provide casings with bolt 3/4-inch threaded high-point and low-point drain taps.
   2. Provide 1/2-inch threaded tap with valve and pressure gauge on the suction and discharge flanges.

2.04 IMPELLERS

A. Type: As scheduled.

B. Material: As scheduled.

C. Water passages: Smooth, machined to reduce turbulence.

D. Method of securing to shafts: Keyed and axially secured by bronze sleeves with nuts.

E. Rotation: Clockwise looking from driver, unless otherwise indicated on the Drawings.

F. Balance: As specified in Section 46_05_10 to meet the vibration criteria as specified in Section 46_05_94.

2.05 WEAR RINGS

A. Impeller wear-ring material:
   1. When low lead bronze impeller is scheduled, provide bronze alloy meeting the requirements of NSF 61 and 372.
   2. When bronze impeller is scheduled, provide UNS Alloy C93200 wear ring.
   3. When zincless-bronze impeller is scheduled, provide UNS Alloy C93700 wear ring.
   4. When cast-iron impeller is scheduled, provide ASTM A48, Class 30 cast-iron wear ring.
   5. When stainless steel impeller is schedule, provide Stainless Steel ASTM A276 CD4MCU wear ring.
   6. Impeller wear ring shall have a Brinell Hardness Number at least 50 less than the casing wear ring Brinell Hardness Number when tested in accordance with ASTM E10.

B. Casing wear-ring material: Same material as impeller wear ring.

C. Features:
   1. Able to allow compensation for minimum 1/8-inch wear.
   2. Removable.
   3. Fastened with recessed screws or keyed to casing to prevent relative rotation.

2.06 PUMP SHAFTS

A. Material:
   1. When low lead bronze impeller is scheduled, provide bronze alloy meeting the requirements of NSF 61 and 372.
   2. When bronze impeller scheduled, provide ASTM A582, Type 416 stainless steel shaft.
   3. When zincless-bronze impeller scheduled, provide ASTM A276, Type 316 stainless steel shaft.
   4. When cast-iron impeller scheduled, provide ASTM A108, Grade 1141 steel shaft.
   5. When stainless steel impeller is schedule, provide Stainless Steel ASTM A276 Type 316 stainless steel shaft.

B. Strength: Able to withstand minimum 1.5 times maximum operating torque and other loads.

C. Resonant frequency: As specified in Sections 46_05_10 and 46_05_94.

D. Deflection: Maximum 0.002 inches under operating conditions.

E. Shaft sleeve:
   1. When low lead bronze impeller is scheduled, provide bronze alloy meeting the requirements of NSF 61 and 372.
   2. When bronze impeller scheduled, provide ASTM B505, UNS Alloy C93200 shaft sleeve.
   3. When zincless-bronze impeller scheduled, provide ASTM A276, Type 316 stainless-steel shaft sleeve.
   4. When cast-iron impeller scheduled, provide ASTM A582, Type 416 stainless-steel shaft sleeve.

5. When stainless steel impeller is schedule, provide Stainless Steel ASTM A276 Type 316 stainless steel shaft.
6. Renewable, key locked or set screws in stuffing box, gland area, and bearings; able to protect shaft from pumped liquid and wear.

2.07 BEARINGS AND BEARING FRAME

A. Bearing type: Anti-friction, grease- or oil-lubricated as scheduled, meeting ABMA standards; self-aligning spherical-roller-type radial bearings; angular-contact ball type or tapered roller for thrust bearings.

B. Bearing lubrication:
   1. When grease lubrication is scheduled, provide:
      a. External grease fittings with grease-relief pipe.
      b. Lip-type grease seals and labyrinth-type grease deflectors at both ends of bearing housings, able to prevent entrance of contaminants.
   2. When oil lubrication is scheduled, provide:
      a. Internal oil reservoir with separate constant-level external oil makeup reservoir type system.
      b. External level indication.
   3. Lubrication system sized sufficiently to safely absorb heat energy normally generated in bearing under maximum ambient temperature of 140 degrees Fahrenheit.

C. Bearing life: Minimum L10 life of 100,000 hours at rated design point but not less than 24,000 hours in accordance with ABMA 9 or 11 at bearing design load imposed by pump shutoff with maximum-sized impeller at rated speed, whichever provides longest bearing life in intended service.

D. Pump bearing frames:
   1. 1-piece rigid construction with bearing housing at outboard (pump) end and at inboard (driver) end.
   2. Materials:
      a. Pump bearing frame: ASTM A48, Class 30 minimum, cast iron.
      b. Bearing housing and end cover: ASTM A48, Class 30 minimum, cast iron.

E. Bearing frame drain hole: Tapped, located as low as possible to drain leakage when adjacent to packing or seal.

2.08 SHAFT STUFFING BOX

A. Provide stuffing box suitable for shaft-seal type scheduled and as specified in Section 46_05_10.

B. Seal flushing: Use pumped fluid; pipes and passages by pump manufacturer with external replaceable filter, pressure-regulating device, seal-flush pressure gauge (with shutoff valve), and site flow indicator.

2.09 SUPPORTS, PEDESTALS, AND BASEPLATES

A. Type: As specified below and in Section 46_05_10.

B. Materials: ASTM A283 steel, hot-dip galvanized after fabrication and coated as specified in Section 09_96_01.

C. Pump and driver support strength: Able to withstand minimum 1.5 times maximum imposed operating loads or imposed seismic loads, whichever is greater.

D. Configuration: Allow easy access to stuffing boxes, bearing frames, and couplings.

E. Vertical mounted: When scheduled, structural base plate and support for vertically mounted pump and driver able to resist torsional and seismic loads and meet vibration criteria as specified in Section 46_05_94.

F. Anchor bolts: As specified in Section 05_05_24.

2.10 COUPLINGS

A. Types: Flexible coupling as recommended by the manufacturer and as specified in Section 46_05_10.

B. Flexible coupling life: Infinite at up to 0.30-degree misalignment angle total or per disk for disk type at maximum operating loads.

C. Design coupling to withstand a minimum of 1.5 times the maximum operating torque and other imposed loads.

2.11 EQUIPMENT GUARDS

A. Provide equipment safety guards as specified in Section 46_05_10.

2.12 DRIVERS

A. Horsepower:
   1. As scheduled.
   2. Listed driver horsepower is the minimum to be supplied.
      a. Increase driver horsepower, if required, to prevent driver overload while operating at any point of the supplied pump operating head-flow curve including runout.
      b. When scheduled driver is a motor, increase motor horsepower if required to prevent operation in the service factor.
      c. Make all structural, mechanical, and electrical changes required to accommodate increased horsepower.

B. Motors: Provide motors as specified in Section 26_05_09 and as specified in this Section:
   1. Revolutions per minute: As scheduled.
   2. Enclosure: As scheduled.
   3. Electrical characteristics: As scheduled.
   4. Efficiency, service factor, insulation, and other motor characteristics: As specified in Section 26_05_09.

5. Motor accessories: As specified in Section 26_05_09 and in this Section.
6. Coordinate motors with the variable frequency drive manufacturer to ensure compatibility between the motor and variable frequency drive.

C. Other drivers: As scheduled and as specified in sections listed in the Pump Schedule.

2.13 FINISHES

A. When a cast-iron pump casing is specified: Line all water passages with a high-solids epoxy system as specified in Section 09_96_01. Where pumps are used for drinking water service, coating shall meet the requirements of NSF 61.

2.14 SPARE PARTS AND SPECIAL TOOLS

A. Special tools: Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.

B. Spare parts: Deliver the following as specified in Section 01_60_00:
   1. Pump thrust bearing set.
   2. Pump radial bearing set.
   3. Motor bearing set of each type.

PART 3 EXECUTION

3.01 INSTALLATION

A. Pump drainpipes:
   1. Connect galvanized steel pipe drains from drip pockets to point indicated on the Drawings or as directed by the Engineer.

B. Carry drainpipes on continuous downgrade to point of discharge using plugged tees and crosses for changes in direction.

3.02 COMMISSIONING

A. As specified in Section 01_75_17 and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer’s Certificate of Source Testing.
      b. Manufacturer’s Certificate of Installation and Functionality Compliance.
   2. Manufacturer’s Representative onsite requirements:
      a. Installation: 1 trip, 5 day minimum.
      b. Functional Testing: 1 trips, 2 day minimum.
   3. Training:
      a. Maintenance: 4 hours per session, 2 sessions.
      b. Operation: 2 hours per session, 2 sessions.
   4. Process operational period:
      a. As required by Owner or Contractor.

C. Source testing: As specified in Pump Schedule.

D. Functional testing: As specified in Pump Schedule.

3.03 PUMP SCHEDULE

Tag Numbers	PMP-101, PMP-102, PMP-201, PMP-202,
General Characteristics:	
Application	Drinking Water
Service	Pressure Boosting
Quantity	4
First Named Manufacturers Model Number	Model 411 10x12x18
Maximum Noise, dBA at 3 feet	85
Torsional Analysis	Not Required
Minimum Pumped Fluid Temperature, degrees Fahrenheit	50
Normal Pumped Fluid Temperature, degrees Fahrenheit	65
Maximum Pumped Fluid Temperature, degrees Fahrenheit	80
Pump Characteristics:	
Pump and Driver Mounting	Horizontal
Suction Configuration	Double
Impeller Type	Enclosed Type
Bearing Lubrication	Grease
Shaft Seal Type	Single Mechanical, Balanced
Speed Control	Variable Frequency Drive
Maximum Pump rpm	1180
Minimum Pump rpm	590
Rated Design Point (At Maximum Revolutions per Minute):	
Flow, gpm	4,167
Head, Feet	110
Minimum Efficiency, Percent	86
Required Condition 2 (At Maximum Revolutions per Minute):	
Flow, gpm	1,500
Head Range, Feet	137
Minimum Efficiency, Percent	60

Tag Numbers	**PMP-101, PMP-102, PMP-201, PMP-202,**
Required Condition 3 (At Maximum Revolutions per Minute):	
Flow, gpm	2,500
Head Range, Feet	131
Minimum Efficiency, Percent	75
Required Condition 4 (At Maximum Revolutions per Minute):	
Flow, gpm	3,500
Head Range, Feet	121
Minimum Efficiency, Percent	85
Required Condition 5 (At Maximum Revolutions per Minute):	
Flow, gpm	5,000
Head Range, Feet	90
Minimum Efficiency, Percent	83
Other Conditions:	
Shutoff Head, Feet	140
Maximum NPSHr at Every Specified Flow, Feet	17
Minimum NPSHa at Every Specified Flow, Feet	22
Maximum Suction Static Head, Feet	30
Minimum Suction Static Head, Feet	-8
Pump Materials:	
Pump Casing	Cast Iron
Impeller	Low Lead Bronze
Driver Characteristics:	
Driver Type	Motor
Drive Arrangement	Horizontal, Flexibly Coupled
Minimum Horsepower	150
Maximum Speed, rpm	1200
Motor Characteristics:	
Inverter Duty Rated	Yes
Motor Voltage/Phases/Hertz	460/3/60
Enclosure Type	TEFC

Tag Numbers	PMP-101, PMP-102, PMP-201, PMP-202,
Source Testing:	
Test Witnessing	Not Witnessed
Performance Test Level	2
Vibration Test Level	2
Noise Test Level	1
Functional Testing:	
Performance Test Level	2
Vibration Test Level	2
Noise Test Level	1

END OF SECTION

SECTION 43_24_50.11

VERTICAL TURBINE DEEP WELL CENTRIFUGAL PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Vertical lineshaft, deep well pump with features as scheduled in the Pump Schedule.

B. Tag numbers: As specified in Pump Schedule.

C. Related section:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01_33_00 - Submittal Procedures.
      b. Section 01_60_00 - Product Requirements.
      c. Section 01_75_17 - Commissioning.
      d. Section 01_78_23 - Operation and Maintenance Data.
      e. Section 01_78_36 - Warranties and Bonds.
      f. Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
      g. Section 40_73_65 - Pressure Measurement: Submersible.
      h. Section 46_05_10 - Common Work Results for Mechanical Equipment.
      i. Section 46_05_94 - Mechanical Equipment Testing.

1.02 REFERENCES

A. American Bearing Manufacturers' Association (ABMA):
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

C. American Water Works Association (AWWA):
   1. C654 - Disinfection of Wells.

D. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A48 – Standard Specification for Gray Iron Castings.
   3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

4. A276 – Standard Specification for Stainless Steel Bars and Shapes.
5. A283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
6. A516 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service.
7. A536 - Standard Specification for Ductile Iron Castings.
8. A582 - Standard Specification for Free-Machining Stainless Steel Bars.
9. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
10. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
11. F594 - Standard Specification for Stainless Steel Nuts.

E. The Hydraulic Institute (HI):
1. 2.1-2.2 - Rotodynamic (Vertical) Pumps for Nomenclature and Definitions.
2. 2.3 - Rotodynamic (Vertical) Pumps for Design and Applications.
3. 2.4 - Rotodynamic (Vertical) Pumps for Manual Describing Installation, Operations, and Maintenance.
4. 9.1-9.5 - Pumps - General Guidelines for Types, Definitions, Application, Sound Measurement, and Decontamination.
5. 14.6 – Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.

F. National Electrical Manufacturers Association (NEMA).

G. NSF International (NSF):
1. Standard 61 - Drinking Water System Components - Health Effects.

1.03 DEFINITIONS

A. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 2.1-2.2, 2.3, 2.4, 9.1-9.5, and 14.6 and as modified in the Specifications. The pump head and efficiency are evaluated at the outlet of the discharge head and include the net losses in the pump column and discharge.

B. Flow, head, efficiency, and motor horsepower specified in this Section are minimums unless stated otherwise.

C. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric.

D. Tolerances: This Section and related sections contain tolerances that may be more stringent than Hydraulic Institute Standard tolerances. Where tolerances are not mentioned, HI 2.1-2.2, 2.3, 2.4, and 9.1-9.5 shall apply.

1.04 SYSTEM DESCRIPTION

A. Components: Pump, driver, motors, and drive arrangements as specified or as scheduled with shafts, columns, intermediate bearings, seals or packing, couplings, base plates, guards, supports, anchor bolts, necessary valves, gauges, taps, lifting eyes, stands, and other items as required for a complete and operational system.

B. Design requirements:
   1. Pump performance characteristics:
      a. As specified in the Pump Schedule.
      b. Performance tolerances shall be the same as the test tolerances specified in Section 46_05_94.
      c. Pump curve shall be continuously rising throughout the design conditions listed in the pump schedule.
   2. Motor characteristics: As specified in the Pump Schedule.

C. Product requirements as specified in Section 01_60_00 and Section 46_05_10.

1.05 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 46_05_10:
   1. For pumps in contact with Drinking Water application submit one of the following:
      a. Pump certification as specified in Section 01_60_00.
      b. Weighted average lead calculations Section 01_60_00.

C. Shop drawings: As specified in Section 46_05_10.

D. Calculations: As specified in Section 46_05_10:
   1. Torsional analysis: Submit as specified in Section 46_05_10 when scheduled.

E. Vendor operation and maintenance manuals: As specified in Section 01_78_23.

F. Commissioning submittals:
   1. Provide Manufacturer’s Certificate of Source Testing as specified in Section 01_75_17.
   2. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01_75_17.

1.06 QUALITY ASSURANCE

A. General: As specified in Section 01_33_00.

B. Provide pumps specified in this Section from same manufacturer.
   1. Require pump manufacturer to furnish and coordinate pump, driver, drive, and pump components as scheduled and to provide written installation and checkout requirements.

C. Pump manufacturer: Preferred to be ISO 9001 certified.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01_33_00.

1.08 WARRANTY

A. As specified in Section 01_78_36.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:
   1. National Pump Company
   2. Weir/Floway.
   3. Simflo.
   4. Flowserve
   5. American-Turbine
   6. Peerless/Grundfos.

2.02 MATERIALS

A. General:
   1. Materials in the Pump Schedule shall be the type and grade as specified in this Section.

B. Drinking water pumps: Provide materials in conformance with Section 46_05_10.

C. Cast iron: In accordance with ASTM A48, Class 30 minimum.

D. Ductile iron: In accordance with ASTM A536, 65-45-12.

E. Tin bronze: In accordance with ASTM B584, Alloy C90300.

F. Silicon bronze: In accordance with ASTM B584, Alloy C87600.

G. Red bronze: In accordance with ASTM B584, Alloy C83600.

H. Type 416 Stainless Steel: In accordance with ASTM A582.

I. Type 304 Stainless Steel: In accordance with ASTM A276.

J. HDPE: Polyethylene.

K. Steel: In accordance with ASTM A283, Grade D or ASTM A516, Grade 70.

L. Steel pipe: In accordance with ASTM A53, Grade B.

2.03 GENERAL PUMP CONSTRUCTION

A. Type: Industrial, heavy duty, vertical turbine, deep well pumps meeting performance requirements and features as scheduled and as specified.

B. Discharge flange: ASME B16.1 or B16.5 drilled; rated for 1.2 times the pump shutoff head at 150 degrees Fahrenheit.

C. Bearings:
   1. Column shaft bearings to be provided for oil lubrication service with helical grooves cut on the inside of the bearing.

2. Design driver/motor bearings to support the line shaft assembly and rated for ABMA L10 life of 40,000 hours at Design Rated Point flow and head in accordance with ABMA 9 or ABMA 11.
3. Design motor to withstand continuous duty full load thrust and momentary upthrust that may occur during pump on/off or other operations.

D. Fasteners: Provide Type 316 stainless steel fasteners in accordance with ASTM F593 or ASTM F594.

2.04 PUMP SUCTION ASSEMBLY

A. Suction case shall be taper threaded to accept an inlet strainer.

B. A sand collar shall be pressed on or set screwed to the bowl shaft, immediately above the housing.

C. Materials:
1. Suction case: ASTM A48 class 30 cast iron.
2. Suction bearing: Bronze with Buna-N A40 rubber (combination type) or Buna-N A40 rubber (marine).
3. Sand collar: Bronze.
4. Suction plug: Cast iron.
5. Suction strainer: 316SS.

2.05 IMPELLER BOWL ASSEMBLIES

A. Pump impeller assembly:
1. Type: As scheduled in the Pump Schedule.
2. Number of stages: As scheduled in the Pump Schedule.
3. Material: Silicon Bronze.
4. Required balance: As specified in Section 46_05_10 to meet vibration criteria as specified in Section 46_05_94.
5. Method of securing impellers to shafts: Tapered collets or locked by other methods acceptable to the Engineer.
6. Impellers shall be of the enclosed type, cast in one piece, and statically balanced.

B. Provisions for adjustment of axial clearance: Make such adjustment through use of motor adjusting nut or adjustable coupling.

C. Shafts:
1. Material: C-1045 carbon steel.
2. Turned, ground and polished.

D. Intermediate and discharge impeller cases:
1. Material: As scheduled.
2. Attached with bolting.

E. Pump impeller bowl bearings:
1. Provide bearing for each impeller.
2. Materials: Combination bronze/rubber.

F. Discharge and suction bowl bearing:
   1. Provide bronze bearings with self-contained lubrication system filled with graphite type non-soluble grease when grease lubrication scheduled; provide bearing with sand cap.
   2. When service is potable water, provide non-toxic grease approved by the Food and Drug Administration for use in potable water.

G. Design with smooth water passages to reduce clogging by stringy or fibrous materials on impellers or shafting.

2.06 SUCTION ADAPTOR

A. Material: Cast iron.

B. Provide a 316SS strainer.

C. Designed to prevent entrance of abrasive material into the top end of the motor.

2.07 LINE SHAFTS AND ENCLOSING TUBES

A. Provide line shaft type and lubrication type as scheduled and as specified in this Section.

B. Enclosed line shaft, water flush:
   1. Shaft and couplings: Provide threaded shaft couplings.
   2. Shaft bearings and spiders: Provide bearings and retainers as scheduled, but not to exceed 5 feet for bearings and 40 feet for spiders.
   3. Line shaft size: 1-11/16"
   4. Enclosing tube: 2.5-inch - Schedule 80; lengths to be no greater than 5 feet.
   5. Materials: As scheduled; when not scheduled provide:
      a. Shaft: C-1045 carbon steel.
      b. Shaft couplings: Carbon steel.
      c. Shaft bearings: Bronze.
      d. Spiders: Neoprene rubber spider on enclosing tube, spaced at 40 ft.
      e. Enclosing tube: Schedule 80.

C. Strength: Able to withstand minimum 1.5 times maximum operating torque and other loads.

D. Resonant frequency: As specified in Sections 46_05_10 and 46_05_94.

E. Design pump line shafting in interchangeable lengths as scheduled, but not to exceed 20 feet; shaft lengths to match scheduled pump column lengths.

F. Coupling strength: Design driver to pump line shaft coupling of sufficient length and strength to maintain line shaft alignment.

G. Adjustment:
   1. Design a means to adjust shaft position to adjust impeller position.
   2. For motor driven units with hollow shafts, an adjusting nut may be provided at the top of the motor shaft.

