JORDAN VALLEY WATER CONSERVANCY DISTRICT

JORDAN VALLEY WATER CONSERVANCY DISTRICT
WEST JORDAN, UTAH

JORDAN VALLEY WTP RECLAIM WATER AND SOLIDS HANDLING IMPROVEMENT PROJECT

ENGINEER PROJECT NO. 10851A.10
JVWCD PROJECT NO. 4072

CONTRACT/TECHNICAL SPECIFICATIONS

BID SET

VOLUME 3 OF 4
DIVISIONS 07 to 17

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SECTION 07900

JOINT SEALANTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Acrylic-Latex sealant.
   2. Precast concrete joint sealant.
   3. Silicone sealant.
   4. Synthetic rubber sealing compound.
   5. Synthetic sponge rubber filler.
   6. Related materials.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. M198 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

B. ASTM International (ASTM):
   1. C920 - Standard Specification for Elastomeric Joint Sealants.
   2. C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
   3. C1330 - Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants.
   4. C1521 - Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints.
   5. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension.
   6. D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomer.

1.03 SUBMITTALS

A. Product data.

B. Samples, include color selections.

C. Manufacturer's Installation Instructions.

D. Warranty.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed product for minimum 5 years with satisfactory performance record.

B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 5 projects of similar scope as Project with satisfactory performance record.

1.05 PROJECT/SITE CONDITIONS

A. Environmental requirements: Do not apply sealant on wet or frosty surfaces or when surface temperature is higher than 100 degrees Fahrenheit or lower than recommended by the manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with manufacturer's recommendations.

B. Code date packages. Do not use material older than manufacturer’s published shelf life. Store materials at temperatures lower than 80 degrees Fahrenheit. Condition materials in accordance with manufacturer’s instructions prior to installation.

1.07 SEQUENCING AND SCHEDULING

A. Caulk joints prior to painting.

1.08 WARRANTY

A. Warrant to correct defective products for minimum 1 year in accordance with manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 SEALANTS

A. General:
   1. Provide colors matching materials being sealed.
   2. Where compound is not exposed to view in finished work, provide manufacturer's color which has best performance.
   3. Nonsagging sealant for vertical and overhead horizontal joints.
   4. Sealants for horizontal joints: Self-leveling pedestrian/traffic grade.
   5. Joint cleaner, primer, bond breaker: As recommended by sealant manufacturer.
   6. Sealant backer rod and/or compressible filler made from closed cell polyethylene, polyethylene jacketed polyurethane foam, or other flexible, nonabsorbent, non-bituminous material recommended by sealant manufacturer to:
      a. Control joint depth.
      b. Break bond of sealant at bottom of joint.
      c. Provide proper shape of sealant bead.
      d. Serve as expansion joint filler.

2.02 ACRYLIC-LATEX SEALANT

A. Permanently flexible, nonstaining, and nonbleeding latex modified acrylic sealant compound, colors as selected by Engineer from manufacturer's standard options:
   1. Manufacturers: One of the following or equal:
      a. Tremco, Tremflex 834.
      b. Pecora Corp., Number AC-20.
      c. Sonneborn, Sonolac.

2.03 PRECAST CONCRETE JOINT SEALANT

A. Preformed, cold-applied, ready-to-use, flexible joint sealant in accordance with ASTM C990 and AASHTO M 198:
   1. Manufacturers: One of the following or equal.
      a. Henry Corp., Ram-Nek.
      b. Concrete Sealants Division, ConSeal.

2.04 SILICONE SEALANT

A. ASTM C920, Type S, Grade NS, Class 25, single component silicone sealant:
   1. Manufacturers: One of the following or equal:
      a. Tremco, Proglaze.
      b. Pecora Corp., Number 864.
      c. Dow Corning, Number 795.
      d. General Electric, Number 1200 Series.

2.05 SYNTHETIC RUBBER SEALING COMPOUND

A. Manufacturer: One of the following or equal:
   1. Sika Corporation, Sikaflex 2c NS or SL
   2. Sika Corporation, Sikaflex 2c NS EZ Mix.
   3. Pacific Polymers, Elastothane 227R.

B. Material: In accordance with ASTM C920 Type M, Grade P (pourable), Class 25 and Type M, Grade NS (non-sag), Class 25; multi-part polyurethane; able to cure at room temperature to firm, highly resilient polymer; able to perform satisfactory when continuously submerged in water or sewage and exposed to direct sunlight in dry condition; with the following properties determined at 75 degrees Fahrenheit and 50 percent relative humidity:
   1. Base: Polyurethane rubber.
   2. Application time: Minimum 2 hours.
   3. Cure time: Maximum 3 days.
   4. Tack free time: Maximum 24 hours.
   5. Ultimate hardness: Non-sag 25, Pourable/SL 40, within 5 Shore A.
   6. Tensile strength: Non-sag 95 pounds per square inch minimum and self-leveling minimum 170 pounds per square inch when tested in accordance with ASTM D412.
   7. Ultimate elongation: Minimum 340 percent when tested in accordance with ASTM D412.
   8. Tear resistance: Non-sag 45 pounds per inch minimum and self-leveling minimum 85 pounds per inch when tested in accordance with ASTM D624, Die C.
   9. Service temperature range: Minus 25 degrees to 158 degrees Fahrenheit.