2.08 COLUMN PIPE

A. Material: 10-inch (0.312-inch wall) ASTM A53 grade B Butt or Taper Threaded, T&C.

B. Design working pressure: Design to withstand a design working pressure not less than 1.20 times the maximum shutoff total dynamic head with the maximum diameter impeller at the maximum operating speed plus the maximum suction static head.

C. Pressure test: Design to withstand a 5-minute hydrostatic test pressure not less than 1.5 times the design working pressure; perform test at source.

D. Lengths and connections: Design with maximum 20-foot length, or less if scheduled, interchangeable column sections with threaded with registered fit screwed connections as scheduled.

E. Diameter: Design column inside diameter for no more than 4 feet of fluid friction loss per 100 feet of column length.

2.09 PUMP DISCHARGE HEAD ASSEMBLY

A. Design the discharge head for above or base discharge as scheduled.

B. Design the discharge vertical to horizontal flow transition as a smooth pipe elbow or from a minimum of 3 pipe pieces mitered to form the elbow.

C. Design discharge head to mate with the driver as scheduled.

D. Head and base plate construction: Sufficient strength, weight, and thickness to provide accurate alignment, prevent excessive deflection and support the drive motor.

E. Packed assembly at tube tension nut.

F. Discharge vent: Provide 3/4 inch NPT threaded high point vent on discharge; install pipe nipple with threaded gate valves in vent.

G. Materials: As scheduled; when not scheduled, provide:
   1. Pump discharge head/driver stand: Steel, ASTM A283, Grade B and/or ASTM A53, Grade B; or Cast iron, ASTM A48, Class 30 minimum.
   2. Pump discharge head sleeve bearing: ASTM B584, Alloy C93800, high lead tin bronze.

2.10 EQUIPMENT GUARDS

A. Provide equipment safety guards as specified in Section 46_05_10.

2.11 DRIVERS

A. Horsepower:
   1. As scheduled.

2. Listed driver horsepower is the minimum to be supplied.
   a. Increase driver horsepower if required to prevent driver overload while operating at any point of the supplied pump operating head-flow curve including runout.
   b. When scheduled driver is a motor, increase motor horsepower if required to prevent operation in the service factor.
   c. Make all structural, mechanical, and electrical changes required to accommodate increased horsepower.

B. Motors: Provide motors as specified in Section 26_05_09 and as specified in this Section:
   1. NSF Standard 61 certified.
   2. Inverter duty rated per NEMA MG 1 Part 31.
   3. Revolutions per minute: As scheduled in the Pump Schedule.
   4. Enclosure: As scheduled in the Pump Schedule.
   5. Electrical characteristics: As scheduled in the Pump Schedule.
   6. Motor accessories: As specified in Section 26_05_09 and in this Section.

C. Other drivers: As scheduled and as specified in Sections listed in the Schedule.

D. Non-reverse ratchets: Provide driver with non-reverse ratchet or pin mechanism to prevent reverse rotation of the pump and driver in the event of discharge valve failure.

2.12 SUPPORTS

A. Strength: Design pump discharge head and driver (motor or engine) supports to withstand a minimum of 1.5 times the maximum imposed operating loads or the imposed seismic loads, whichever is greater.

B. Resonant frequency: Design supports in conjunction with the pump, shafting, drivers, bearings, and other components to avoid natural resonant frequencies, either torsional, radial, or axial as specified in Section 46_05_94.

C. Coordinate pump and drive system supports with the foundation designs as indicated on the Drawings.

2.13 ACCESSORIES

A. Pressure transmitter enclosing tube:
   1. The pressure transmitter enclosing tube shall be 1-1/4-inch Schedule 80, NSF-PW PVC (polyvinyl chloride) plastic pipe.
      a. The PVC pipe shall be furnished in 1-1/4-inch I.D., color-gray, 20 feet – 0 inches foot joints with bell and spigot ends for PVC cement-solvent welding.
      b. Tube shall be strapped to the pump column pipe every 30 feet with stainless steel bands.
      c. Access tube shall extend to the top of the pump bowls (approximate depth of 300 feet). The access tube shall extend through the sole plate and be fitted with a threaded cap.

B. Metal enclosure:
   1. Enclosure base dimensions shall be 48 in x 48 in.

2. Enclosure height shall be sized to accommodate the pump discharge head and motor with a minimum of 18 in between top of motor and apex of shed roof.
3. Enclosure shall be equipped with multiple lifting eyes to remove the shed for well maintenance.
4. Enclosure shall be designed to allow the 10 in discharge pipe through enclosure wall.
5. Venting shall be included to allow airflow through enclosure.
6. Manufacturer:
    a. RS Industries or equal.
7. Color: Per client recommendation
8. Performance requirement:
    a. Maximum 70 dBA at 10 ft.

2.14 FINISHES

A. Apply coatings in accordance with manufacturer's instructions, except as specified in 2.15.B below.

B. Apply coatings to discharge head and motor as specified in Section 09_96_01.

2.15 SOURCE QUALITY CONTROL

A. Witnessing: Source or factory testing shall be witnessed by the Engineer or Owner when scheduled; provide advanced notice of source testing as specified in Section 46_09_54.

B. Equipment performance test: Test level as scheduled; test as specified in Section 46_09_54.

C. Vibration test: Test level as scheduled; test as specified in Section 46_09_54.

D. Motor factory tests: Test as specified in Section 26_05_09.

E. Hydrostatic pressure tests: As specified for components in this Section.

PART 3 EXECUTION

3.01 STERILIZATION

A. Disinfection procedures shall be in accordance with AWWA C654.

B. The water discharged by the pump following disinfection shall be dechlorinated to a level of 2.0 or less milligrams per liter chlorine before it is allowed to leave the site.

3.02 COMMISSIONING

A. As specified in Section 01_75_17 and this Section.

B. Manufacturer services:
1. Provide certificates:
    a. Manufacturer's Certificate of Source Testing.
    b. Manufacturer's Certificate of Installation and Functionality Compliance.

2. Manufacturer's Representative onsite requirements:
   a. Functional Testing and Operation & Maintenance Training: 1 trip, 4 hours minimum.
3. Process operational period:
   a. As required by Owner or Contractor.

C. Source testing: As specified in Pump Schedule.

D. Functional testing: As specified in Pump Schedule.

Tag Numbers	**PMP-130**	**PMP-230**
	J Street Well Pump	**Alpine Well Pump**
General Characteristics:		
Application	Drinking Water	Drinking Water
Service	Raw Well Water	Raw Well Water
Quantity	1	1
Inner / Outer Casing Diameter at land surface, inches	--	--
First Named Manufacturer's Model Number	--	--
Maximum Noise, dBA at 3 feet	85	85
Torsional Analysis	Not Required	Not Required
Minimum Pumped Fluid Degrees Fahrenheit		
Normal Pumped Fluid Degrees Fahrenheit		
Maximum Pumped Fluid Degrees Fahrenheit		
Estimated static water level to surface, feet	200	200
Estimated pumping water level to surface, feet	255	255
Estimated discharge static head above surface, feet of water	150	150
Column pipe, airline and pressure transducer setting, feet below surface	300	300
Pump Characteristics:		
Number of Stages	Per Manufacturer	Per Manufacturer
Impeller type	Enclosed	Enclosed
Pump Impeller Bowl Bearing Lubrication	Grease	Grease
Suction Strainer	Stainless Steel	Stainless Steel
Line Shaft Type	Enclosed	Enclosed
Minimum Line Shaft Bearing Spacing, Feet	5	5

Tag Numbers	PMP-130	PMP-230
	J Street Well Pump	**Alpine Well Pump**
Line Shaft Lubrication	Food Grade Oil	Food Grade Oil
Column Connection Type	Threaded	Threaded
Maximum Column Section Lengths, Feet	20	20
Coupling Type	Threaded	Threaded
Maximum diameter pump bowl assembly, inches	--	--
Column pipe internal diameter, inches	10	10
Speed Control	Variable Speed	Variable Speed
Maximum Pump rpm	1,770	1,770
Rated Design Point (at Maximum Revolutions per Minute):		
Flow, gpm	1400	1100
Head, Feet	408	412
Minimum Efficiency, Percent	80	80
Other Conditions:		
Minimum Shut Off Head, Feet	--	--
Maximum NPSHr at every Specified Flow, Feet	--	--
Pump Materials:		
Suction Bearing	Marine (rubber only)	Marine (rubber only)
Impeller Cases	Cast iron	Cast iron
Impeller (enclosed)	CDAH76 bronze	CDAH76 bronze
Impeller Bearing	Marine or bronze	Marine or bronze
Impeller Shaft Key or Collet	316 Stainless Steel	316 Stainless Steel
Bowl Shaft	416 Stainless Steel	416 Stainless Steel
Line Shaft	C-1045 Carbon Steel	C-1045 Carbon Steel
Line Shaft Coupling	Carbon Steel	Carbon Steel
Line Shaft Bearings	Bronze	Bronze
Shaft Enclosing Tube	Schedule 80 Steel Pipe	Schedule 80 Steel Pipe
Column Material and Thickness, Inch or Schedule	Steel Pipe, 0.312	Steel Pipe, 0.312
Discharge Head/Driver Stand	A36 & A53 gr. B or APE X42 steel or Cast Iron	A36 & A53 gr. B or APE X42 steel or Cast Iron

Tag Numbers	PMP-130	PMP-230
	J Street Well Pump	**Alpine Well Pump**
Driver Characteristics:		
Driver Type	Motor	Motor
Drive Arrangement	Vertical, Coupled	Vertical, Coupled
Non-Reverse Ratchets	Required	Required
Minimum Driver rpm	1800	1800
Minimum Driver Horsepower	200	200
Motor Characteristics (when motor is driver type):		
Inverter Duty Rated	Yes	Yes
Motor Voltage/Phase/Hertz	460/3/60	460/3/60
Enclosure Type	WP I	WP I
Service Factor	1.0	1.0
Source Testing:		
Test Witnessing	Not Witnessed	Not Witnessed
Performance Test Level	1	1
Vibration Test Level	Not Required	Not Required
Noise Test Level	Not Required	Not Required
Functional Testing:		
Performance Test Level	3	3
Vibration Test Level	1	1
Noise Test Level	Not Required	Not Required

END OF SECTION

SECTION 43_33_30.01

LIQUID CHEMICAL SOLENOID METERING PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Positive displacement, solenoid metering pumps for pumping chemical solutions, complete with drives, controls, and features specified and scheduled in this Section.

B. Tag numbers: As specified in Pump Schedule.

C. Related section:
1. Section 01_33_00 - Submittal Procedures.
2. Section 01_60_00 - Product Requirements.
3. Section 01_75_17 - Commissioning.
4. Section 01_78_23 - Operation and Maintenance Data.
5. Section 01_78_36 - Warranties and Bonds.
6. Section 01_81_02 - Seismic Design Criteria.
7. Section 10_14_00 - Signage.
8. Section 40_05_06.10 - Strainers and Filters.
9. Section 40_05_63 - Ball Valves.
10. Section 40_05_67.37 - Pressure Reducing and Pressure Relief Valves.
11. Section 40_61_00) - Common Work Results for Process Control and Instrumentation Systems.
12. Section 40_61_16 – Specific Control Strategies.
13. Section 40_73_13 - Pressure/Vacuum Measurement: Gauges.
14. Section 40_73_36 - Pressure/Vacuum Measurement: Switches.
15. Section 40_73_63 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals.
16. Section 46_05_10 - Common Work Results for Mechanical Equipment.

1.02 REFERENCES

A. International Society of Automation (ISA):
1. ISA5.4 - Instrument Loop Diagrams.

B. National Electrical Manufacturer's Association (NEMA):
1. 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).

C. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.

1.03 DEFINITIONS

A. NEMA: Type 4X enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. General: Provide solenoid actuated, positive displacement, diaphragm type chemical metering pumps, accessories, and other items required for a complete and operational system. Each chemical metering pump system shall include, but not be limited to, the following items, which shall be supplied by the chemical metering pump manufacturer except as noted.
   1. Pumps.
   2. Pulsation dampeners.
   3. Calibration columns.
   4. Diaphragm back pressure valves.
   5. External pressure relief valves.

B. Fluid characteristics:
   1. Sodium hypochlorite:
      a. Dry chemical formula: NaOCl.
      b. Solution concentration: 12.5 percent by weight.
      c. Solution pH: 9.
      d. Solution specific gravity: 1.1 to 1.3.

C. Design requirements:
   1. Pump performance characteristics: As specified in Pump Schedule in this Section. Dry self-priming, capable of being run dry without damaging effects to pump.
   2. Positive flow shall be ensured by a minimum of 4 ball-type check valves and valve functions for pressure relief, backpressure, anti-siphon, air bleed, and discharge drain.
   3. The pumps shall be suitable for operation with the chemicals specified below under performance requirements.
   4. All solenoid metering pumps shall be especially designed, adapted, and fully guaranteed for the respective, intended use.

D. Performance requirements:
   1. Systems shall deliver the pressures and volumes listed for their respective services in the Pump Schedule in this Section.

E. Product requirements as specified in Section 01_60_00 and Section 46_05_10.

1.05 SUBMITTALS

A. Submit as specified in Section 01_33_00.

B. Product data: As specified in Section 46_05_10.
   1. Provide all safety considerations relating to operations and handling of the associated chemical.
   2. Maintenance data shall include all information and instructions required by plant personnel to keep equipment properly cleaned and adjusted so that it functions economically throughout its full design life.
   3. Name, address, and phone number of manufacturer and manufacturer's local service representative.

C. Shop drawings:
1. Provide a list of parameters, ratings, or other characteristics where the proposed chemical feed systems deviate from the requirements.
2. Dimensions, materials of construction, size, weight, and performance data.
3. Drawings: Provide electrical and instrumentation drawings showing coordination with electrical control devices operating in conjunction with the associated feed system.
4. Dimensioned inlet and outlet connections.
5. Current NSF 61 Certification for components to be in contact with associated chemical or potable water.
6. Provide data showing chemical compatibility and history of service with the associated chemical for materials in the system.
7. Control panel shop drawings:
   a. Control panel views showing equipment arrangement, doors, equipment layout inside the panel and dimensional information.
   b. Internal interconnecting wiring diagrams showing terminal strips and external devices connected to the panel as specified in Section 40_61_00.
   c. Loop drawings for analog and discrete signals in accordance with ISA5.4.
   d. Complete schematic and diagrams including terminal block and wire identification numbers and device location symbols consistent with the Contract Documents.
   e. Panel bill of material with detailed description of components and equipment data sheets.
8. Field cable numbers and terminations.

D. Shop drawings: As specified in Section 46_05_10.
1. Electrical and control drawings.

E. Calculations: As specified in Section 46_05_10.
1. For each pump type, submit calibration charts and tables relating flow rate to stroke length and stroke rate.
2. Confirm scheduled values or recommend new pressure setpoints for the backpressure valves and pressure relief valves listed in the Pump Schedule.
3. Submit calculations recommending dimensions of pulsation dampener indicated on the Drawings.
4. Calibration curves for each pump relating potentiometer reading to flow rate shall be supplied.
   a. Capacity control shall be 0 to 100 percent with delivery repeatable within plus or minus 1 percent accuracy over at least a 10 to 1 range.
   b. Motor and VFD supplier shall carefully review the intended application of the VFD and certify in writing that sizes provided are adequate for continuous or intermittent operations (whichever is the most severe operating condition.

F. Vendor operation and maintenance manuals: As specified in Section 01_78_23.

G. Commissioning submittals:
1. Provide Certificate of Source Testing as specified in Section 01_75_17.
2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17.
3. Provide manufacturer's certificate stating that the materials of construction are compatible with the pumped fluid.

1.06 DELIVERY, STORAGE AND HANDLING

A. Packing, shipping, handling and unloading:
   1. Pack for shipping and outdoor storage at the project site for up to 6 months.
   2. Ship all pumps and drives completely assembled.
   3. Deliver spare parts at same time as equipment. Deliver to Owner after completion of the work.

1.07 WARRANTY

A. Provide warranty as specified in Section 01_78_36.

PART 2 PRODUCTS

2.01 GENERAL

A. A single pump manufacturer shall furnish and coordinate all drives and pump components specified in this Section, calibration columns and other specified accessories and appurtenances to ensure compatibility and integrity of the individual components.

B. The manufacturer of the pumps shall have sole-source responsibility for furnishing the complete assemblies and meeting the specified performance requirements.

2.02 PUMPS

A. Manufacturers: All solenoid metering pumps shall all be of the same manufacturer. One of the following or equal:
   a. ProMinent, Delta Series
   b. Wallace & Tiernan, Premia 75 Micro Series.
   c. Walchem, EHE Series.

B. Equipment:
   1. Type: Simplex chemical proportioning pumps of the positive displacement diaphragm type.
   2. Materials:
      a. Flat, composite, mechanically actuated diaphragms shall be Hypalon, Viton, EPDM or PTFE faced as pump manufacturer deems suitable for the pumped liquid, fiber reinforced and bonded to an elastomeric support with a Type 316 stainless steel backing plate.
      b. All other wetted parts shall be PVDF, Teflon, PVC or other suitable thermoplastic material.
      c. All other non-specified materials are to be manufacturer's standard, for continuous service with the specified pumped liquids.
      d. Manufacturer shall submit the materials for each component to be used for each chemical service with record of service with same chemical.
   3. Characteristics: Chemical proportioning pumps of the positive displacement, non-hydraulic, solenoid driven, diaphragm type. Pump shall be water resistant for outdoor installation, and internally dampened for noise reduction.
      a. Pumps for sodium hypochlorite service shall be equipped with an off-gassing valve.

b. Liquid end of each metering pump shall be fitted with a system to detect early stage diaphragm failure. Upon actuation, the leak detector shall STOP the pump, light a locally visible LED and sound a remote alarm.

4. Components:
   a. Electronically controlled stroke controllers.
   b. Suction and discharge double check valves.
   c. Built-in internal or external, adjustable pressure relief valve to relieve pressure in the event of discharge line stoppage; which shall be factory set to relieve at manufacturer's recommended pressure limit.
5. Accessories: As indicated on the Drawings, pumps shall be equipped with:
   a. Calibration column in suction piping.
   b. Diaphragm backpressure valve, pulsation dampener, and pressure relief valve in discharge piping.
6. Tests and inspections:
   a. As scheduled in this Section.

2.03 ELECTRONIC DRIVE

A. Characteristics: Electric drive shall have the following characteristics:
   1. All metering pumps shall operate with 120 VAC single-phase power.
   2. Solenoid shall have automatic reset thermal overload protection, and be rated for continuous or intermittent duty, whichever is the most severe condition.
   3. Pump control panel shall have an accessible, resettable circuit breaker which provides circuit overload protection.
   4. Internal wiring between electronic circuit board, solenoid, and power shall be quick disconnect terminal at least 3/16 inch wide.
   5. The electronic circuitry shall be EMI resistant and shall employ a metal oxide varistor for lightning protection.
   6. Pump shall automatically stop pulsing when the discharge pressure exceeds pump pressure rating by not more than 35 percent with the pump at maximum stroke rate.

2.04 CONTROLS

A. Provide chemical metering pump control indicated on the Drawings and as specified in Sections 40_61_16.

B. Each metering pump shall be provided with:
   1. Manual stroke controller, graduated in 2 percent increments, to adjust the capacity from 0 to 100 percent while the pump is operating, and having a locking mechanism.
   2. Electronic automatic stroke controller.
   3. Stroke controller shall include a digital stroke length indicator, calibrated from 0 to 100 percent.

C. Control functions shall include manual, external pulse input 4-20 mA and stop. Controller shall be capable of dividing or multiplying pulse inputs. A single relay control signal output shall be provided to allow for interfacing the pump with external equipment.
   1. For all operating modes, a green indicator light on the control panel shall illuminate when pump is in operation and strobe once for each stroke. In all

operating modes, a red indicator light on the control panel shall illuminate when pump operation is halted via the stop function.

2. Stop: A non-voltage contact closure to the stop function shall cause the pump to halt operation, in either manual or automatic mode, and illuminate a red indicator light on the control panel. Pump shall resume normal operation when the contact opens.
3. Pulse input: Pump shall have the capability of being paced by pulse rates up to 125 contacts per minute.
4. Manual control: Pump control shall be selectable between ON and OFF by means of a 2-position switch. Stroke rate shall be infinitely adjustable from 1 to 100 percent.

D. Locate panel near the chemical metering pumps as indicated on the Drawings.

E. Provide a sunshade for the entire panel when located outside.

2.05 ACCESSORIES

A. Pulsation dampeners:
1. Manufacturers: One of the following or equal:
   a. Kemlon Products.
   b. Blacoh Fluid Controls, Inc.
   c. Pulsafeeder.
2. Pulsation dampeners shall be furnished and installed on each chemical metering pump’s discharge lines as indicated on the Drawings and scheduled in this Section.
3. Materials:
   a. Diaphragms shall be Hypalon.
   b. Chamber shall be PVC or PVDF
   c. Materials shall be compatible with the pumped liquid at the specified concentration, and suitable for outdoor use and exposure.
4. Pulsation dampener shall be provided/designed by the pump manufacturer.
5. Pulsation dampeners shall allow no more than 6 percent discharge pressure fluctuation.
6. Pulsation Dampeners shall be mounted within 6 feet of the pump discharge port and upstream of associated flow meters. No other equipment shall be installed between the discharge pulsation dampener and pump.
7. Dampener shall be provided with a true-union ball valve for shutoff.

B. Calibration columns:
1. Materials:
   a. Materials shall be compatible with the pumped liquid and concentration specified in this Section, and suitable for outdoor use and exposure.
2. Characteristics:
   a. Furnish and install calibration columns, 1 for each chemical metering pump, on each chemical pump’s inlet line as indicated on the Drawings and specified in this Section. Columns shall be translucent.
   b. Provide top cap threaded connection with vent piped to floor to prevent entry of foreign materials and to direct spillage or overflow.
   c. End connections shall be threaded.
   d. Capacities and graduations shall be as shown in the schedule in this Section.

C. Diaphragm backpressure valves and pressure relief valves:
   1. As specified in Section 40_05_67.37.
   2. Manufacturer: One of the following or equal:
      a. Wallace and Tiernan.
      b. Pulsafeeder.
      c. Griffco.
   3. Materials:
      a. Valves shall be of suitable materials for the pumped liquid.
   4. Characteristics:
      a. Ported to serve as either a backpressure valve or a pressure relief valve.
      b. Valves shall have an adjustable spring range of 25-175 pounds per square inch. Valves shall be factory adjusted for the backpressure recommended by the pump manufacturer.
      c. Valves shall produce a back pressure no greater than 10 pounds per square inch above valve set pressure when metering pumps are operating at full capacity, pulsating flow.
   5. Relief valves shall be plumbed to the nearest chemical drain, or back to the pump suction on the non-pump side of the pump suction isolation valve, to avoid spillage, as indicated on the Drawings.
   6. Valves shall be furnished and installed on each chemical metering pump's discharge lines as indicated on the Drawings and scheduled in this Section.
   7. As an alternative to separate backpressure and pressure relief valves, each metering pump may be supplied with a multi-function valve. The valve shall perform the following functions: Pressure relief, back pressure, anti-siphon, pump head air bleed, and discharge drain. Multi-function valve shall be from the pump manufacturer with the proper materials of construction selected and design features made specifically for its intended chemical service.

D. Pressure relief valves:
   1. Furnish and install pressure relief valves on each chemical metering pump's discharge line as indicated on the Drawings.
   2. Materials:
      a. Wetted materials shall be compatible with the pumped liquid.
   3. Characteristics:
      a. Valves shall have an adjustable spring range of 25-175 pounds per square inch. Valves shall be factory adjusted for the relief pressure recommended by the pump manufacturer.

E. Additional accessories:
   1. Additional accessories required for the system but not required to be supplied by the pump manufacturer include:
      a. Diaphragm seals as specified in Section 40_73_63, except as modified in this Section:
         1) Materials shall be compatible with the pumped liquid at the specified concentration and suitable for outdoor use and exposure.
      b. Pressure switches as specified in Section 40_73_36.
      c. Pressure gauges as specified in Section 40_73_13.
      d. Isolation valves as specified in Section 40_05_63 for suction and discharge piping as indicated on the Drawings.
      e. Strainers as specified in Section 40_05_06.10 for suction piping as indicated on the Drawings.

2.06 SPARE PARTS

A. Spare parts:
   1. Furnish the following spare parts packed and labeled for warehouse storage:
      a. 1 complete spare parts kit as recommended by the manufacturer for each pump provided.
      b. 1 spare parts kit for each size and type of backpressure and pressure relief valve.

PART 3 EXECUTION

3.01 INSTALLATION

A. Alignment of piping may vary from that indicated on the Drawings to suit the equipment furnished, without additional cost to Owner.

B. Contractor shall provide non-metallic unistrut piping supports to adequately support piping, valves, and accessories.

3.02 IDENTIFICATION

A. Identification of the health, flammability, and reactivity of hazardous materials shall be affixed to each chemical storage tank, as specified in Section 10_14_00.

3.03 COMMISSIONING

A. As specified in Section 01_75_17 and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer’s Certificate of Source Testing.
      b. Manufacturer’s Certificate of Installation and Functionality Compliance.
   2. Manufacturer’s Representative onsite requirements:
      a. Installation: 1 trip, 5 day minimum.
      b. Functional Testing: 2 trips, 2 day minimum each.
   3. Training:
      a. Maintenance: 4 hours per session, 2 sessions.
      b. Operation: 2 hours per session, 2 sessions.
   4. Process operational period:
      a. As required by Owner or Contractor.

C. Source testing: As specified in Pump Schedule.

D. Functional testing: As specified in Pump Schedule.

3.04 SCHEDULES

A. Pumps:

Tag Number	**PMP-153, PMP-154 PMP-253, PMP-254**	**PMP-151, PMP-152 PMP-251, PMP-252**
Feed Point	Booster Pump Discharge	Well Discharge
Service	Sodium Hypochlorite	Sodium Hypochlorite
Pump Type	Solenoid Actuated	Solenoid Actuated
Number of Pumps	4	4
Named Manufacturer	Prominent	Prominent
Named Manufacturer Model	Delta 1020	Delta 1020
Pump Characteristics		
Design conditions:		
Maximum Flow, (gallons per hour)	5.5	5.5
Minimum Flow, (gallons per hour)	0.3	0.3
Normal Flow, (gallons per hour)	1.1	1.2
Pump Stroke Range (spm)	1-200	1-200
Maximum Discharge Pressure (psig)	145	145
Minimum Suction Lift (feet)	10	10
Relief Valve Setting (psig)	90	90
Pump Materials		
Pump Housing/Enclosure	PVDF	PVDF
Diaphragm	PTFE	PTFE
Valve Seat	PTFE	PTFE
Valve Seals	PTFE	PTFE
Valve Balls	Ceramic	Ceramic
Driver Characteristics		
Driver Type	Solenoid	Solenoid
Maximum Driver Speed (spm)	200	200
Service Factor	1.0	1.0
Voltage/Phases/Hertz	120/1/60	120/1/60
NEMA Enclosure Type	4X	4X

Source Testing		
Test Witnessing	Not Witnessed	Not Witnessed
Performance Test Level	None	None
Vibration Test Level	None	None
Noise Test Level	None	None
Functional Testing		
Performance Test Level	1	1

1. Provide pumps that deliver the maximum capacity, listed in the above table, when at full speed and maximum stroke length.

END OF SECTION

SECTION 43_41_65

STRAND-WOUND CIRCULAR PRESTRESSED CONCRETE TANK WITH A TYPE I CORE WALL AND FLAT ROOF

PART 1 GENERAL

1.01 SUMMARY

A. Work includes:
   1. This section specifies the design and construction of an AWWA D110, Type 1, strand-wrapped circular prestressed concrete tank, furnishing, installation, testing, and disinfection. The tank shall consist of: foundation, underdrain system, concrete membrane floor slab, cast-in-place concrete core wall, cast-in-place concrete roof support columns and drop panels, flat cast-in-place concrete roof slab, and all associated appurtenances. The core wall shall be vertically post-tensioned with thread bars, prestressed circumferentially with machine-wrapped seven-wire galvanized strand, and protected with several coats of shotcrete. The foundation shall be constructed with continuous shallow concrete spread footings below the perimeter wall. The column footings shall be spread footings that are cast on top of the concrete floor. The concrete floor shall be constructed with a concrete slab on grade.
   2. In the event of a discrepancy between this section of the Specifications and any other section of the Specifications, this section shall govern.
   3. The Tank Contractor shall furnish all labor, materials, tools, and equipment necessary to design, construct, disinfect, and test the prestressed concrete tank.

B. Related sections:
   1. Section 01_41_00 - Regulatory Requirements.
   2. Section 01_75_18 – Disinfection.
   3. Section 01_75_19 – Water Leakage Test for Concrete Structures.
   4. Section 03_11_07 - Concrete Formwork.
   5. Section 03_15_00 - Concrete Accessories.
   6. Section 03_20_00 - Concrete Reinforcing.
   7. Section 03_30_00 - Cast-In-Place Concrete.
   8. Section 03_64_24 - Epoxy Injection System.
   9. Section 09_97_24 - Painting Prestressed Concrete Water Tanks.

1.02 REFERENCES

A. Abbreviations:
   1. cfm - cubic feet per minute.
   2. f'c - specified compressive strength of concrete.
   3. g - gravitational constant, equal to 32.2 feet per second squared.
   4. gpm - gallons per minute.
   5. ksi - kips per square inch.
   6. MG - million gallons.
   7. mph - miles per hour.
   8. pcf - pounds per cubic foot.
   9. psf - pounds per square foot.

10. psi - pounds per square inch.
11. PVC - polyvinyl chloride.
12. sec - seconds.

B. Definitions:
   1. Core Wall - That portion of the concrete tank wall that is circumferentially post-tensioned.
   2. Prestressed Concrete - Concrete in which internal compressive stresses of such magnitude and distribution have been introduced through post-tensioning to offset tensile stress development from service loads.
   3. Prestressing Reinforcement - High-strength steel used to prestress the concrete tank wall.
   4. Rebound - The shotcrete material that ricochets off of the receiving surface and falls.
   5. Shotcrete - Pneumatically applied wet mortar or concrete used for embedment protection of the circumferential prestressed wall reinforcement.
   6. Strand - A symmetrically arranged and helically twisted assembly of seven high-strength steel wires used for prestressing reinforcement or as nonprestressed seismic cables.
   7. Stressing Machine - May refer to the automated wrapping machinery used to post-tension the strand around the tank circumference or vertical post-tensioning equipment used to post-tension vertical thread bars.
   8. Tank Contractor - A qualified tank manufacturer and/or contractor that specializes in the design and construction of an AWWA D110 type of tank specified herein.
   9. Tendon - High-strength thread bar, including end anchorages, used to impart vertical prestressed forces to the tank wall.
   10. Wire - High-strength, cold-drawn steel wire used to assemble strands.

C. Reference Standards:
   1. American Concrete Institute (ACI):
      a. ACI 301-16 - Specifications for Structural Concrete, 2016.
      b. ACI 305.1-14 - Specification for Hot Weather Concreting, 2014.
      c. ACI 306.1-90 - Standard Specification for Cold Weather Concreting, 1990.
      d. ACI 350-06 - Code Requirements for Environmental Concrete Structures and Commentary, 2006.
      e. ACI 350.1-10 - Specification for Tightness Testing for Environmental Engineering Concrete Containment Structures and Commentary, 2010.
      f. ACI 350.3-06 - Seismic Design of Liquid-Containing Concrete Structures and Commentary, 2006.
      g. ACI 350.5-12 - Specifications for Environmental Concrete Structures, 2012.
      h. ACI 372R-13 – Design and Construction of Circular Wire- and Strand-Wrapped Prestressed Concrete Structures, 2013.
      i. ACI 506R-16 - Guide to Shotcrete, 2016.
      j. ACI 506.2-13 – Specification for Shotcrete, 2013.
   2. ASTM International (ASTM):
      a. A 185 - Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
      b. A 416 - Standard Specifications for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.
      c. A 475 - Standard Specification for Zinc-Coated Steel Wire Strand.

d. A 615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
e. A 706 - Standard Specification for Low-Alloy Deformed and Plain Bars for Concrete Reinforcing.
f. A 722 - Standard Specification for Uncoated High-Strength Steel Bars for Prestressed Concrete.
g. C 33 - Standard Specification for Concrete Aggregates.
h. C 150 – Standard Specification for Portland Cement.
i. C 171 - Standard Specification for Sheet Materials for Curing Concrete.
j. C 618 - Type F Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
k. D 570 - Standard Test Method for Water Absorption of Plastics.
l. D 624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
m. D 638 – Standard Test Method for Tensile Properties of Plastics.
n. D 746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
o. D 747 - Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.
p. D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
q. D 1056 - Standard Specification for Flexible Cellular Materials- Sponge or Expanded Rubber.
r. D 2000 - Standard Classification System for Rubber Products in Automotive Applications.
s. D 2240 - Standard Test Method for Rubber Property-Durometer Hardness.

3. American Society of Civil Engineers (ASCE):
   a. 7-10 - Minimum Design Loads for Buildings and Other Structures.
4. American Water Works Association (AWWA):
   a. C652 - Standard for Disinfection of Water-Storage Facilities.
   b. D110-13 - Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks, 2013.
5. Code of Federal Regulations (CFR):
   a. Part 1910 – Occupational Safety and Health Standards (OSHA).
6. NSF International (NSF):
   a. 61 - Drinking Water System Components - Health Effects.
7. U. S. Army Corps of Engineers (USACE):
   a. CRD C 572 - Corps of Engineers Specifications for Polyvinylchloride Waterstop.

1.03 SUBMITTALS

A. Product data:
1. Waterstops:
   a. Submit samples, prints, and complete physical property data covering waterstops.
   b. Laboratory test reports: Submit reports indicating that average properties of polyvinyl chloride waterstops material and finish conform to requirements specified in this Section.
2. Epoxy grouting equipment: Submit product information.
3. Neoprene bearing pads: Submit product information.

4. Stressing machine:
    a. Submit a description of the proposed equipment.
    b. Submit calibration reports for force recording equipment used installation of vertical thread bars and circumferential prestressing.

B. Shop drawings:
    1. Drawings showing all plan views, sections, and details of the tank construction, including, but not limited to, all structural elements, all appurtenances, connections, joints, waterstop, roof hatches, vents, ladders, fall arrest and protection systems, guardrails, piping, pipe penetrations, pipe supports, sub-grade preparation, base liners, tank instrumentation, and materials for roof drainage and conductance.

    2. Drawings of entire prestressing operation showing vertical thread bar and circumferential strand placement with associated schedules and intermediate lock-off elevations, prestressing bar and strand size, ducts for vertical thread bars, and anchorage details.
    3. Drawings for placement and detailing of all reinforcing steel.
    4. Drawings showing:
        a. Neoprene bearing pads and methods of pad installation.
        b. Waterstop and methods of installation.
        c. Sponge filler pads or sleeves and methods of installation.
        d. Exterior coating system.
    5. All shop drawings shall be signed and sealed by a registered California structural or civil engineer.

C. Design Submittals:
    1. Structural calculations for all aspects of the structural design of the tank, along with calculations for prestressing reinforcement, elongation estimates, soil capacity checks, and calculations for any other structural design aspect.
    2. Concrete mix designs in accordance with Specification 03_30_00 and additional provisions specified herein.
    3. Shotcrete mix designs in accordance with the provisions specified herein.
    4. Admixtures to be used in the concrete and/or shotcrete and their purpose.
    5. All design submittals shall be signed and sealed by a registered California structural or civil engineer.

D. Tank responsibility statement:
    1. The Tank Contractor shall submit a statement attesting that they have assumed responsibility for the tank design and construction. The statement shall be signed and sealed by the Tank Contractor’s engineer-in-responsible-charge of the tank design. No other submittal items will be reviewed until a satisfactory statement has been received.

E. Qualifications statement:
    1. Failure to submit a qualifications statement package will be deemed an irregularity, which will cause bid to be rejected as nonresponsive.
    2. Submit pertinent information that demonstrates conformance with Quality Assurance requirements specified herein.
    3. To include:
        a. Company history, contact person(s), address, and telephone number.
        b. Project references with owner and engineer’s contact information.

c. Name and work history of the on-site project manager to be assigned to the project.

F. Quality control submittals:
   1. Certificates of Compliance:
      Thread Bars: Submit certified test reports that verify bars and anchorage meet specified material standards.
      a. Waterstop: Submit certificates certifying that waterstops provided on this project meet or exceed physical property requirements of current USACE CRD C 572.
      b. Circumferential prestressing: Submit certified test reports for each size, heat, and reel that verify conformance to applicable ASTM standards for materials, strength, and yield properties.

G. Test reports:
   1. Strand and vertical thread bar prestressing records.

H. Manufacturer's instructions:
   1. Tank appurtenances: Submit manufacturer’s installation instructions.

I. California Department of Public Health (CDPH) Requirements:
   1. All materials used in or on the concrete for the water tank, including but not limited to cement, potable water, admixtures, and aggregate, shall be compliant with NSF 61.
      a. Submit the letter from NSF certifying compliance with standard 61.

1.04 NON-RESPONSIVE BID

A. Qualifications statement package:
   1. Submit a qualifications statement package with the bid. The package shall contain information as required per Section 1.03.E.
   2. Failure to submit a qualifications statement package will be deemed an irregularity that may cause bid to be rejected as non-responsive.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Singular Responsibility:
      a. It is the intent of these Specifications to create singular responsibility for design, construction, and performance of the prestressed concrete tank. The design and construction of all aspects of the foundation, floor slab, core wall, columns, prestressing, shotcrete, and roof of the tank shall be performed by the Tank Contractor.
         1) No portion of the work on the tank shall be subcontracted unless:
            a) Prior acceptance is obtained from the Engineer; and
            b) The Tank Contractor’s on-site project manager personally supervises the work of any subcontractors and their personnel.
      b. If the Tank Contractor believes that any requirement of this Section represents a departure from its normal recommendations that will affect the quality or performance of the tank, notify the Engineer in writing of such concerns. For each provision of concern, cite the relevant

paragraphs of this Section and indicate the Tank Contractor's recommended modifications or alternatives to those provisions.

1) Acceptance of Tank Contractor's alternatives shall be at the discretion of the Engineer, and the decision of the Engineer shall be final.

2. The specified tank shall be designed and constructed by a single Tank Contractor. The Tank Contractor shall be experienced in the design and construction of circumferentially prestressed tanks with cast-in-place concrete core wall sections using freed neoprene bearing pad connections at the top and base of the wall, PVC waterstops, seismic cables placed between the wall and the foundation, and a flat supported concrete roof deck.
   a. No Tank Contractor is considered qualified unless it has designed and built the following projects in its own name:
      1) At least twenty circumferentially prestressed concrete tanks with flat concrete roofs conforming to AWWA D110, Type I in the last ten years.
      2) At least ten circumferentially prestressed concrete tanks with flat concrete roofs conforming to AWWA D110, Type I used for potable water storage that have been in successful operation for at least five years.
      3) At least five circumferentially prestressed concrete tanks with flat concrete roofs conforming to AWWA D110, Type I that are 1.5 MG or larger in the last ten years.
   b. The Tank Contractor shall have in its employ a design engineer with a minimum of ten years of experience in the design of AWWA D110 Type I tanks with flat concrete roofs. The design engineer shall have been the engineer of record for a minimum of ten AWWA D110 Type I tanks designed for and constructed by the Tank Contractor in its own name. The design engineer shall be licensed as a civil or structural engineer in the state of California.
   c. The Tank Contractor shall have in its employ for this project a team consisting of an on-site project manager, concrete foreman, shotcrete foreman, shotcrete nozzleman, and prestressing foreman, each of whom shall have constructed in the last ten years a minimum of five AWWA D110 Type I tanks with flat concrete roofs having a capacity of 1.5 MG or greater.
      1) Experience gained on shotcrete pool and ditch construction will not be considered as qualifying experience for nozzleman.
      2) Skill of nozzleman:
         a) Capable of applying thin coats of even and uniform thickness.
         b) Certified shotcrete nozzleman in accordance with ACI 506R.
3. Experience in the design and construction of AWWA D110 Type II, Type III, or Type IV tanks will not be accepted as demonstrating the qualifications required by the preceding paragraphs.

1.06 DESIGN CRITERIA

A. Except as modified herein, the prestressed concrete tank shall be designed and constructed in compliance with the provisions of AWWA D110 for strand-wound circular, prestressed concrete water tanks with Type I core wall.
   1. The prestressed concrete tank core wall shall be of cast-in-place concrete construction. Shotcrete or precast core walls are not permitted under the provisions of this Section.

B. Standards/Codes:
   1. The prestressed concrete tank shall be designed and constructed as specified herein, and in accordance with provisions of the following standards and codes:
      a. AWWA D110-13.
      b. ACI 350-06.
      c. ACI 350.3-06.
      d. ASCE 7-10.
   2. Where conflicts between the requirements of this Section and of these standards and codes occur, the more restrictive provisions shall apply.
      a. Exception: Requirements for concrete cover and member thickness shall be as specified in this Section.

C. Load criteria and requirements to be used by the Tank Contractor in the design calculations:
   1. Capacity: 2.0 MG usable storage below the maximum water elevation shown on the Drawings.
      a. Inside Diameter: 100 feet.
   2. Dead Load: shall be the estimated weight of all permanent imposed loads.
      a. Unit weight of concrete shall be taken as 150 pounds per cubic foot.
      b. Unit weight of steel shall be taken as 490 pounds per cubic foot.
   3. Fluid Load: shall be the lateral pressure and weight of the water when the tank is filled to a level that is 6 inches above the elevation of the top of the overflow elevation as indicated on the Drawings (to allow for overflow conditions).
      a. Unit weight of water shall be taken as 62.4 pounds per cubic foot.
   4. Roof Live Load:
      a. Uniform: 40 pounds per square foot, non-reducible.
      b. Any concentrated reactions due to the use of fall protection equipment.
      c. Application of fall protection equipment reaction loads shall be applied concurrently with uniform roof live load. However, load factors for the load case where the combination of uniform and fall protection reactions are considered simultaneously may be taken as unity.
   5. Construction Loads:
      a. Loads applied to the tank during construction shall be accounted for in the design of the tank.
   6. Geotechnical Report: refer to the report prepared by BSK Associates, File No. G16-217-11F, dated December 15, 2016.
   7. Foundation Loads: the tank foundation shall be proportioned so that the net foundation bearing pressure shall be less than the net allowable soil bearing pressure specified in the Geotechnical Report.
      a. The allowable soil bearing pressure may be increased by 33 percent for load combinations that include wind or seismic loads.

b. Settlement Loads: the tank shall be designed to resist the effects of total and differential settlement indicated in the Geotechnical Report.

c. Backfill Pressure: earth loads shall be based on the recommendations set forth in the Geotechnical Report. Backfill pressure shall not be used to reduce the amount of required prestressing.

8. The final design for wind and seismic loads shall consider a reduced capacity to resist sliding due to any membranes placed between the bottom of the concrete foundation and the soil.

9. Wind Load: determined in accordance with ASCE 7-10.
   a. Exposure Category C.
   b. Basic Wind Speed = 115 mph (3-sec gust).
   c. Importance Factor, I_W = 1.00.

10. Seismic Design Criteria: seismic design shall be based on the applicable sections of AWWA D110-13, ASCE 7-10, and ACI 350.3-06. The seismic forces shall be calculated using each code separately. The total base shear used for design shall be the maximum value obtained from the three codes used.
   a. When comparing force and base shear values, those obtained from ASCE and ACI shall be based on service level loads.
   b. AWWA D110-13 Design Criteria:
      1) Occupancy Category, IV.
      2) Importance Factor, I = 1.50.
      3) Mapped Spectral Acceleration for Short Period, S_S = 0.597g.
      4) Mapped Spectral Acceleration for 1-second Period, S_1 = 0.255g.
      5) Site Class D.
      6) Impulsive Structure Coefficient, R_I = 3.5.
      7) Convective Structure Coefficient, R_C = 1.0.
      8) Overstrength Factor,Ω_o, 2.0.
   c. ASCE 7-10 Design Criteria:
      1) Risk Category IV.
      2) Mapped Spectral Acceleration for Short Period, S_S = 0.597g.
      3) Mapped Spectral Acceleration for 1-second Period, S_1 = 0.255g.
      4) Site Class D.
      5) Response Modification Factor, R = 3.25.
      6) Overstrength Factor,Ω_o, 2.0.
      7) Long-period Transition Period, T_L = 12 sec.
      8) Importance Factor, I = 1.50.
   d. ACI 350.3-06 Design Criteria:
      1) Mapped Spectral Acceleration for Short Period, S_S = 0.597g.
      2) Mapped Spectral Acceleration for 1-second Period, S_1 = 0.255g.
      3) Site Class D.
      4) Response Modification Factor, R = 3.25.
      5) Long-period Transition Period, T_L = 12 sec.
      6) Importance Factor, I = 1.50.
   e. The sloshing wave height shall be taken as the larger of the values calculated in accordance with AWWA D110-13, ASCE 7-10, and ACI 350.3-06.
      1) In the event that the calculated height of the "sloshing wave" exceeds the freeboard of the tank (distance from the maximum operating water surface elevation to the bottom of the roof deck at the wall), the

tank and the roof deck shall be designed to accommodate the dynamic effects as follows:

a) Any portion of the convective sloshing wave that extends above the top of the tank wall (bottom of the roof deck at the wall) shall be calculated and applied to the roof deck as an uplift pressure in accordance with section 15.7.6.1.2.c of ASCE 7-10.

b) Additionally, the mass of any confined portion of the convective sloshing wave shall be included with the impulsive mass used in the estimation of the hydrodynamic forces applied to the tank for design, also in accordance with section 15.7.6.1.2.c of ASCE 7-10.

c) Any revisions to the tank, including but not limited to, the roof elevation, water overflow level, and roof slab that are required to meet the specified provisions to resist sloshing loads and its effect on the hydrodynamic design shall not result in additional costs to the Owner.

11. Temperature and moisture gradients: effects due to changes in temperature and due to temperature and moisture gradients across structural members shall be considered in the design. Refer to Section 01_81_00.
12. Prestressing application: forces applied to the wall shall be considered in the design of the wall, especially where wall penetrations result in locally increased prestressing force application to the wall.
13. Vent Capacity Requirements (after accounting for resistance to air flow based on screen mesh size and screen open area):
    a. The vent shall be sized for a minimum rate of 750 cfm or the rate of volumetric withdrawal assuming the outlet pipe has ruptured, whichever is greater.
14. Overflow Design Capacity: 5,600 gpm with maximum 9-inch water height over the top of the overflow weir.

D. Floor Slab and Wall Footing Requirements:
1. The floor slab shall be designed as a membrane floor slab as defined in ACI 372R, Section 3.2.2 that is not less than 6 inches thick; or the floor slab may be designed as a slab-on-ground with a thickness not less than 6 inches.
2. Construction joint locations shall be submitted to the Engineer for review.
    a. Where construction joint spacing exceeds 50 feet, provide means for reducing shrinkage below the limit specified in Section 03_30_00 in proportion to the extent the spacing limit of 50 feet is exceeded.
    b. Use of construction joints in the floor slab shall be minimized.
3. Minimum ratio of floor slab reinforcement area to concrete area shall be 0.5 percent for each orthogonal direction, with bars spaced no greater than 12 inches on center or two times the slab thickness, whichever is less.
4. Minimum concrete cover over reinforcing steel shall be in accordance with Table 3.3.2.3 of ACI 350.5.
5. Wall footings shall bear below floor sub-grade and shall be placed monolithically with the floor slab.
    a. The bottom of the wall footing shall be embedded a minimum of 24 inches below the lowest finish grade elevation over the outside edge of the footing or as indicated on the Drawings, whichever is greater.
6. Design of the floor and wall footing shall consider the differential base stiffness and at concrete encasements or hard points below the floor and wall footing.

E. Column Footing Design Requirements:
   1. Column footings shall be designed in accordance with ACI 350.
   2. Column footings shall be constructed on top of the floor slab (no projections below the floor slab).
   3. Where column footings are to be located, recess the floor slab 2 inches and roughen the top surface of the slab in the recessed area to a 1/4-inch magnitude.

F. Wall Design Requirements:
   1. The prestressed concrete tank wall shall be constructed with a cast-in-place core wall that is circumferentially wrapped with seven-wire strand prestressing reinforcement at the exterior and encapsulated within protective shotcrete layers. The core wall is to be vertically prestressed with post-tensioned thread bars.
   2. The thickness of the core wall shall not be less than 10 inches thick.
   3. The minimum average vertical compressive axial prestress in the core wall provided by the vertical prestressing reinforcement shall be 200 psi after deduction for all losses.
      a. Vertical prestressing reinforcement shall be spaced on average no greater than 50 inches on center or seven times the thickness of the core wall, whichever is less.
   4. The minimum average circumferential residual prestress compression in the wall shall not be less than 200 psi for the aboveground portion of the tank wall, tapering linearly to 50 psi at 6 feet below grade.
   5. The connection between the base of the wall and the foundation shall be an anchored flexible connection in accordance with Section 4.2.1 and Figure 4B of AWWA D110-13.
      a. The joint at the base of the wall shall permit unrestrained radial expansion and contraction of the wall relative to the foundation.
      b. The joint at the base of the wall shall provide restraint against lateral seismic loads acting tangentially to the wall.
      c. Restraint cables shall be provided between the core wall and the foundation to resist seismic loads. The cable installation shall be detailed in a manner that does not introduce radial restraint between the wall and the foundation.
   6. The joint at the wall to the roof shall allow the roof to expand and contract radially while maintaining full vertical load bearing capacity under all conditions.
   7. The minimum concrete cover over non-prestressed reinforcing shall be in accordance with Table 3.3.2.3 of ACI 350.5.
   8. Vertical non-prestressed reinforcing:
      a. Provide vertical non-prestressed reinforcing over the full height of the wall.
      b. The tensile stress shall be limited to a maximum of 18,000 psi.
      c. Reinforcing size shall not exceed 3/4-inch in diameter.
      d. Reinforcing spacing shall not exceed 12 inches on center.

G. Flat Roof and Column Design Requirements:
   1. The roof shall be a flat, cast-in-place concrete structure that spans in two directions.
   2. The minimum thickness of the roof slab shall be 9 inches.
   3. The roof slab shall be provided with drop panels at concrete column supports.
   4. Columns shall be limited to a maximum spacing of 25 feet.

5. Columns shall be circular with a minimum diameter of 18 inches.
6. Columns shall be reinforced with spirals.
7. Minimum concrete cover over reinforcing steel shall be in accordance with Table 3.3.2.3 of ACI 350.5.
8. The reinforcing steel for the roof structure shall be sized in accordance with ACI 350 with the environmental durability factor, S_d, applied to limit flexural stress. Reinforcing steel shall be proportioned and distributed to control cracking for normal environmental exposure.
9. The effects of thermal expansion and contraction shall be accounted for in the design of the roof structure. Appurtenances and roof connections shall be detailed to limit restraint to thermal radial movement.
10. The Tank Contractor shall submit, for the Engineer's approval, a plan showing the roof configuration that includes construction joints. Construction joints shall incorporate a 6-inch PVC waterstop.

1.07 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Prestressing steel shall be adequately packaged for protection against corrosion and physical damage during shipping and storage.

B. Prestressing steel that has rusted or has otherwise sustained damage will be rejected.

C. Prestressing material and appurtenances delivered to project site: Store off ground on planks, supported by 4-by-4 timber. Cover with polyethylene sheeting or treated paper to prevent exposure to moisture.

1.08 PROJECT CONDITIONS

A. Environmental requirements:
1. Cold weather epoxy grouting of tendons:
   a. In cold weather, and especially during frosts, take special precautions to avoid freezing of epoxy.
   b. In event that grouting procedure cannot be postponed, keep wall temperature above freezing point with hot blankets or by other means acceptable to Engineer.

B. Site safety precautions:
1. Take every precaution to keep personnel and visitors outside the area of danger from breaking prestressing strands or bars.
2. At no time shall anyone stand in the line of stressed circumferential strand.
3. No work shall be performed by anyone, other than the prestressing crew within 100 feet of circumferential wrapping operation or vertical bar stressing operation.
4. Where access to the site by unauthorized persons cannot be controlled while prestressing work is in progress, or where property lines are less than 100 feet from the wrapping operation, erect protective fencing to prevent breaking strands from endangering such persons.

C. Welding:
1. Perform no welding to anchor plates after prestressing tendons have been assembled.
2. Do not use prestressing steel as ground for welding operations.

1.09 SEQUENCING AND SCHEDULING

A. Polyvinyl chloride waterstops:
   1. Welding of polyvinyl chloride waterstops: Prior to installing waterstops in forms, demonstrate ability to weld acceptable joints in waterstops.
   2. Quality of welded joints: Are to be subject to acceptance of the Engineer.

B. Restrictions on shotcrete operations:
   1. Abrasive Blasting:
      a. Do not commence prior to the completion date of curing period of tank corewall.
      b. Do not commence until all form tie holes have been drypacked.
   2. Wind conditions: Do not apply shotcrete under such strong wind conditions that considerable amount of cement and moisture is removed by wind from mortar spray between nozzle and surface on which shotcrete is applied.
   3. Temperature requirements:
      a. Peak temperature during day must be expected to rise to at least 55 degrees Fahrenheit.
      b. Night temperature of first night after shotcrete application must not be expected to drop below 33 degrees Fahrenheit.
   4. Cold weather conditions:
      a. Application of shotcrete under cold weather conditions is solely at the Tank Contractor's risk.
      b. Shotcrete may be applied in cold weather provided surfaces are not frozen.
      c. Damage to shotcrete: Whenever rain or frost damages shotcrete which has not had chance to take set:
         1) Remove and replace such shotcrete.
         2) Remove damaged shotcrete before applying any new layers of shotcrete.
      d. Type III Portland cement may be utilized for shotcrete for cold weather application.

C. Ultimate initial prestressing force for vertical thread bars: Do not apply until concrete compressive strength in walls reaches specified strength.

D. Wrapping of circumferential prestressing strands:
   1. May start when core wall concrete has reached a compressive strength of 3,000 pounds per square inch and intermediate layers of shotcrete coats over prestressing strands has reached a compressive strength of 250 pounds per square inch or 12 hours after the shotcrete coat was applied, whichever is greater.
   2. The compressive stress in the concrete due to wrapping shall not exceed 55 percent of f'_c at any time.

E. Backfilling of tanks:
   1. Do not backfill until and unless the Engineer has accepted leakage testing results and the concrete has reached specified strength.

1.10 GUARANTEE

A. The Tank Contractor shall guarantee the structure against defective materials or workmanship for a period of two years from the final date of completion. If any materials or workmanship prove to be defective within two years, those materials shall be replaced or repaired by the Tank Contractor at the expense of the Tank Contractor.

B. Access hatch (through-roof access) warranty:
   1. Manufacturer is to warranty proper operation and against defects in material or workmanship for a period of 5 years.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
   1. Materials of construction for the strand-wound prestressed concrete tank shall be selected by the Tank Contractor, subject to the limitations of this Section.

B. Concrete:
   1. Concrete shall conform to Section 03_30_00 and ACI 301, except as modified herein.
   2. Unless otherwise specified, all concrete for tank construction shall have a minimum 28-day compressive strength of 4,000 psi.
   3. The concrete for the tank floor, footings, and pipe encasement shall conform to the following requirements.
      a. Concrete shall not be air-entrained.
      b. The coarse and fine aggregate shall meet the requirements of ASTM C33 and sized to meet member thickness and clearance requirements of ACI 350.
      c. Superplasticizer and water-reducing admixtures shall be incorporated into the concrete for the floor slab and wall footing.
   4. Proportioning for concrete shall be in accordance with ACI 301.
   5. All concrete shall have a maximum water-soluble chloride ion concentration of 0.06 percent by weight of cement.
   6. Cement shall conform to ASTM C 150, Type I or Type II.
   7. Accelerating and retarding admixtures shall not be incorporated into the any concrete mix without prior acceptance by the Engineer.

C. Reinforcing Steel:
   1. Reinforcing steel shall be new billet steel Grade 60 meeting the requirements of ASTM A 615.
   2. Reinforcing steel that is to be welded shall be ASTM A 706, Grade 60.
   3. Reinforcing steel shall be accurately fabricated and shall be free from loose rust, scale, and contaminants.
   4. Reinforcing steel shall be accurately positioned on supports, spacers, hangers, or other reinforcement and shall be secured in place with wire ties or suitable clips. Rebar chair supports shall be provided in accordance with Section 03_20_00.

D. Prestressing Materials:
   1. Seven-wire strand:
      a. Prestressing strand shall be in accordance with ASTM A 416 prior to hot-dip galvanizing.

b. Individually hot-dip galvanize each wire of strand before forming the wires into a strand.
c. Hot-dip galvanized 7-wire strand shall meet following minimum requirements:

Physical Characteristics	Required Results
Nominal Strand Diameter Before Galvanizing	3/8 inch
Nominal Area After Galvanizing	0.089 square inch
Nominal Weight Per 1,000 Linear Feet	303 pounds
Pitch of Strand	12 to 16
Minimum Yield Strength At 1 Percent Extension	180,000 psi
Minimum Ultimate Strength After Galvanizing	240,000 psi
Elongation In 24 Inches At Fracture	4.5 percent
Weight Of Zinc Coating per ASTM A475	0.85 ounces per square foot

2. High strength thread bars:
   a. Thread bars and deformations: Hot rolled.
      1) Thread bars with cold rolled threads or with quenched or tempered steels will not be permitted.
   b. Deformations of thread bars:
      1) Provide deformations that form screw-thread suitable for mechanically coupling lengths of thread bar and provide positive attachment of anchor assemblies.
      2) Provide deformations that are in accordance with ASTM A 722, Type II requirements and are uniform such that any length of bar may be cut at any point and internal threads of coupler designated for that size of bar can be freely screwed on bar.
   c. Tensile and physical properties: Bars manufactured in accordance with ASTM A 722, Type II requirements are to comply with following minimum requirements:

Physical Characteristics	Required Results
Nominal Diameter	1.25 inches or 1.375 inches
Nominal Cross-sectional Area	1.245 square inches or 1.577 square inches
Nominal Bar Weight	4.39 pounds per foot or 5.56 pounds per foot
Minimum Tensile Stress	150 ksi
Minimum Yield Stress at 0.2 Percent Offset	120 ksi
Elongation At Rupture In Gauge Length of 20 Bar Diameters	4 percent minimum
Maximum Carbon Content of Bar	0.55 percent

   d. Nuts: Minimum ultimate strength shall be 95 percent of minimum ultimate strength of thread bar.

3. Anchorages for vertical post-tensioned thread bars:
    a. All post-tensioned prestressing shall be secured at the ends by means of approved permanent anchoring devices, which shall hold the prestressing steel at a force not less than 95 percent of the guaranteed minimum tensile strength of the prestressing steel.
    b. The load from the vertical prestressing anchoring device shall be distributed to the concrete through steel bearing plates and shall not exceed the values specified by the Post-Tensioning Institute (PTI), Guide Specifications, Paragraph 3.1.7.
    c. Fully-threaded anchor connections shall be used at both ends of the vertical prestressing bar, which shall incorporate a spherical-shaped bearing surface to match the conical surface in the bearing plate.
    d. Wedge anchors shall not be used for permanent anchor hardware.
4. Testing of Prestressing Material:
    a. Provide mill certificates.
    b. Prior to preparation of shop drawings and installation of vertical thread bars, provide proof that the thread bar anchorage system meets the requirements specified herein.
    c. Before any prestressing operations may be started, the Tank Contractor shall calibrate all recording equipment at an approved testing laboratory to the satisfaction of the Engineer.
    d. All continuous force readings for either the vertical or the circumferential prestressing operations shall be developed with electronic (or the substantial equivalent) force (strain gauge method) sensing transducers, all having a maximum nonlinearity error of +/- 0.5 percent and a maximum hysteresis error of +/- 0.25 percent.
5. Anchor pockets for vertical thread bars:
    a. Consist of steel cans fabricated from steel tubing, hot-dip galvanized after cutting and subsequently welded to the top bearing plate.
    b. Provide adequate means for flushing of vertical ducts during concrete placement.
6. Ducts for vertical thread bars:
    a. Duct enclosures shall be standard 1.25" or 1.375” diameter PVC pipe class 160 or class 200, respectively, unless otherwise specified on the Drawings.
    b. Threaded hose connections shall be provided at the top of each duct for water flushing.
    c. All ducts shall be provided with expandable valves to facilitate the injection of epoxy grout after prestressing.
7. Epoxy grout for vertical thread bars:
    a. The vertical thread bar system shall offer complete two-part epoxy protection of the prestressing steel inside ducting and anchors.
    b. Portland cement grout will not be accepted.

E. Seismic Cables and Sleeves:
1. Seismic cables:
    a. Hot-dipped galvanized seven-wire strand:
    b. Prestressing strand shall be in accordance with ASTM A 416 prior to galvanizing and ASTM A 475 after galvanizing.
    c. Individually hot-dip galvanize each wire of strand before forming the wires into a strand.

d. The galvanized strand shall have a minimum ultimate tensile strength of 240,000 psi.
e. The cables shall be installed to connect the wall and the foundation.
f. The minimum weight of zinc galvanic coating shall be 0.85 ounces per square foot.
g. Only seven-wire strand will be allowed. Single wire will not be allowed.

2. Neoprene sleeves for seismic cables shall conform to SCE-43 of ASTM D 1056 and as further modified by the following:

Physical Characteristics	Required Results
Compressive deflection	9 to 13 psi
Shore 00 durometer	60 to 80 pcf
Density	12 to 28 pcf
Water absorption by weight	5 percent
Temperature range: Low (flex without cracking) High continuous High intermittent	-40 degrees F 150 degrees F 250 degrees F
Compressive set (average): 1/2-inch sample compressed at 50 percent for 22 hours at 70 degrees F and 24 hour recovery	15 to 35 percent
Maximum linear shrinkage during heat aging (7 days at 158 degrees F)	5 percent
Minimum tensile strength	175 psi
Minimum elongation	180 percent
Resilience (bayshore – percent rebound average 1/2-inch thickness at 72 degrees F)	20 to 40 percent

F. Shotcrete:

1. General:
   a. Shotrcrete shall conform to ACI 506.2, except as modified herein.
   b. Minimum compressive strength of shotcrete shall be 4,500 psi at 28 days.
   c. Shotcrete used in the tank construction shall have a maximum water soluble chloride ion concentration of 0.06 percent by weight of cement.
   d. Rebound materials shall not be reused in any form for shotcrete
2. Portland cement shall meet the general requirements in Section 03_30_00.
3. Fine aggregates:
   a. Fine aggregates shall meet the requirements as specified in Section 03_30_00 and the following paragraphs.
   b. Coarse sand:
      1) Shotcrete applications: Use well graded coarse sand, unless otherwise noted.

2) Gradations:

Sieve Size	Percent Passing by Weight
3/8 inch	100
Number 4	95-100
Number 8	80-100
Number 16	50-85
Number 30	25-60
Number 50	10-30
Number 100	2-10

c. Fineness modulus shall be between 2.7 and 3.0.

4. Water shall be in accordance with Section 03_30_00.
5. Class F fly ash shall conform to ASTM C618 and shall not make up more than 20 percent of the cementitious material in the shotcrete mix.

G. Elastomeric Materials:

1. Bearing pads shall be natural rubber or neoprene:
   a. Natural rubber bearing pads shall contain only virgin natural polyisoprene as the raw polymer and the physical properties shall comply with ASTM D 2000 Line Call-Out M4AA414A13.
   b. Neoprene bearing pads shall have a hardness of 40 to 50 durometer, a minimum tensile strength of 1,500 psi, a minimum elongation of 500 percent, and a maximum compressive set of 50 percent. Pads shall meet the requirements of ASTM D 2000 Line Call-Out M2BC410 A14 B14 or 2 BC 415 A1 4 B14 for 40 durometer material.
2. Sponge filler shall be closed-cell neoprene or rubber conforming to ASTM D 1056, Type 2, Class A, and Grade 3. Compression deflection limited to 25 percent at two to five psi.

H. Waterstops:

1. Requirements:
   a. Material: Polyvinyl chloride.
   b. Size and type:
      1) Centered at construction joints in cast-in-place concrete: 6-inch flat ribbed type.
      2) At tank walls to tank wall-footing joints: 9-inch wide with 1-inch diameter hollow bulb ribbed type.
      3) Type not allowed: Dumbbell type.
   c. Physical characteristics:

Physical Characteristics	Test Method	Required Results
Specific Gravity	ASTM D 792	Not less than 1.3
Hardness	ASTM D 2240	70 to 90 Type A Shore durometer
Tensile Strength	ASTM D 638	Not less than 2,000 pounds per square inch
Ultimate Elongation	ASTM D 638	Not less than 300 percent

Physical Characteristics	Test Method	Required Results
Alkali Extraction	CRD C 572	7 day weight change between minus 0.1 percent and plus 0.25 percent. Hardness change within 5 points.
Low Temperature Brittle Point	ASTM D 746	No sign of cracking or chipping at minus 35 degrees Fahrenheit
Water Absorption	ASTM D 570	24 hours, not more than 0.15 percent
Accelerated Extraction Tensile	CRD C 527	Not less than 1,600 pounds per square inch
Stiffness in Flexure	ASTM D 747	Not less than 600 pounds per square inch
Tear Resistance	ASTM D 624	225 pounds per square inch
Weight Requirements		
Thickness		3/8 inch
Center Bulb Outside Diameter		1 inch nominal
Allowable Tolerances		
Width		Plus or minus 3/16 inch
Thickness		Plus or minus 1/32 inch

d. Manufacturers: One of the following or equal:
   1) Burke Concrete Accessories, Inc.
   2) Greenstreak PVC Waterstops, Sika Corporation.
   3) Kirkhill Rubber Company.
   4) Williams Products, Inc.
   5) Vinylex Corporation.

I. Tank Appurtenances:
1. General:
   a. Provide and install all appurtenances as shown on the Drawings and as specified herein.
2. Piping:
   a. Inlet: As indicated on the Drawings.
   b. Outlet: As indicated on the Drawings,
   c. Overflow piping and overflow cone: As indicated on the Drawings.
3. Pipe Supports:
   a. Provide as required to adequately support piping under all load and operating conditions.
   b. Refer to Section 40_05_07.01.
4. Ladders
   a. Conforming to all requirements of OSHA and as indicated on the Drawings.
      1) Provide brackets and fasteners required for support and secure mounting to tank structure.
      2) Rungs: solid bar stock.

3) Welds: fillet or full penetration as appropriate to the condition.
4) Fasteners Ladder bolts, concrete anchors, nuts, washers, and flush steel inserts: Type 316 stainless steel.

b. Interior:
1) Materials: Type 304/304L stainless steel.
2) Fall protection: Fall arrest device as specified in the following paragraphs. Material to match that of ladder. Provide removable center rail extension projecting at least 48 inches above top rung of ladder.

c. Fall arrest device consisting of sliding/locking mechanism with safety belt and belt attachment to center climbing rail.
1) Device material: Type 304 stainless steel.
2) Devices: To include following items, all fabricated of device material unless otherwise accepted by the Engineer:
a) Rails: Lengths as required.
b) Brackets: Complete with brackets necessary for attaching rail to ladders.
c) Removable rail extension: 48-inch long.
3) Sleeve assemblies and safety belts: 2.
4) Manufacturers: The following or equal:
a) Norton Company, Air Space Device Division, Cerritos, CA, Saf-T-Climb with SAF-T-NOTCH RAIL and SAF-T-LOCK SLEEVE.

5. Access hatches (through-roof access):
a. Sizes: Nominal size(s) as indicated on the Drawings.
b. Material and construction:
1) Door leaf/leaves: Aluminum diamond pattern plate with reinforcement if required for spans provided.
2) Frame: Minimum 1/4-inch thick, aluminum channel with anchor flange around perimeter.
3) Door hardware: Equip doors with following:
a) Hinges: Minimum 2 heavy forged stainless steel hinges and pins for each leaf.
b) Operators, hold-open and handle: Spring operators and automatic hold-open arm with release handle for each leaf.
c) Lock: A Type 316 stainless steel snap lock with fixed handle shall be mounted on the underside of one cover. In addition, the lock shall be a cylinder style with a threaded security cover plug.
d) Seals: Leaf seals shall be dust and water tight.
e) Drainage coupling: 1-1/2-inch coupling located in front right corner of frame. Drain shall be installed to drain to the exterior side of the tank, adjust curb height as required.
4) Finish: Manufacturer's standard mill finish.
5) Manufacturers: One of the following or equal:
a) Bilco Co., Type JD-AL.
b) Babcock-Davis Associates, Inc., Type AM or GT.
c) Nystrom, Inc.

6. Grating, Guardrail, and Miscellaneous Fabrications:
a. Refer to Section 05_50_00.
b. Materials: As indicated on the Drawings.

7. Roof Ventilator:
    a. Size: As required to meet the air flow design requirements, but not less than indicated on the Drawings.
    b. Materials and construction:
        1) Aluminum components.
        2) Stainless steel anchors.
        3) Flashing shall wrap over the edge of the concrete curb and extend down a minimum of 2 inches.
        4) 2-inch aluminum filters.
        5) Insect screens.
        6) 12-inch tall base.
        7) Fiberglass hood insulation.
    c. Manufacturers: The following or equal:
        1) Greenheck Fabra Hood.
    d. Finish: Manufacturer’s standard mill finish.
8. Downspouts and conductor heads:
    a. Minimum 22 gauge steel.
    b. Galvanized in accordance with ASTM A 653 to G90 designation.
    c. Fastened to the tank wall with stainless steel anchors.
    d. Field painted. Color to be selected by Owner.

J. Form ties:
    1. General: The requirements of this Section supplement the form ties requirements stated in Section 03_11_07.
    2. Requirements:
        a. Form ties for forming system selected for concrete other than corewall: Cone-snap tie or flat bar type with waterstops.
        b. Form ties for forming system selected for tank corewall: Tapered ties.

K. Wall Forms: As specified in Section 03_11_07 SYMONS, ALUMA, and regular plywood forms may be used for forming of circular walls, as long as there are no straight sections longer than 36 inches at any place around the outside circumference of such walls.
    1. Forms shall be designed to resist the construction loads for full height wall pours.

L. Polyethylene sheeting:
    1. Minimum 6-mils thick and in accordance with ASTM C 171.

M. Granular leveling base:
    1. Material shall meet the requirements for aggregate base course specified in Section 31_05_15.

N. Epoxy injection materials: As specified in Section 03_64_24 and the following products:
    1. Epoxy materials: Nontoxic to potable water.
    2. Grout injection pipes: Provide with positive mechanical shutoff valves.

O. Materials for repair of chipped out concrete areas:
    1. Epoxy bonding agent: As specified in Section 03_63_01.

2.02 SOURCE QUALITY CONTROL

A. Concrete testing:
   1. As specified in Section 03_30_00.

2.03 COMPLIANCE TESTING

A. California Safe Drinking Water Act compliance testing:
   1. Concrete that will be placed in direct contact with potable water shall be tested to determine compliance with NSF/ANSI 61 by one of the following methods:
      a. Method 1: Constituent Verification.
         1) Confirmation the components of the concrete are certified or tested using the following parameters:
            a) Cement shall be NSF/ANSI 61 certified.
            b) Admixtures shall be NSF/ANSI 61 certified.
            c) Aggregates shall be tested and approved by one of the following testing methods:
               (1) Soak Testing: Aggregates shall be supplied to an ANSI accredited lab, accompanied by the appropriate chains-of-custody and tested for regulated metals and gross alpha radionuclides. Testing shall be conducted by an ANSI accredited product certification body for Drinking Water Quality.
               (2) Hardened Concrete Specimen Testing: Provide hardened concrete specimens using the proposed mix designs for the concrete that will be placed in direct contact with potable water to an ANSI accredited lab, accompanied by the appropriate chains-of-custody. Concrete specimens shall be soak tested for regulated metals and radionuclides.
      b. Method 2: Mix Design Verification through Concrete Specimen Testing.
         1) Provide hardened concrete specimens for each mix design for concrete that will be placed in direct contact with potable water with the appropriate chains-of-custody to an ANSI accredited lab. Concrete specimens shall be tested for the items listed in NSF/ANSI 61 Table 3.1 - Portland and Hydraulic Cements.
   2. Concrete mix designs that contain fly ash shall be compliance tested using Method 2 specified herein.
   3. Compliance testing results prepared for other projects shall not be acceptable.
   4. Compliance testing shall be in addition to the testing requirements specified in Section 03_30_00.

PART 3 EXECUTION

3.01 SUPERVISION

A. The Tank Contractor shall provide a full-time on-site project manager during all aspects of tank construction.

3.02 INSTALLATION

A. Waterstops:
   1. General: The requirements of this Section supersede the waterstop requirements stated in Section 03_15_00.
   2. Requirements:
      a. Install in concrete joints where indicated on the Drawings.
      b. Connect the ends of the radial waterstop in the wall footing joints to the circumferential waterstop in the wall to wall footing joint and to the circumferential waterstops in the floor to wall-footing joints if they should exist.
      c. Provide waterstop in each joint in water-bearing structures, whether indicated on the Drawings or not.
      d. Provide waterstops that are continuous.
      e. Set accurately to position and line indicated on the Drawings.
      f. Hold and securely fix edges in position at intervals of not more than 12 inches and secure in manner that they cannot move during placing of concrete.
      g. A hog-ring or nail may be driven through both ends of the waterstop to facilitate placing and tying of waterstops to reinforcing steel forms or form-ties.
      h. Tank Contractor's option: One of the following:
         1) Use waterstop tie wires at not more than 12 inches on centers, near outer ribs, to tie waterstops into position.
         2) Use special clips.
      i. Waterstop terminations: Terminate 3 inches from top of finished surfaces of walls and slabs unless otherwise specified or indicated on the Drawings.
      j. Installation of waterstops:
         1) Install so that joints are watertight.
         2) Provide field welded polyvinyl chloride waterstop joints such as unions, crosses, ells, and tees.
         3) Make all splices to waterstop in accordance with manufacturer's recommendations.
         4) Clean waterstops of all concrete, dirt, and foreign matter.

B. Form and accessories removal:
   1. General: The requirements of this Section supercede the form and accessories removal requirements stated in Section 03_11_07.
   2. Requirements:
      a. Other forms supporting concrete and shoring: Remain in place as follows:
         1) Sides of footings, sides of slabs, and columns: 24 hours minimum.
         2) Core walls: 12 hours minimum.

C. Neoprene bearing pads:
   1. General:
      a. Secure bottom surface of pads by positive attachment to structure such that horizontal crawling is prevented.

D. Closed cell neoprene joint fillers and sleeves (“sponge filler”):
   1. When joint filler pads or sponge filler sleeves are indicated on the Drawings or specified, place materials in correct position before concrete is placed against them.
   2. Holes and joints in pads are to be filled with caulking to prevent passage of mortar or concrete from one side of the joint to the other.

3.03 FLOOR

A. Prior to placement of the floor reinforcing, a 6-mil polyethylene moisture barrier shall be placed over the leveling base material. Joints in the polyethylene shall be overlapped a minimum of six inches.

B. Prior to placement of the floor concrete, all piping that penetrates the floor shall be set and encased in concrete to the limits indicated on the Drawings. Provide waterstops at the joints between the encasement and the concrete floor slab where indicated on the Drawings.

C. The vertical waterstops between the wall and footing shall be placed and supported to locate the center bulb within the joint as indicated on the Drawings and as required by the Tank Contractor. The waterstop shall be spliced using a thermostatically controlled sealing iron and each splice shall be successfully spark tested prior to encasement in concrete.

D. The floor shall be poured without construction joints, except as otherwise allowed by the Engineer. There shall be no construction joints between the floor and wall footing.

3.04 CONCRETE

A. All concrete shall be conveyed, placed, finished, and cured as specified in Section 03_30_00, except as modified herein.

B. Requirements:
   1. Cold joints:
      a. Cold joints in floors, roof slabs, and wall footings are not allowed.
      b. Continuously cover joints with new concrete, and thoroughly integrate through vibration, even if it means that horizontal passes of only 6 inches in width can be made until additional concrete and equipment becomes available to permit wider passes in concrete placement.
   2. Blockouts or other types of wall openings: Do not provide openings other than those indicated on the Drawings.

C. Weather Limitations:
   1. Unless specifically authorized in writing by the Engineer, concrete shall not be placed without special protection during cold weather when the ambient temperature is below 35 degrees Fahrenheit and when the concrete is likely to be subjected to freezing temperatures before initial set has occurred and the concrete strength has reached 500 psi. Concrete shall be protected in accordance with ACI 306.1. The temperature of the concrete shall be maintained in accordance with the requirements of ACI 301 and ACI 306.1. All methods and equipment for heating and for protecting concrete in place shall be subject to the approval of the Engineer.

2. During hot weather, concreting shall be in accordance with the requirements of ACI 305.1.
3. Placement of concrete during periods of low humidity (below 50 percent) shall be avoided when feasible and economically possible, particularly when large surface areas are to be finished. In any event, surfaces exposed to drying wind shall be covered with polyethylene sheets immediately after finishing, or flooded with water, or shall be water cured continuously from the time the concrete has taken initial set. Curing compounds may be used in conjunction with water curing, provided they are compatible with coatings that may be applied later and if they are degradable.

D. Finishes:
1. Provide manufacturer's standard finish unless otherwise noted.
2. Coordinate finishes and surface preparation with coatings indicated on the Drawings.

E. Curing:
1. Except where specified herein, concrete curing shall be as specified in Section 03_30_00.
2. Requirements:
    a. Any concrete surface that is designated to receive paint or upon which any material is to be bonded: No curing compound shall be used.
    b. Concrete designated to be painted: Water or plastic membrane cure.
    c. Tank core walls: Water curing.
    d. Floor slab:
        1) The floor shall be cured by flooding with water, and shall remain saturated for a minimum of seven days after placement.
        2) Alternatively, the floor slab may be cured with a sprayed on curing compound and prepared as follows:
            a) After the surface is dry to the touch, a 6-mil thick polyethylene sheet shall be carefully taped and sealed to the concrete surface and kept on such surface for as long as possible, but not less than 7 days, to minimize the loss of moisture trapped between the polyethylene sheet and the concrete.
            b) Alternatively, heavy curing blankets may be used in lieu of the polyethylene sheet.
    e. Roof slab: Water or plastic membrane cure.
    f. Other concrete surfaces: Water curing.

F. Testing Cast-in-Place Concrete:
1. All concrete testing shall be in accordance with Section 03_30_00, except as noted herein.
2. Testing shall be at the expense of the Tank Contractor, and shall be conducted by an independent testing agency approved by the Engineer.

3.05 SEISMIC CABLES

A. Requirements:
1. Provide seismic cables to connect wall and wall footing.
2. Quantity and spacing of seismic cables shall be as indicated on the Shop Drawings.

3. Where necessary, seismic cables shall be pre-bent before placing units in wall and wall footing.
4. Tie seismic cables to lower horizontal circumferential tie-bar for vertical prestress tendons as indicated on the Drawings.
5. In wall-footing, tie seismic cables to radial footing bars.

3.06 PRESTRESSING

A. Circumferential Prestressing Equipment:
   1. The circumferential stressing system shall produce a continuously, electronically (or substantial equivalent) monitored permanent stress or force recording along its full length as it is being applied and the stress variation in any strand at any point around the circumference shall not be greater than +/- 1.5 percent of the ultimate strength of the steel. In addition to this recording, any system which deflects the tensioned prestressing material between the tensioning device and the wall after it has left the tensioning device, shall provide a similar continuously monitored stress or force record along its full length as it is being applied to the wall. These recordings shall show that either before or after deflection that the stress variation in the prestressing material at any point around the circumference shall not be greater than +/- 1.5 percent of the ultimate strength of the steel.
   2. Due to prior instances of force measurement inaccuracies and the inherent problems associated with hand-held stressometers, no manually recorded force readings will be accepted. This requirement shall be strictly followed.
   3. Any wrapping that does not meet the stress tolerances specified and/or cannot meet the requirements of above will not be accepted and will be removed at the expense of the Tank Contractor. The Tank Contractor is responsible for all costs associated with meeting the specified tolerances.
   4. Since intermittent force applications can result in an unequal stress distribution around the wall (due to friction losses), the prestressing system shall be capable of applying a continuous wrapped force at any point around the circumference within the specified tolerances. Circumferential stressing systems based on jack-operated cable or rod-type tendons (such as those placed inside of ducts incorporated in the corewall or placed manually around the exterior of the corewall) will not be allowed.
   5. Since wrapping systems which utilize single solid prestressing material will not provide the desired bond between the prestressing material and the shotcrete and since single solid prestressing material will not provide an adequate safety factor against failure, only machine wrapping systems which utilize seven-wire prestressing strandwrapping will be allowed.

B. Circumferential Prestressing Application:
   1. All cracks in the core wall and floor slab shall be repaired as specified following the circumferential prestressing of the tank walls.
   2. Wrapped strand shall be anchored to the wall at least once for every coil or reel.
   3. Permanently anchoring one strand to a previously wrapped strand will not be permitted. Wrapped strand ends shall be joined by suitable splicing methods that shall develop 90 percent of the full strength of the strand.
   4. Use of different alloys in the splicing material shall not be permitted.
   5. The clear vertical spacing between any two wrapped strands shall be 1.5 strand diameters or 3/8-inch, whichever is larger. A 1/4-inch construction

tolerance shall apply to strand spacing, as well as to this minimum spacing requirement.

6. All wrapped strand not meeting the spacing requirements shall be spread by approved methods or shall otherwise be removed.

C. Vertical Prestressing Equipment:
   1. The Tank Contractor shall provide a continuously, electronically (or substantial equivalent), monitored permanent force elongation record from zero to full force at the final lock-off for all of the vertical prestressing work.
   2. The ordinate of the permanent recording shall show the elongation in inches and the abscissa shall show the force in pounds or kips.
   3. Manually recorded force and elongation readings will not be accepted.
   4. The vertical prestressing machinery shall have automatic electronic tensioning cut-off devices or equivalent means to ensure that the specified force and elongation is not exceeded at any time during any thread bar stressing operation.
   5. The force readings at the stressed bar ends, immediately after lock-off, for any stressing operation, on any thread bar, shall not fluctuate more than +/- 1.5 percent (of the minimum ultimate strength of the steel) from the desired average force setting.
   6. The applied force, immediately after lock-off for the final stressing operation on any thread bar, shall be no less than 72 percent of the ultimate strength of the steel and the applied force before lock-off shall be no greater than 75 percent of the ultimate strength of the steel.

D. Vertical Prestressing Application:
   1. All permanent anchor hardware shall have a ball-shaped threaded nut that can be screwed down on to a matching cone-shaped bearing surface in the bearing plate after the desired tension on the anchor hardware and/or prestressing steel has been applied.
   2. The number and spacing of the thread bars shall not be altered under any condition.
   3. High-strength thread bars shall be used for vertical prestressing.
   4. All ducts shall be clean and free of water and deleterious materials that would impair bonding of the grout or interfere with grouting procedures.
   5. Grout injection pipes shall be fitted with positive mechanical shutoff valves, which shall not be removed within the first 24 hours.
   6. Grouting of thread bars shall begin at the lowest grout connection.
   7. Each vertical thread bar duct shall be pumped until the entire nut at the top anchor has been covered with epoxy.
   8. In cold weather, and especially during frosts, special precautions must be taken to avoid the freezing of grout. In the event that the grouting procedure cannot be postponed, the wall temperature must be kept above the freezing point with hot blankets or by other approved means.
   9. Upon completion of the vertical stressing and grouting operation, all anchor pocket areas above the anchor nuts shall be dry packed with a 1 part cement to 2 parts sand mortar mix immediately after the epoxy coating on the inside can surface has become tacky, or alternatively, the metal can may be filled with concrete aggregates and epoxy.
   10. The inside surfaces of any metal cans to be dry packed shall be coated with a 2 part epoxy. Dry packing shall not proceed until the epoxy coat has become

tacky. The dry pack surface shall be finished flush with the adjoining concrete surface.

11. Damaged PVC tubing shall be replaced unless repairs are made and approved by the Engineer.
12. Vertical thread bar components shall be assembled off the ground and as detailed on the Shop Drawings. All vertical thread bars must be fully assembled before they are installed in the forms.
13. Vertical thread bars shall be accurately placed and fastened securely in place to reinforcing steel and form ties to prevent movement during placement of concrete.
14. All vertical thread bars must be flushed with water from the top immediately upon completion of the concrete vibrating operation. Water shall be introduced through a taped-off hole in the wooden lids on the anchor pockets and be permitted to drain through the bottom grout tube. Flushing shall not be accomplished by introducing water through the bottom connection. Should a thread bar duct not flush properly, the Engineer shall be notified immediately.
15. Cleaning of ducts with air only (not water), or removal of water with air from the bottom connection, will not be permitted.
16. Placing of vertical thread bars shall be done to proper locations, elevations, and alignments, with a maximum tolerance of plus or minus 1/4 inch.
17. All vertical thread bars shall be properly tied at the anchor plates and shall be tied with No. 4 bars at intervals of 24 inches or less between the anchor plates. The maximum permissible misalignment of the anchor plate to the vertical thread bar is +/- 2.5 degrees.
18. Anchor plates must be installed at right angles to the thread bar alignment near the anchor. Anchor plates must be installed with long sides, aligned parallel with the wall forms and secured to prevent their rotation while concrete is placed.
19. Unless indicated otherwise on the Plans, the minimum concrete cover around steel anchor pockets and bearing plates shall be 1.5 inches.
20. The vertical clearance between bottom anchor plate and the waterstop at the base of the tank walls shall be no less than 2 inches nor more than 4 inches.

E. Circumferential and Vertical Prestressing Operations:
1. The maximum initial electronically recorded steel stress shall not exceed 75 percent of the guaranteed minimum ultimate strength of the steel at any time during or after stressing.
2. An automatic, continuously electronically (or substantial equivalent) monitored permanent recording of the applied force, at any point on the strand, at any point on and around the tank wall, must be made during the entire circumferential prestressing application. All such recordings must be based on a continuous sensing of the applied force on the strand between the tensioning drum and the wall when, and as, the strand is being wrapped and laid on the wall.
3. The force setting on wrapping and vertical thread bar stressing machinery shall be such that the applied forces fall within the specified minimum or maximum stress or force limitations; the force setting shall be corrected immediately when the applied force falls outside the required force tolerance limitations.
4. In the event that the stressing machinery is incapable of holding the applied forces within the specified stress or force limitations, the Engineer will order, at the expense of the Tank Contractor, the removal and replacement of such

machinery in favor of a different unit capable of maintaining such tolerance requirements.

5. The loss in stress in post-tensioned prestressing steel due to creep and shrinkage of concrete and sequence stressing is to be assumed as 25,000 psi. The final stress is the average initial stress reduced by the stress loss of 25,000 psi.
6. The final force is the steel section multiplied by the final stress.
7. The final force for the vertical thread bars shall be no less than the required final force shown on the Shop Drawings.
8. The initial force for the circumferential wrapped strand shall be no less than the required initial force shown on the Shop Drawings.
9. The continuous, electronically-produced force application chart during the wrapping application becomes the property of the Owner.
10. An automatic, continuously electronically (or substantial equivalent) monitored and simultaneously recorded force-elongation reading must be made for each vertical stressing application.
11. The force-elongation reading must represent the true relationship between the elongation at any given point of the vertical stressing operation and the applied force on the prestressing steel at that same point.
12. The force-elongation relationship must be constantly maintained from the beginning, starting with the removal of the slack to the point of lock-off and complete release of the force on the vertical prestressing steel after retraction of the stressing piston or equivalent stressing device.
13. All electronically produced force-elongation readings during the vertical thread bar stressing operations become the property of the Owner.
14. After the concrete core wall has reached the specified 28-day compressive strength, the vertical thread bars shall be stressed.
15. Circumferential wrapping shall not start until the vertical thread bars have been stressed.
16. In the event gaps between concrete core wall and wrapped strand develop that exceed 3/8 inch, discontinue wrapping. Before resuming any wrapping, either:
    a. Build-up walls with shotcrete to provide proper curvature before resuming any wrapping.
    b. If acceptable to Engineer, drypack gaps after wrapping is completed and before shotcreting is started.
17. Wrapping over intermediate shotcrete coats or built-up shotcrete areas may commence 12 hours after shotcrete has been applied, or when the shotcrete has reached a strength of 250 psi, whichever duration is longest.
18. Prestressing strand exposed to excessive temperatures greatly increases the possibility of irrevocable damage to the strand such as steel embrittlement, stress corrosion, and strand splitting. The temperature of the prestressed strand during wrapping shall not be allowed to increase by more than 50 degrees at any time during application due to stressing technique.
19. All vertical thread bar ducting and anchors (both vertical and circumferential prestressing) shall be pressure grouted with an approved 2 part water insensitive epoxy and approved epoxy grouting equipment.

3.07 ABRASIVE BLASTING

A. Exterior surfaces of concrete walls shall be prepared prior to the commencement of any shotcreting or strand wrapping, to remove all deteriorated concrete and bondinhibiting contaminants. The surface preparation shall achieve a minimum profile of International Concrete Repair Institute (ICRI) CSP5 over a minimum of 90 percent of the surface area required to be prepared. The prestresing operator who is performing the abrasive blasting shall make available to the inspector an ICRI surface preparation sample to assist with evaluation of the surface preparation.

B. The concrete surface shall have no traces of laitance, form-oil, original surface smoothness, or surface color.

C. In order to mitigate environmental concerns, conform to environmental constraints, and achieve the desired profile, the Tank Contractor shall utilize either a self-contained mechanical etching or shot blast system, combined with a vacuum recovery system, or a high pressure water jetting system. Abrasive blasting systems which rely on sandblasting or steel shot without a vacuum recovery system, or systems that have not been used successfully in the past to prepare surfaces for shotcreting and standwrapping, will not be permitted.

3.08 SHOTCRETING

A. Shotcrete Equipment:
1. Shotcrete mixing shall be in conformance with the requirements of Section 03_30_00.
2. The delivery equipment shall be of an approved design and size that has given satisfactory results in similar previous work.
3. The equipment must be capable of discharging mixed materials into the hose under close control and it must be able to deliver a continuous smooth stream of uniformly mixed material at the proper velocity to the discharge nozzle, free from slugs of any kind.
4. The nozzle shall be of a design and size that will insure a smooth and uninterrupted flow of materials.
5. Delivery equipment shall be thoroughly cleaned at the end of each shift.
6. Equipment parts shall be regularly inspected and replaced as required.
7. The capacity of the compressor shall be large enough that the minimum amount of air to be available at the nozzle shall be no less than 400 cfm, irrespective of whether or not air from the same air supply is used for other purposes.

B. Placement and Testing of Shotcrete:
1. Shotcrete shall be applied by an ACI 506 certified nozzleman.
2. Manually applied shotcrete shall be applied with the nozzle held at a small upward angle not exceeding five degrees and constantly moving during application in a smooth motion with the nozzle pointing in a radial direction toward the center of the tank. The nozzle distance from the prestressing shall be such that shotcrete does not build up or cover the front face of the wire or strand until the spaces behind and between the prestressing elements are filled.
3. Unless applied by an automated shotcrete process, total cover coat thickness shall be controlled by shooting guide wires. Vertical wires shall be installed under tension and spaced no more than two feet apart to establish uniform and correct coating thickness. Monofilament line (100 lb. test) or 18 or 20 gauge high tensile strength steel wire shall be used. Guide wires shall be removed after placement of the cover coat.

4. Shotcrete applied by an automated shotcrete process shall be applied using the wet mix only. Nozzles shall be kept mounted on power driven machinery enabling the nozzle to travel parallel to the surface to be sprayed at a uniform linear or bi-directional speed. The nozzle shall be kept at a uniform constant distance from the surface, always maintaining a right angle spray of the material to the surface. The high velocity impact shall be developed pneumatically by injecting compressed air at the nozzle.
5. Testing:
    a. Testing shall be by an independent testing laboratory, acceptable to Engineer, and engaged by and at the expense of the Tank Contractor.
    b. Test shotcrete in accordance with ACI 506, except as specified herein. One test panel shall be made for each of the following operations: core wall, cove, wire cover, and cover coat. Test panels shall be made from the shotcrete as it is being placed, and shall, as nearly as possible, represent the material being applied. The method of making a test sample shall be as follows: A frame of wire fabric (one foot square, three inches in depth) shall be secured to a plywood panel and hung or placed in the location where shotcrete is being placed. This form shall be filled in layers simultaneously with the nearby application. After 24 hours, the fabric and plywood backup shall be removed and the sample slab placed in a safe location at the site.
    c. The sample slab shall be moist cured in a manner identical to that used for the regular surface application. The sample slab shall be sent to the testing laboratory. Nine three-inch cubes shall be cut from the sample slab and subjected to compression tests in accordance with current ASTM Standards. Three cubes shall be tested at the age of 7 days, three shall be tested at the age of 28 days, and three shall be retained as spares.

C. Shotcrete Placing and Finishing:
1. Shotcrete shall be applied in a steady, uninterrupted flow. Should the flow become intermittent for any cause, the machine operator shall direct the nozzle away from the work until it again becomes constant, or shut off the flow of materials.
2. The nozzle shall be held at approximately right angles to the surface and shall be kept at the proper and the same distance from the surface dictated by good practice standards for the type of application, type of nozzle and air pressure employed.
3. Sufficient time shall be allowed for each layer of shotcrete to set up so it may take the next layer without sagging.
4. The shotcrete shall be started at the bottom of the wall until all wrapped strand has been covered. Subsequent shotcrete layers may be applied from the top down or from the bottom up at the discretion of the Tank Contractor.
5. While the nozzle travels around the wall, the nozzle shall be raised or lowered at a uniform rate in such a manner that an adequate overlapping of coatings and a uniform finish will develop.
6. The nozzle shall be spiraled up or down around the tank to either the top or the bottom of the wall or to the termination of the intermediate strand layer.
7. To ensure proper penetration around the strand and proper conveyance of the material through the hose, a 5 to 7-inch slump of the mortar at the pump is recommended.
8. The application of the shotcrete in the number and thickness of layers specified herein is mandatory for proper penetration of shotcrete behind

prestressing material and to reduce shrinkage due to more uniform in-depth drying of the shotcrete.

9. Each layer of wrapped prestressing steel shall be covered with shotcrete until a minimum clear cover of 3/8-inch or the diameter of the strand, whichever is greater, has been placed over the prestressing steel.
10. The final cover coat, to make up for the full thickness of shotcrete over the final strand layer, shall be applied in at least 3 layers of equal thickness.
11. Each layer of shotcrete shall be completed for the full circumference of the tank and substantially the full height of that layer before the next layer of shotcrete may be applied.
12. All shotcrete coatings shall be built up in layers of approximately 3/8-inch in thickness until the final required thickness has been obtained. The Tank Contractor shall demonstrate by a reliable means that the proper thickness of shotcrete has been obtained with each layer applied.
13. Unless otherwise specified on the Drawings, the minimum shotcrete cover over all wrapped steel shall not be less than the following:
    a. For shotcrete in contact with soil: 2 inches.
    b. For other shotcrete exposures: 1.5 inches.
14. The Tank Contractor shall make provisions to protect adjacent structures, equipment, vehicles, etc., from being damaged by overshooting shotcrete and rebound materials. Overshot shotcrete deposited onto the roof slab shall be removed before it adheres to the concrete surface.
15. After the minimum shotcrete cover specified over the wrapped prestressing strand has been completed by the automated shotcrete procedure, and if such finish requirements are shown on the Drawings, the exterior surface shall be given an acceptable float finish true to line and curvature and to details shown on the Drawings.
16. If a float finish is required on the Drawings, plaster or hand-applied shotcrete may be used to build up and level the surface and to obtain the desired surface finish and projections.
17. The finish coat mix (if a smooth float finish is required on the Drawings), shall consist of a minimum of one sack of cement for each 3-1/2 cubic feet of moist plaster sand.
18. The Tank Contractor shall be responsible for all damages caused by shotcreting operations and shall bare the cost for making repairs.

D. Hand Placed Shotcrete for Repairs Only:
1. To ensure a high quality shotcrete, the Tank Contractor shall satisfy the Engineer that the nozzleman has had sufficient and acceptable experience in the application of structural shotcrete and is a certified nozzleman in accordance with ACI 506.
2. Experience gained on shotcrete pool and ditch construction will not be considered as experience for qualifying the nozzleman.
3. The nozzleman shall be capable of applying thin coats of even and uniform thickness.
4. The nozzleman's skill shall be tested and the results of such tests shall be acceptable to the Engineer before that nozzleman may start any work.

E. Restrictions on Shotcrete Operation:
1. Shotcrete shall not be applied under such strong wind conditions that a considerable amount of cement and moisture will be removed by the wind from

the mortar spray between the nozzle and the surface on which the shotcrete is applied.

2. Shotcrete may be applied in cold weather provided the surfaces are not frozen.
3. The temperature during the day must be expected to rise to at least 40 degrees Fahrenheit and the night temperature of the first night after the shotcrete application must not be expected to drop below 27 degrees Fahrenheit.
4. The use of Type 3 Portland cement is required (when readily available) in the event shotcrete is applied at temperatures below 40 degrees Fahrenheit.
5. The Tank Contractor may apply shotcrete under the conditions specified herein solely at his own risk.
6. Whenever rain or frost has damaged shotcrete which has not had a chance to set up, such shotcrete must be removed and replaced.
7. The Tank Contractor shall consult with the Engineer to determine whether or not he will accept the shotcrete damaged by rain or frost before applying any new layers of shotcrete.

F. Shotcrete Curing:
1. Intermediate layers of shotcrete shall be kept damp by hand curing or other means no sooner than 12 hours after the shotcrete has been applied.
2. Watercuring is not required should additional shotcrete be applied on the entire wall surface within the following 12 hours.
3. Indiscriminate use of continuous watercure for intermediate layers should be avoided.
4. Complete shotcrete surfaces, which do not receive any additional shotcrete coatings, shall be membrane cured with plastic for a period of at least seven (7) days. Plastic membrane used shall contain and prevent loss of moisture from shotcrete as much as possible. Membrane curing methods utilizing curing compounds or wax-based residuals will not be permitted.
5. Wall coatings, specified in Section 09_97_24 shall be applied no later than five (5) days after completion of the curing. If conditions make it impossible to apply coatings within the five (5) day period, or if no coatings are required, shotcrete shall be membrane cured for a period of ten (10) days instead of the seven (7) days specified here-in.

3.09 CLEANING

A. After construction is completed, the interior of the tank shall be completely cleaned of debris and flushed with clean water to remove all dirt and loose material.

3.10 DISINFECTING

A. The Tank Contractor shall notify the Engineer prior to disinfecting the tank.

B. Disinfect the tank floor, roof slab, and interior wall surfaces using a solution of chlorine and water per Method 3 of AWWA C652 and as specified in Section 01_75_18.

C. Prior to placing the tank in service, a bacteriological test shall be taken in accordance with AWWA C652 and successful results received. Testing shall be by an independent testing laboratory at the expense of the Owner.

3.11 FILLING AND WATERTIGHTNESS TESTING

A. Filling:
   1. The water used for the first filling of the tank will be furnished by the Owner. If the leakage test fails, the Tank Contractor shall refill the tank and retest it. The Tank Contractor shall be responsible for the cost of refilling the tank for subsequent tests.
   2. The tank shall be filled in approximately 8-foot increments with 8 working hours between each increment for observation of possible leaks through ring drains, wall, and wall-footing.

B. Testing:
   1. If only damp spots and small puddles of water are observed during filling, the filling of tank can continue. If leaks that are large enough to potentially fail the leakage test specified in Section 01_75_19 are observed, the filling process shall cease, and those leaks shall be thoroughly investigated prior to continuing to fill the tank.
   2. Fill tank with water and hold water level at 3 inches below the overflow level for a period of 24 hours.
   3. Test tank for leakage in accordance with the provisions of Section 01_75_19.
   4. Examine the tank and soil at the perimeter of the tank footings for evidence of leaks.
      a. Acceptance criteria shall be as specified in Section 01_75_19.

C. Repairing tank leaks:
   1. Repair leaks to satisfaction of the Engineer.
   2. Any areas that, in opinion of the Engineer, are exposed to contamination during repair work shall be sprayed with disinfection water mix.
   3. Leakage through joints, which may have resulted from bent over waterstops or honeycomb under or around waterstops, may require removal of concrete around waterstops in suspected areas.
   4. Repair of chipped out concrete areas:
      a. Coat chipped out concrete surface with epoxy bonding agent.
      b. Properly drypack with drypack mix for repair of concrete tank areas.
   5. Any cracks, voids, honeycomb, or cold joints showing or causing running leaks of water, shall be repaired by epoxy injection as specified in Section 03_64_24 until such cracks and voids have been completely sealed.

END OF SECTION

SECTION 46_05_10

COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic design and performance requirements for building mechanical equipment and process mechanical equipment.

B. Related sections:
1. Section 01_33_00 - Submittal Procedures.
2. Section 01_60_00 - Product Requirements.
3. Section 01_75_17 - Commissioning.
4. Section 01_77_00 - Closeout Procedures.
5. Section 01_78_23 - Operating and Maintenance Data.
6. Section 01_81_01 - Project Design Criteria.
7. Section 01_81_02 - Seismic Design Criteria.
8. Section 03_60_00 - Grouting.
9. Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
10. Section 05_12_00 - Structural Steel.
11. Section 09_96_01 - High-Performance Coatings.
12. Section 10_14_00 - Signage.
13. Section 26_05_09 - Low Voltage Motors Up to 500 Horsepower.
14. Section 26_08_50 - Field Electrical Acceptance Tests.
15. Section 40_05_00.01 - Common Work Results for General Piping.
16. Section 40_05_06.55 - Piping Insulation.
17. Section 40_05_51.01 - Common Work Results for Valves.
18. Section 40_67_01 - Control Systems: Panels, Enclosures, and Panel Components.
19. Section 40_80_01 - Testing, Calibration, and Commissioning.
20. Section 46_05_94 - Mechanical Equipment Testing.

1.02 REFERENCES

A. American Gear Manufacturer's Association (AGMA) Standards:
1. 6001-E08 - Design and Selection of Components for Enclosed Gear Drives.

B. American Bearing Manufactures Association (ABMA) Standards:
1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. American Petroleum Institute (API):
1. 682 - Shaft Sealing Systems for Centrifugal and Rotary Pumps.

D. ASTM International (ASTM):
1. A36 - Standard Specification for Carbon Structural Steel.
2. A48 - Standard Specification for Gray Iron Castings.
3. A125 - Standard Specification for Steel Springs, Helical, Heat-Treated.

4. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
6. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
7. A536 - Standard Specification for Ductile Iron Castings.
8. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
9. B61 - Standard Specification for Steam or Valve Bronze Castings.
10. B62 - Standard specification for Composition Bronze or Ounce Metal Castings.
11. B505 - Standard Specification for Copper Alloy Continuous Castings.
12. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
13. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
14. F594 - Standard Specification for Stainless Steel Nuts.

E. Hydraulic Institute (HI).

F. Occupational Safety and Health Administration (OSHA).

G. Unified Numbering System (UNS).

1.03 DEFINITIONS

A. Resonant frequency: That frequency at which a small driving force produces an ever-larger vibration if no dampening exists.

B. Rotational frequency: The revolutions per unit of time usually expressed as revolutions per minute.

C. Critical frequency: Same as resonant frequency for the rotating elements or the installed machine and base.

D. Peak vibration velocity: The root mean square average of the peak velocity of the vibrational movement times the square root of 2 in inches per second.

E. Rotational speed: Same as rotational frequency.

F. Maximum excitation frequency: The excitation frequency with the highest vibration velocity of several excitation frequencies that are a function of the design of a particular machine.

G. Critical speed: Same as critical frequency.

H. Free field noise level: Noise measured without any reflective surfaces (an idealized situation); sound pressure levels at 3 feet from the source unless specified otherwise.

I. Operating weight: The weight of unit plus weight of fluids or solids normally contained in unit during operation.

1.04 DESIGN REQUIREMENTS

A. General:
   1. Product requirements as specified in Section 01_60_00.
   2. Project conditions as specified in Section 01_81_01.
   3. Provisions specified under each technical equipment specification prevail over and supersede conflicting provisions specified in this Section.
   4. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries required for proper operation.
   5. Vibration considerations:
      a. Resonant frequency:
         1) For single-speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the operating rotational frequencies or multiples of the operating rotational frequencies that may be excited by the equipment design.
         2) For variable-speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the range of operating frequencies.
      b. Design, balance, and align equipment to meet the vibration criteria specified in Section 46_05_94.
   6. Equipment units weighing 50 pounds or more: Provide with lifting lugs or eyes to allow removal with hoist or other lifting device.

B. Power transmission systems:
   1. V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, variable frequency drives, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints are to be rated for 24 hour-a-day continuous service or frequent stops-and-starts intermittent service, whichever is most severe, and sized with a service factor of 1.5 or greater in accordance with manufacturer recommendations:
      a. Apply service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
      b. Apply service factors in accordance with AGMA 6001-E08, other applicable AGMA standards, or other applicable referenced standards.

C. Equipment mounting and anchoring:
   1. Mount equipment on cast-iron or welded-steel bases with structural steel support frames.
      a. Utilize continuous welds to seal seams and contact edges between steel members.
      b. Grind welds smooth.
   2. Provide bases and supports with machined support pads, dowels for alignment of mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits.
   3. Provide jacking screws in bases and supports for equipment weighing over 1,000 pounds.
   4. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load specified in

Section 01_81_02, and other loads as required for proper operation of equipment.

a. For equipment with an operating weight of 400 pounds or greater and all equipment that is supported higher than 4 feet above the floor, provide calculations for:
    1) The operating weight and location of the centroid of mass for the equipment.
    2) Forces and overturning moments.
    3) Shear and tension forces in equipment anchorages, supports, and connections.
    4) The design of equipment anchorage, supports, and connections based on calculated shear and tension forces.

5. Anchorage of equipment to concrete or masonry:
    a. Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
    b. Unless otherwise indicated on the Drawings, select and provide anchors from the types specified in Section 05_05_24.
    c. Provide bolt sleeves around cast-in anchor bolts for 400 pounds or greater equipment.
        1) Adjust bolts to final location and secure the sleeve.
6. Anchorage of equipment to metal supports:
    a. Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.
7. Unless otherwise indicated on the Drawings, install equipment supported on concrete over non-shrink grout pads as specified in this Section.

1.05 SUBMITTALS

A. As specified in Section 01_60_00.

B. Product data:
1. For each item of equipment:
    a. Design features.
    b. Load capacities.
    c. Efficiency ratings.
    d. Material designations by UNS alloy number or ASTM Specification and Grade.
    e. Data needed to verify compliance with the Specifications.
    f. Catalog data.
    g. Nameplate data.
    h. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
2. Gear reduction units:
    a. Engineering information in accordance with applicable AGMA standards.
    b. Gear mesh frequencies.

C. Shop drawings:
1. Drawings for equipment:
    a. Drawings that include cut-away drawings, parts lists, material specification lists, and other information required to substantiate that proposed equipment complies with specified requirements.

2. Outline drawings showing equipment, driver, driven equipment, pumps, seal, motor(s) or other specified drivers, variable frequency drive, shafting, U-joints, couplings, drive arrangement, gears, base plate or support dimensions, anchor bolt sizes and locations, bearings, and other furnished components.
3. Installation instructions including leveling and alignment tolerances, grouting, lubrication requirements, and initial Installation Testing procedures.
4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
5. Recommended or normal operating parameters such as temperatures and pressures.
6. Alarm and shutdown setpoints for all controls furnished.

D. Calculations:
1. Structural:
a. Substantiate equipment base plates, supports, bolts, anchor bolts, and other connections meet minimum design requirements specified and seismic design criteria as specified in Section 01_81_02.
2. Mechanical:
a. ABMA 9 or ABMA 11 L10 life for bearings calculation methods for drivers, pumps, gears, shafts, motors, and other driveline components with bearings.
b. Substantiate that operating rotational frequencies meet the requirements of this Section.
c. Torsional analysis of power transmission systems: When torsional analysis specified in the equipment sections, provide:
1) Sketch of system components identifying physical characteristics including mass, diameter, thickness, and stiffness.
2) Results of analysis including first and second critical frequencies of system components and complete system.
d. Calculations shall be signed and stamped by a licensed engineer.
3. Drinking water:
a. If applicable, conform to the requirements of Section 01_60_00 for materials in contact with drinking water.

E. Operation and maintenance manuals:
1. As specified in Section 01_78_23.
2. Equipment with bearings:
a. Include manufacturer and model number of every bearing.
b. Include calculated ball pass frequencies of the installed equipment for both the inner and outer raceways.

F. Commissioning submittals: As specified in Section 01_75_17.

G. Project closeout documents: As specified in Section 01_77_00.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials as specified in Section 01_60_00 including special requirements for materials in contact with drinking water.

B. Ferrous materials:
1. Steel for members used in fabrication of assemblies: ASTM A36.
2. Iron castings: ASTM A48, tough, close-grained gray iron, free from blowholes, flaws, and other imperfections.
3. Ductile iron castings: ASTM A536, Grade 65-45-12, free from flaws and imperfections.
4. Galvanized steel sheet: ASTM A653, minimum 0.0635 inch (16 gauge).
5. Expanded metal: ASTM A36, 13 gauge, 1/2-inch flat pattern expanded metal.
6. Stainless steel:
   a. As specified in Section 05_12_00.
   b. In contact or within 36 inches of water: Type 316 or 316L.
   c. In sea air environment: Type 316 or 316L.
   d. Other locations: Type 304 or 304L.
   e. Source cleaning and passivation as specified in Section 05_12_00.

C. Non-ferrous materials:
1. Bronze in contact with drinking water: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C89833 or C89520 in accordance with ASTM B61, B62, B505, or B584, when not specified otherwise.

D. Dielectric materials for separation of dissimilar metals:
1. Neoprene, bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other materials as specified.

E. Non-shrink grout and epoxy non-shrink grout: As specified in Section 03_60_00.

2.02 ANCHORS AND FASTENERS

A. Mechanical anchoring to concrete and masonry:
1. As specified in Section 05_05_24:
   a. Type 316 stainless steel.
2. Design as specified in Section 01_81_02.

B. High-strength fasteners:
1. As specified in Section 05_12_00.

C. Flange bolts:
1. As specified in Section 40_05_00.01.

D. Mechanical assembly fasteners:
1. Stainless steel:
   a. High-temperature service or high-pressure service:
      1) Bolts: ASTM A193, Grade B8 (Type 304) or Grade B8M (Type 316), Class 1, heavy hex.
      2) Nuts: ASTM A194, Grade 8, heavy hex.
      3) Washers: Alloy group matching bolts and nuts.
   b. Low-temperature service:
      1) Bolts: ASTM A320, Grade B8 (Type 304) or Grade B8M (Type 316), Class 1, heavy hex.
      2) Nuts: ASTM A194, Grade 8 (Type 304) or Grade B8M (Type 316), heavy hex.
      3) Washers: Alloy group matching bolts and nuts.

c. General service:
    1) Bolts: ASTM F593, Alloy Group 1 (Type 304) or Alloy Group 2 (Type 316).
    2) Nuts: ASTM F594, Alloy Group 1 (Type 304) or Alloy Group 2 (Type 316).
    3) Washers: Alloy group matching bolts and nuts.

2.03 SHAFT COUPLINGS

A. General:
1. Type and ratings: Provide non-lubricated type, designed for not less than 50,000 hours of operating life.
2. Sizes: Provide as recommended by manufacturer for specific application, considering horsepower, speed of rotation, and type of service.

B. Shaft couplings for close-coupled electric-motor-driven equipment:
1. Use for:
    a. Equipment 1/2 horsepower or larger.
    b. Reversing equipment.
    c. Equipment subject to sudden torque reversals or shock loading:
    d. Examples:
        1) Reciprocating pumps, blowers, and compressors.
        2) Conveyor belts.
2. Manufacturers: One of the following or equal:
    a. Lovejoy.
    b. T.B. Woods.
3. Provide flexible couplings designed to accommodate angular misalignment, parallel misalignment, and end float.
4. Manufacture flexible component of coupling from synthetic rubber or urethane.
5. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
6. Do not allow metal-to-metal contact between driver and driven equipment.

C. Shaft couplings for direct-connected electric-motor-driven equipment:
1. Use for 1/2 horsepower or larger and subject to normal torque, non-reversing applications.
2. Manufacturers: One of the following or equal:
    a. Rexnord.
    b. T.B. Woods.
3. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.
4. Provide flexible connecting element of rubber and reinforcement fibers.
5. Provide service factor of 2.0.
6. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.

D. Spacer couplings: Where cartridge-type mechanical seals or non-split seals are specified, provide a spacer-type coupling of sufficient length to remove the seal without disturbing the driver or driven equipment unless noted otherwise in the individual equipment specifications.

E. Specialized couplings: Where requirements of equipment dictate specialized features, supply coupling recommended for service by manufacturer:
   1. Includes any engine-driven equipment.

2.04 STUFFING BOX, SEAL CHAMBER, AND SHAFT SEALS

A. General:
   1. Unless otherwise noted in the equipment section, provide cartridge-type, double mechanical shaft seals for pumps.
   2. Provide a stuffing box large enough for a double mechanical seal.
   3. Where packing is specified, provide stuffing box large enough to receive a double mechanical seal.
   4. Provide seal or packing flush connections, (3/4-inch size unless another size is indicated on the Drawings).
   5. Provide and route leakage drain line to nearest equipment floor drain indicated on the Drawings.
   6. For pumps with packing, design packing gland to allow adjustment and repacking without dismantling pump except to open up packing box.
   7. Seal or packing flush requirements shall be in accordance with API Standard 682 requirements. Unless otherwise indicated, specified or required by the equipment and seal manufacturers, the following API flushing Plan arrangements shall be utilized as appropriate for the application:
      a. Single seal, clean water applications: Plan 11 (Discharge bypass to seal).
      b. Single seal, vertical pump applications: Plan 13 (Seal bypass to suction).
      c. Single seal, clean hot water (greater than 180 degrees Fahrenheit) applications: Plan 23 (Seal cooler and pumping ring).
      d. Single seal, solids, or contaminants containing water applications: Plan 32 (External seal water).
      e. Double seal applications: Plan 54 (External seal water).

B. Packing: When specified in the equipment section of the specifications, provide the following type of packing:
   1. Wastewater, water, and sludge applications:
      a. Asbestos free.
      b. PTFE (Teflon) free.
      c. Braided graphite.
      d. Manufacturers: One of the following or equal:
         1) Chesterton, 1400.
         2) John Crane, equivalent product.
   2. Drinking water service:
      a. Asbestos free.
      b. Material: Braided PTFE (Teflon).
      c. Manufacturers: One of the following or equal:
         1) Chesterton, 1725.
         2) John Crane, equivalent product.

C. Mechanical seals: Provide seal types specified in the equipment sections and as specified.
   1. Provide seal types meeting the following requirements:
      a. Balanced hydraulically.
      b. Spring: Stationary, out of pumping fluid, Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.

c. O-ring: Viton 747.
d. Gland: Type 316L stainless steel.
e. Set screws: Type 316L stainless steel.
f. Faces: Reaction bonded, silicon carbide.
g. Seal designed to withstand 300 pounds per square inch gauge minimum differential pressures in either direction; no requirement for seal buffer pressure to be maintained when pump is not operational even though process suction head may be present in pump.

2. Cartridge-type single mechanical: Manufacturers: One of the following or equal:
   a. Chesterton, S10.
   b. John Crane, 5610 Series.
3. Cartridge-type double mechanical: Manufacturers: One of the following or equal:
   a. Chesterton, S20.
   b. John Crane, 5620 Series.
4. Split-face single mechanical: Manufacturers: One of the following or equal:
   a. Chesterton, 442.
   b. John Crane, 3740.

2.05 GEAR REDUCTION UNITS

A. Type: Helical or herringbone, unless otherwise specified.

B. Design:
   1. Made of alloys treated for hardness and for severe service.
   2. AGMA Class II service:
      a. Use more severe service condition when such is recommended by unit's manufacturer.
   3. Cast-iron housing with gears running in oil.
   4. Anti-friction bearings.
   5. Thermal horsepower rating based on maximum horsepower rating of prime mover, not actual load.
   6. Manufactured in accordance with applicable AGMA standards.

C. Planetary gear units are not to be used.

2.06 BELT DRIVES

A. Sheaves:
   1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap tightening screws.
   2. When 2 sheave sizes are specified, provide separate belts sized for each set of sheaves.
   3. Statically balanced for all; dynamically balanced for sheaves that operate at a peripheral speed of more than 5,500 feet per minute.
   4. Key bushings to drive shaft.

B. Belts: Anti-static type when explosion-proof equipment or environment is specified.
   1. When spare belts are specified, furnish 1 spare belt for every different type and size of belt-driven unit:
      a. Where 2 or more belts are involved, furnish matched sets.

b. Identify as to equipment, design, horsepower, speed, length, sheave size, and use.
c. Package in boxes labeled with identification of contents.

C. Manufacturers: One of the following or equal:
1. Dodge, Dyna-V belts with matching Dyna-V sheaves and Taper-Lock bushings.
2. T.B. Woods, Ultra-V belts with matching Sure-Grip sheaves and Sure-Grip bushings.

2.07 BEARINGS

A. Type: Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.

B. Oil-lubricated bearings: Provide either pressure lubricating system or separate oil reservoir splash-type system:
1. Size oil-lubrication systems to safely absorb heat energy generated in bearings when equipment is operating under normal conditions and with the temperature 15 degrees Fahrenheit above the maximum design temperature as specified in Section 01_81_01.
2. Provide an external oil cooler when required to satisfy the specified operating conditions:
a. Provide air-cooled system if a water-cooling source is not indicated on the Drawings.
b. Equip oil cooler with a filler pipe and external level gauge.

C. Grease lubricated bearings, except those specified to be factory sealed: Fit with easily accessible grease supply, flush, drain, and relief fittings.
1. Lubrication lines and fittings:
a. Lines: Minimum 1/4-inch diameter stainless steel tubing.
b. Multiple fitting assemblies: Mount fittings together in easily accessible location.
c. Use standard hydraulic-type grease supply fittings:
1) Manufacturers: One of the following or equal:
a) Alenite.
b) Zerk.

D. Ratings: Rated in accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours:

2.08 MOTORS

A. As specified in Section 26_05_09.

2.09 GEAR MOTORS

A. Motors as specified in Section 26_05_09.

B. Helical gearing for parallel shaft drives and worm gearing for right-angle drives.

C. One of the following or equal:
1. Baldor Electric Company.

2. Bodine Electric Company.

2.10 VENDOR CONTROL PANELS

A. As specified in Section 40_67_01.

2.11 EQUIPMENT SUPPORT FRAMES

A. Bolt holes shall not exceed bolt diameter by more than 25 percent, up to a limiting maximum diameter oversize of 1/4 inch.

2.12 PIPING AND VALVES

A. Piping as specified in Section 40_05_00.01.

B. Valves as specified in Section 40_05_51.01.

2.13 SAFETY EQUIPMENT

A. Safety guards:
   1. Provide guards that protect personnel from rotating shafts or components within 7.5 feet of floors or operating platforms.
   2. Requirements:
      a. Allow visual inspection of moving parts without removal.
      b. Allow access to lubrication fittings.
      c. Prevent entrance of rain or dripping water for outdoor locations.
      d. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.
   3. Materials:
      a. Sheet metal: Carbon steel, 12-gauge minimum thickness, hot-dip galvanized after fabrication.
      b. Fasteners: Type 304 stainless steel.

B. Insulation:
   1. Insulate all surfaces with normal operating temperatures above 120 degrees Fahrenheit when surface is within 7.5 feet height from any operating floor or level.
   2. Insulation thickness such that temperature is below 120 degrees Fahrenheit.
   3. Insulation Type 3 and cover Type 5 as specified in Section 40_05_06.55.

C. Warning signs:
   1. Provide warning signs in accordance with OSHA requirements for equipment that starts automatically or remotely.
   2. Material, sign size, and text: As specified in Section 10_14_00.
   3. Mount warning signs with stainless steel fasteners at equipment.

2.14 SPRING VIBRATION ISOLATORS

A. Design requirements:
   1. Telescopic top and bottom housing with vertical stabilizers to resist lateral and vertical forces.

2. Use steel coil springs.
3. Design vibration isolators in accordance with seismic design criteria as specified in Section 01_81_02.

B. Performance requirements: Minimum spring deflection of 1 inch under static load and capable of limiting transmissibility to 15 percent maximum at design operating load.

C. Manufacturers: One of the following or equal:
1. California Dynamics Corporation, Type RJSD.
2. Mason Industries, equivalent product.

D. Materials:
1. Fabricate isolators using welded-steel or shatterproof ductile iron in accordance with ASTM A536 Grade CS-45-12.
2. Spring steel: ASTM A125.

2.15 NAMEPLATES

A. Fastened to equipment at factory in an accessible and visible location.

B. Stainless steel sheet engraved or stamped with text, holes drilled or punched for fasteners.

C. Fasteners: Number 4 or larger oval head stainless steel screws or drive pins.

D. Text:
1. Manufacturer’s name, equipment model number and serial number, motor horsepower when appropriate, and identification tag number.
2. Indicate the following additional information as applicable:
   a. Maximum and normal rotating speed.
   b. Service class per applicable standards.
3. Include for pumps:
   a. Rated total dynamic head in feet of fluid.
   b. Rated flow in gallons per minute.
   c. Impeller, gear, screw, diaphragm, or piston size.
4. Include for gear reduction units:
   a. AGMA class of service.
   b. Service factor.
   c. Input and output speeds.

2.16 SHOP FINISHES

A. Provide appropriate factory coatings as specified in Section 09_96_01.
1. Motors and gear reducers: Shop finish paint with manufacturer's standard coating, unless otherwise specified in the individual equipment specification.

2.17 SPECIAL TOOLS

A. Supply one set of special tools as specified in Section 01_60_00.

2.18 SOURCE TESTING

A. Testing requirements unless specified otherwise in the individual equipment specifications:
   1. Mechanical equipment: Level 1 General Equipment Performance Test as specified in Section 46_05_94.
   2. Motors: As specified in Section 26_05_09.
   3. Vendor control panels: As specified in Section 40_80_01.

2.19 SHIPPING

A. As specified in Section 01_60_00.

B. Prior to shipment of equipment:
   1. Bearings (and similar items):
      a. Pack separately or provide other protection during transport.
      b. Greased and lubricated.
   2. Gear boxes:
      a. Oil filled or sprayed with rust preventive protective coating.
   3. Fasteners:
      a. Inspect for proper torques and tightness.

PART 3 EXECUTION

3.01 DELIVERY, HANDLING, STORAGE, AND PROTECTION

A. As specified in Section 01_60_00.

B. Inspect fasteners for proper torques and tightness.

C. Storage:
   1. Bearings:
      a. Rotate units at least once per month or more often as recommended by the manufacturer to protect rotating elements and bearings.
   2. Gear boxes:
      a. Inspect to verify integrity of protection from rust.

D. Protection:
   1. Equipment Log shall include description of rotation performed as part of maintenance activities.

3.02 INSTALLATION

A. Field measurements:
   1. Prior to shop drawings preparation, take measurements and verify dimensions indicated on the Drawings.
   2. Ensure equipment and ancillary appurtenances fit within available space.

B. Sequencing and scheduling:
   1. Equipment anchoring: Obtain anchoring material and templates or setting drawings from equipment manufacturers in adequate time for anchors to be cast-in-place.

2. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.

C. Metal work embedded in concrete:
   1. Accurately place and hold in correct position while concrete is being placed.
   2. Clean surface of metal in contact with concrete immediately before concrete is placed.

D. Concrete surfaces designated to receive non-shrink grout:
   1. Heavy sandblast concrete surface in contact with non-shrink grout.
   2. Clean concrete surfaces of sandblasting sand, grease, oil, dirt, and other foreign material that may reduce bond to non-shrink grout.
   3. Saturate concrete with water. Concrete shall be saturated surface damp at time non-shrink grout is placed.

E. Install equipment in accordance with manufacturer's installation instructions and recommendations.

F. Lubrication lines and fittings:
   1. Support and protect lines from source to point of use.
   2. Fittings:
      a. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
      b. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
      c. Fittings for underwater bearings: Bring fittings above water surface and mount on edge of structure above.

G. Alignment of drivers and equipment:
   1. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after complete unit has been leveled on its foundation.
   2. Comply with procedures of appropriate HI, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
      a. Maximum total coupling offset (not the per-plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).
      b. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.
   3. Use reverse-indicator arrangement dial-type or laser-type alignment indicators: Mount indicators on the driver/coupling flange and equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.
   4. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.

5. When alignment satisfies most stringent tolerance of system components, grout between base and foundation.
    a. Allow minimum 48 hours for grout to harden.
    b. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
    c. Correct alignment as required.
6. After functional testing is complete, dowel motor or drivers and driven equipment:
    a. Comply with manufacturer's instructions.

H. Grouting under equipment bases, baseplates, soleplates, and skids:
1. Unless otherwise indicated on the Drawings, grout with non-shrink grout as specified in Section 03_60_00.
    a. Non-shrink epoxy grout required only when indicated on the Drawings.
2. Comply with equipment manufacturer's installation instructions for grouting spaces, and tolerances for level and vertical and horizontal alignment.
3. Install grout only after:
    a. Equipment is leveled and in proper alignment.
    b. Piping connections are complete and in alignment with no strain transmitted to equipment.
4. Do not use leveling nuts on equipment anchors for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting.
5. Use jack screws for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting following the procedure defined below:
    a. Drill and tap equipment base plates, sole plates, and skids for jack screws.
    b. Use suitable number and size of jack screws.
    c. End of jack screws shall bear on circular steel plates epoxy bonded to equipment foundation.
    d. Jack screw threads that will be in contact with grout: Wrap with multiple layers of tape or other material, acceptable to Engineer, to prevent grout from bonding to threads.
    e. Place and cure grout as specified in Section 03_60_00.
    f. After grout is cured, remove jack screws and material used to prevent bonding to grout.
        1) Provide jack screws to Owner for future use.
    g. Tighten equipment anchors in accordance with equipment manufacturer requirements.
    h. Fill holes where jack screws have been removed with grout.
    i. Cure as specified in Section 03_60_00.
6. For equipment bases, baseplates, soleplates, and skids where it is not practical to use jack screws, use steel wedges and shims.
    a. Wrap wedges and shims that contact grout with multiple layers of tape or other material, acceptable to Engineer, to prevent grout from bonding.
    b. Place and cure grout as specified in Section 03_60_00.
    c. Remove wedges or shims.
    d. Tighten equipment anchors to in accordance with equipment manufacturer requirements.
    e. Fill voids where wedges and shims have been removed with grout.
    f. Cure as specified in Section 03_60_00.

7. Preparation of equipment bases, baseplates, soleplates, and skids for grouting:
   a. Metal in contact with grout: Grit blast to white metal finish.
   b. Clean surfaces of equipment bases, baseplates, soleplates, and skids in contact with grout of dirt, dust, oil, grease, paint, and other material that will reduce bond.
8. Preparation of concrete equipment foundation for grouting:
   a. Rough concrete surfaces in contact with grout.
   b. Concrete contact surface shall be free of dirt, dust, laitance, particles, loose concrete, or other material or coatings that will reduce bond.
   c. Saturate concrete contact surface area with water for minimum of 24 hours prior to grouting.
   d. Remove standing water just prior to grout placement, using clean rags or oil-free compressed air.

9. Forms and header boxes:
   a. Build forms for grouting of material with adequate strength to withstand placement of grouts.
   b. Use forms that are rigid and liquid tight. Caulk cracks and joints with an elastomeric sealant.
   c. Line forms with polyethylene film for easy grout release. Forms carefully waxed with 2 coats of heavy-duty paste wax will also be acceptable.
10. Grout placement requirements:
   a. Minimum ambient and substrate temperature: 45 degrees Fahrenheit and rising:
      1) Conform to grout manufacturer's temperature requirements.
   b. Pour grout using header box.
   c. Keep level of grout in header box above bottom of equipment bases, baseplates, soleplates, and skids at all times to prevent air entrapment.
   d. Grout shall flow continuously from header box to other side of forms without trapping air or forming voids.
   e. Vibrate, rod, or chain grout to facilitate grout flow, consolidate grout, and remove entrapped air.
   f. After grout sets, remove forms and trim grout at 45-degree angle from bottom edge of equipment bases, baseplates, soleplates, and skids.
   g. Cure as specified in Section 03_60_00.

I. Special techniques:
   1. Use applicable special tools and equipment, including precision machinist levels, dial indicators, and gauges as required in equipment installations.

J. Tolerances:
   1. Completed equipment installations: Comply with requirements for intended use and specified vibration and noise tolerances.

K. Warning signs:
   1. Mount securely with stainless fasteners at equipment that can be started automatically or from remote locations.

3.03 FIELD PAINTING

A. Compatible with factory painting.

B. As specified in Section 09_96_01.

3.04 COMMISSIONING

A. As specified in Section 01_75_17.

B. Functional testing requirements unless specified otherwise in the individual equipment specifications:
   1. Mechanical equipment: Level 1 tests as specified in Section 46_05_94.
   2. Motors: As specified in Sections 26_05_09 and 26_08_50.
   3. Vendor control panels: As specified in Section 40_80_01.

END OF SECTION

SECTION 46_05_11

EQUIPMENT IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Equipment nameplates.
   2. Special items.

B. Related sections:
   1. Section 01_33_00 - Submittal Procedures.
   2. Section 01_60_00 - Product Requirements.
   3. Section 01_77_00 - Closeout Procedures.
   4. Section 09_96_01 - High-Performance Coatings.

1.02 SUBMITTAL

A. Submit as specified in Section 01_33_00.

B. Shop drawings:
   1. Product data.
   2. Installation instructions.

C. Samples.

1.03 QUALITY ASSURANCE

A. Regulatory requirements: Comply with requirements of the state of California.

PART 2 PRODUCTS

2.01 EQUIPMENT NAMEPLATES

A. Material and fabrication:
   1. Stainless steel sheet engraved or stamped with text, holes drilled, or punch for fasteners.

B. Fasteners:
   1. Number 4 or larger oval head stainless steel screws or drive pins.

C. Text:
   1. Manufacturer's name, equipment model number and serial number, identification tag number; and when appropriate, drive speed, motor horsepower with rated capacity, pump rated total dynamic head, and impeller size.

2.02 SPECIAL ITEMS

A. In addition, special coating of following items will be required:

Item	Color
Valve handwheels and levers	Match adjacent piping
Hoist hooks and blocks	Yellow and black stripes
Steel guard posts	In accordance with standard details

B. Paint minimum 2 inches high numbers on or adjacent to accessible valves, pumps, flowmeters, and other items of equipment which are indicated on the Drawings or in Specifications by number.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01_60_00.

3.02 PREPARATION

A. Prepare and coat surfaces of special items as specified in Section 09_96_01.

B. Prepare surface in accordance with product manufacturer's instructions.

END OF SECTION

SECTION 46_05_94

MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Testing of mechanical equipment and systems.

B. Related sections:
   1. Section 01_75_17 - Commissioning.
   2. Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
   3. Section 31_23_17 - Trenching.
   4. Section 40_05_00.09 - Piping Systems Testing.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. S1.4 Specification for Sound Level Meters.

B. Hydraulic Institute (HI).

C. National Institute of Standards and Technology (NIST).

1.03 SUBMITTALS

A. Schedule of source (factory) tests, Owner training, installation testing, functional testing, clean water facility testing, closeout documentation, process start-up and process operational period as specified in this Section and in Section 01_75_17 and equipment sections.

B. Test instrumentation calibration data:

C. Operation and maintenance manual:
   1. Include motor rotor bar pass frequencies for motors larger than 500 horsepower.

D. Commissioning and Process Start-up Plan: As specified in Section 01_75_17.

E. Test plan as specified in Section 01_75_17 and equipment sections.

F. Test reports as specified in this Section and in Section 01_75_17 and equipment sections.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 GENERAL

A. Commissioning and process start-up of equipment as specified in:
   1. This Section.
   2. Section 01_75_17.
   3. Equipment sections.
      a. If testing requirements are not specified, provide Level 1 Tests.

B. Comply with latest version of applicable standards.

C. Test and prepare piping as specified in Sections 31_23_17 and 40_05_00.09.

D. Provide necessary test instrumentation that has been calibrated within 1 year from date of test to recognized test standards traceable to the NIST or approved source.
   1. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for tests.
   2. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.

E. Test measurement and result accuracy:
   1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments.
      a. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
   2. Do not adjust results of tests for instrumentation accuracy.
      a. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

F. Report features:
   1. Report results in a bound document in generally accepted engineering format with title page, written summary of results compared to specified requirements, and appropriate curves or plots of significant variables in English units.
   2. Include appendix with a copy of raw, unmodified test data sheets indicating test value, date and time of reading, and initials of person taking the data.
   3. Include appendix with sample calculations for adjustments to raw test data and for calculated results.
   4. Include appendix with the make, model, and last calibration date of instrumentation used for test measurements.
   5. Include in body of report a drawing or sketch of the test system layout showing location and orientation of the test instruments relative to the tested equipment features.

G. Provide necessary fluids, utilities, temporary piping, temporary supports, temporary access platforms or access means and other temporary facilities and labor necessary to safely operate the equipment and accomplish the specified testing.
   1. With Owner's permission, some utilities may be provided by fully tested permanently installed utilities that are part of the Work.

H. Prepare and submit test reports as specified.

I. Testing levels:
   1. Level 1 Tests:
      a. Level 1 General Equipment Performance Test:
         1) For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.
         2) Operate at rated design load conditions.
         3) Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
      b. Level 1 Pump Performance Test:
         1) Measure flow and head while operating at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
         2) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 26_05_09 or the applicable equipment section. Use actual driver for field tests.
         3) Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.
      c. Level 1 Vibration Test:
         1) Test requirement:
            a) Measure filtered vibration spectra versus frequency in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component.
            b) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
         2) Equipment operating condition: Test at specified maximum speed.
      d. Level 1 Noise Test:
         1) Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.
   2. Level 2 Tests:
      a. Level 2 General Performance Test:
         1) For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
         2) Operate at rated design load conditions.
         3) Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
      b. Level 2 Pump Performance Test:
         1) Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at a reduced speeds with flow and

head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.

2) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 26_05_09. Use actual driver for field tests.

3) Test for flow and head at 2 additional conditions; 1 at 25 percent below the rated flow and 1 at 10 percent above the rated flow.

4) Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.

c. Level 2 Vibration Test:

1) Test requirement:

a) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.

b) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.

2) Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.

3) Natural frequency test of field installed equipment:

a) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears, and supports.

b) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.

c) Perform with equipment and attached piping full of intended service or process fluid.

d. Level 2 Noise Test:

1) Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at 3 feet horizontally from the surface of the equipment at mid-point height of the noise source.

3. Level 3 Tests:

a. Level 3 General Equipment Performance Tests:

1) For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.

2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.

3) Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.

4) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
5) Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.

b. Level 3 Pump Performance Test:
1) Test 4 hours minimum for flow and head at or near the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
2) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 26_05_09. Use actual driver for field tests.
3) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes; for factory testing, test at other speeds may be omitted if test driver at reduced speeds is used for rated condition testing.
4) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.

c. Level 3 Vibration Test:
1) Requirements: Same as Level 2 vibration test except data taken at each operating condition tested and with additional requirements below.
2) Perform High Frequency Enveloping Analysis for gears and bearings.
a) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a smooth surface and direct path to the bearing to detect bearing defects.
b) Report results in units of acceleration versus frequency in cycles per minute.
3) Perform Time Wave Form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).
4) Plot vibration spectra on 3 different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.

d. Level 3 Noise Test: Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at 4 locations approximately 90 degrees apart in plan view; report results for each of 8 octave band mid-points beginning at 63 hertz.

4. Level 4 Tests:
   a. Level 4 General Equipment Performance Test:
      1) For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.
      2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
      3) Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.
      4) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
      5) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
   b. Level 4 Pump Performance Test:
      1) Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test with furnished motor at full speed.
      2) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
      3) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.
      4) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
      5) Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
         a) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
         b) Perform efficiency testing with test fluids at maximum rated speed.
         c) Perform priming time testing with test fluids at maximum rated speed.
   c. Level 4 Vibration Test: Same as Level 3 vibration test.
   d. Level 4 Noise Test: Same as Level 3 Noise Test except with data taken at each operating condition tested.

J. Variable speed equipment tests:
   1. Establish performance over the entire speed range and at the average operating condition.
   2. Establish performance curves for the following speeds:
      a. The speed corresponding to the rated maximum capacity.
      b. The speed corresponding to the minimum capacity.
      c. The speed corresponding to the average operating conditions.

K. Pump tests, all levels of testing:
   1. Test in accordance with the following:
      a. Applicable HI Standards.
      b. This Section.
      c. Equipment sections.
   2. Test tolerances: In accordance with appropriate HI Standards, except the following modified tolerances apply:
      a. From 0 to plus 5 percent of head at the specified flows.
      b. From 0 to plus 5 percent of flow at the rated design point head.
      c. No negative tolerance for the efficiency at the specified flows.
      d. No positive tolerance for vibration limits. Vibration limits and test methods in HI Standards do not apply, use limits, and methods specified in this or other Sections of the Specifications.

L. Drivers tests:
   1. Test motors as specified in Section 26_05_09.
   2. Test other drivers as specified in the equipment section.

M. Noise requirements and control:
   1. Perform noise tests in conjunction with vibration test analysis.
   2. Make measurements in relation to reference pressure of 0.0002 microbar.
   3. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.
   4. Set sound level meter to slow response.
   5. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.

N. Pressure testing:
   1. Hydrostatically pressure test pressure containing parts at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher.

O. Inspection and balancing:
   1. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits.
   2. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.
   3. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.

P. Critical speed of rotating equipment:
1. Satisfy the following:
a. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, all non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment's maximum operating speed.
b. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall at least 25 percent below the equipment's lowest operating speed.
c. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.

Q. Vibration tests:
1. Definitions:
a. Root mean square: for pumps operating at speeds greater than 600 rpm, the vibration measurement shall be measured as the overall velocity in inches per second root mean square (RMS).
b. Peak-to-peak displacement: The root mean squared average of the peak-to-peak displacement multiplied by the square root of 2.
c. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.
d. Peak acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.
e. High frequency enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectrum of acceleration versus frequency.
1) Manufacturers: One of the following or equal:
a) Rockwell Automation, Entek Group, "Spike Energy" analysis.
b) CSI, "PeakVue."
f. Low speed equipment: Equipment or components of equipment rotating at less than 600 revolutions per minute.
g. High speed equipment: Equipment and equipment components operating at or above 600 revolutions per minute.
h. Preferred operating range: Manufacturer's defined preferred operating range (POR) for the equipment.
i. Allowable operating range: Manufacturer's defined allowable operating range (AOR) for the equipment.
2. Vibration instrumentation requirements:
a. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12 bit A/D converter, fast fourier transform circuitry, phase measurement capability, time wave form data storage, high frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles per minute, adjustable fast fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra,

data output port, circuitry for integration of acceleration data to velocity or double integration to displacement.

1) Manufacturers: One of the following or equal:
   a) Computational Systems Inc., (CSI) Division of Emerson Process Management, Model 2120A, Data Collector/analyzer with applicable analysis software.
   b) Pruftechnik, VIBXPERT II.

b. Analyzer settings:
   1) Units: English, inches/second, mils, and gravitational forces.
   2) Fast fourier transform lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 revolutions per minute; 3,200 lines minimum for High Frequency Enveloping; 1,600 lines minimum for low speed equipment.
   3) Sample averages: 4 minimum.
   4) Maximum frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
   5) Amplitude range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
   6) Fast fourier transform windowing: Hanning Window.
   7) High pass filter: Minus 3 dB at 120 cycles per minute for high speed equipment. Minus 3 dB at 21 cycles per minute for low speed equipment.

c. Accelerometers:
   1) For low speed equipment: Low frequency, shear mode accelerometer, 500 millivolts per gravitational force sensitivity, 10 gravitational force range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount.
      a) Manufacturers: One of the following or equal:
         (1) Wilcoxon Research, Model 797L.
         (2) PCB, Model 393C.
   2) For high speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder.
      a) Manufacturers: One of the following or equal:
         (1) Wilcoxon Research, Model 793.
         (2) Entek-IRD Model 943.

3. Accelerometer mounting:
   a. Use magnetic mounting or stud mounting.
   b. Mount on bearing housing in location with best available direct path to bearing and shaft vibration.
   c. Remove paint and mount transducer on flat metal surface or epoxy mount for High Frequency Enveloping measurements.

4. Vibration acceptance criteria:
   a. Testing of rotating mechanical equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.
   b. Vibration displacement limits: Unless otherwise specified, equipment operating at speeds 600 revolutions per minute or less is not to exhibit unfiltered readings in excess of following:

Operating Conditions & Application Data	Overall Peak-to-Peak Displacement	
	Field, mils	Factory, mils
Operation within the POR	3.0	4.0
Operation within the AOR	4.0	5.0
Additive value when measurement location is greater than 5 feet above foundation.	2.0	2.0
Additive value for solids-handling pumps	2.0	N/A
Additive value for slurry pumps	2.0	N/A

c. Vibration velocity limits: Unless otherwise specified, equipment operating at speeds greater than 600 revolutions per minute is not to exceed the following peak velocity limits:

HI Pump Type	Horsepower	Field Test	Factory Test
		Overall RMS	Overall RMS
Horizontal Solids Handling Centrifugal Pumps	Below 33 hp	0.25	0.28
Horizontal and Vertical In-Line Centrifugal Pumps (other than Non-Clog type)	Between 33 and 100 hp	0.28	0.31
	100 hp and above	0.31	0.34
Vertical Solids Handling Centrifugal Pumps	Below 33 hp	0.30	0.33
Vertical Turbine, Mixed Flow, and Propeller Pumps	Between 33 and 100 hp	0.32	0.35
	100 hp and above	0.34	0.35
Non-Solids Handling Centrifugal Pumps	Below 268 hp	0.15	0.19
HI Types BB1, BB2, BB3, BB4, BB5, OH1, OH2, OH3, OH4, OH5, and OH7	268 hp and above	0.19	0.22
Vertical Turbine, Mixed Flow, and Propeller Pumps HI Types VS1, VS2, VS3, VS4, VS5, VS6, VS7, and VS8	Below 268 hp	0.13	
Gear Reducers, Radial	268 hp and above	0.17	
Slurry Pumps		0.25	0.30
Motors		See Applicable Motor Specification	See Applicable Motor Specification

HI Pump Type	Horsepower	Field Test Overall RMS	Factory Test Overall RMS
Gear Reducers, Radial		Not to exceed AGMA 6000-B96 limits	Not to exceed AGMA 6000-B96 limits
Other Reducers, Axial		0.1	N/A

d. Equipment operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.

e. Additional criteria:

1) No narrow band spectral vibration amplitude components, whether sub-rotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without manufacturer's detailed verification of origin and ultimate effect of such excitation.

2) The presence of discernable vibration amplitude peaks in Test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.

3) For motors, the following shall be cause for rejection:

a) Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that are more than 40 percent of the peak at rotational frequency.

b) Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.

c) Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around 2 times the rotor bar pass frequency.

d) Phasing problems evidenced by 1/3 line frequency side band spectral peaks around the 2 times electrical line frequency peak.

4) The presence of peaks in a High Frequency Enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high frequency envelope analysis repeated.

5. Vibration testing results presentation:

a. Provide equipment drawing with location and orientation of measurement points indicated.

b. For each vibration measurement take and include appropriate data on equipment operating conditions at the time vibration data is taken; for pumps, compressors, and blowers record suction pressure, discharge pressure, and flow.

c. When Vibration Spectra Data required:

1) Plot peak vibration velocity versus frequency in cycles per minute.

2) Label plots showing actual shaft or part rotation frequency, bearing inner and outer race ball pass frequencies, gear mesh frequencies and relevant equipment excitation frequencies on the plot; label

probable cause of vibration peaks whether in excess of specification limits or not.

3) Label plots with equipment identification and operating conditions such as tag number, capacity, pressure, driver horsepower, and point of vibration measurement.

4) Plot motor spectra on a log amplitude scale versus frequency.

d. For low speed equipment, plot peak vibration displacement versus frequency as well as velocity versus frequency.

e. Provide name of manufacturer and model number of the vibration instrumentation used, including analyzer and accelerometer used together with mounting type.

3.02 PLANNING PHASE

A. Submit test plans as specified in Section 01_75_17 and this Section.

1. Indicate test start time and duration, equipment to be tested, other equipment involved or required; temporary facilities required, number and skill or trade of personnel involved; safety issues and planned safety contingencies; anticipated effect on Owner's existing equipment and other information relevant to the test.
2. Provide locations of all instruments to be used for testing. Provide calibration records for all instrumentation.

3.03 COMMISSIONING PHASE

A. Source testing:

1. Witnessing not required unless specified otherwise in equipment section.
2. Witnessed tests: Schedule test date and notify Engineer at least 30 days prior to start of test.
3. Test equipment as specified in Section 01_75_17 and equipment sections.
4. Test fluids as specified in Section 01_75_17.
5. Submit reports as specified in Section 01_75_17.

B. Installation testing:

1. Test equipment as specified in Section 01_75_17 and equipment sections.

C. Functional testing:

1. Witnessing required as specified in Section 01_75_17.
2. Schedule test date and notify Engineer at least 7 days prior to start of test.
3. Test equipment as specified in equipment sections. Test fluids as specified in Section 01_75_17.
4. Submit reports as specified in Section 01_75_17.

D. Clean Water Facility Testing:

1. Test equipment as specified in Section 01_75_17 and equipment sections.

E. Closeout documentation:

1. Provide closeout documentation as specified in Section 01_75_17 and equipment sections.

3.04 PROCESS START-UP PHASE

A. Process start-up:
   1. Process start-up equipment as specified in Section 01_75_17 and equipment sections.

B. Process Operational Period:
   1. Operate equipment as specified in Section 01_75_17 and equipment sections.
   2. Test fluids as specified in Section 01_75_17.

END OF SECTION