C. Color: Gray to match concrete, unless indicated on the Drawings.

2.06 SYNTHETIC SPONGE RUBBER FILLER

A. Closed cell expanded sponge rubber manufactured from synthetic polymer neoprene base, or resilient polyethylene foam backer rod. In accordance with ASTM C1330, Type C:
   1. Manufacturers: The following or equal:
      a. Presstite, No. 750.3 Ropax Rod Stock.

B. Characteristics:
   1. Suitable for application intended.
   2. Strength: As necessary for supporting sealing compound during application.
   3. Resiliency: Resistance to environmental conditions of installation.
   4. Bonding: No bonding to the sealing compound.
   5. Structure: Cellular, prevents absorption of water.
   6. Compatibility with other materials in joint and acceptance by manufacturer of sealing compound.
   7. Size: Minimum 25 percent greater than nominal joint width.

2.07 RELATED MATERIALS

A. Primer: Nonstaining type, recommended by sealant manufacturer to suit application.

B. Joint cleaner: Noncorrosive, nonstaining, compatible with joint forming materials and as recommended by sealant manufacturer.

C. Bond breaker tape: Pressure-sensitive tape recommended by sealant manufacturer to suit application.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify acceptability of joint dimensions, physical, and environmental conditions.

B. Verify that surfaces are dry, clean, and free of dirt, grease, curing compound, and other residue which might interfere with adhesion of sealants.

3.02 PREPARATION

A. Allow concrete to cure thoroughly before caulking.

B. Synthetic sponge rubber filler:
   1. Prepare surfaces designated to receive filler in accordance with manufacturer's installation instructions.
   2. Do not stretch filler beyond its normal length during installation.

C. Caulking:
   1. Verify that surfaces are dry, clean, and free of dirt, grease, curing compounds, and other residue that might interfere with adhesion of sealant.

2. Concrete, masonry, wood, and steel surfaces: Clean and prime in accordance with manufacturer's instructions prior to caulking.

D. Synthetic rubber sealing compound:
   1. Ensure surfaces to which synthetic rubber must bond are dry and free of dust, dirt, and other foreign residue.
   2. Heavy sandblasted caulking groove to sound surface, and prime with manufacturer's recommended primer for particular surface.

E. For sidewalks, pavements, and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, fill joints to depth equal to 75 percent of joint width, but neither more than 5/8 inches deep nor less than 3/8 inches deep.

F. For normal moving building joints sealed with elastomeric sealants not subject to traffic, fill joints to depth equal to 50 percent of joint width, but neither more than 1/2 inch deep nor less than 1/4 inch deep.

G. For joints sealed with acrylic-latex sealants, fill joints to depth in range of 75 percent to 125 percent of joint width.

H. Use joint filler to achieve required joint depths, to allow sealants to perform properly.

I. Prepare surfaces and install synthetic sponge rubber filler in accordance with manufacturer's recommendations.

J. Do not stretch filler beyond normal length during installation.

K. Apply bond breaker when recommended by joint sealer manufacturer.

3.03 INSTALLATION

A. Synthetic sponge rubber filler: Install filler in accordance with manufacturer's installation instructions.

B. Caulking, joints, and sealing:
   1. Construct expansion, contraction, and construction joints as indicated on the Drawings.
   2. Install pipe and conduit in structures as indicated on the Drawings.
   3. Caulk doors, windows, louvers, and other items installed in or over concrete openings inside and out.
   4. Use synthetic rubber sealing compound for caulking where indicated on the Drawings or as specified, except for masonry construction and where specified otherwise.
   5. Complete caulking prior to painting.
   6. Verify that concrete is thoroughly cured prior to caulking.
   7. When filler compressible material is used, use untreated type.
   8. Apply caulking with pneumatic caulking gun.
   9. Use nozzles of proper shape and size for application intended.
   10. Maintain continuous bond between caulking and sides of joint to eliminate gaps, bubbles, or voids and fill joint in continuous operation without layering of compound.

11. Employ experienced applicators to caulk joints and seams in neat workmanlike manner.
12. To hasten curing of compound when used on wide joints subject to movement, apply heat with infrared lamps or other convenient means.
13. Apply synthetic rubber sealing compound with pneumatic caulking tool or other acceptable method.

3.04 CLEANING

A. Clean surfaces adjacent to sealant as work progresses.

B. Remove excess uncured sealant by soaking and scrubbing with sealant cleaning solvent.

C. Remove excess cured sealant by sanding with Number 80 grit sandpaper.

D. Leave finished work in neat, clean condition.

3.05 SCHEDULE

A. Acrylic latex:
   1. Use where indicated on the Drawings.
   2. Interior joints with movement less than 7.5 percent and not subject to wet conditions.

B. Silicone:
   1. Use where indicated on the Drawings.
   2. Joints and recesses formed where window, door, louver and vent frames, and sill adjoin masonry, concrete, stucco, or metal surfaces.
   3. Door threshold bedding.
   4. Moist or wet locations, including joints around plumbing fixtures.
   5. Stainless steel doors and frames, including joints between applied stops and frames, and around anchor bolts.
   6. Plenum joints.

C. Synthetic rubber sealing compound, non-sag Type II:
   1. Use where indicated on the Drawings.
   2. Water-bearing and earth-bearing concrete structures.
   3. Joints in masonry, concrete vertical surfaces, and metal-faced panels in vertical surfaces.
   4. Joints between sheet metal flashing and trim.
   5. Joints between sheet metal flashing and trim, and vertical wall surfaces.
   6. Small voids between materials requiring filling for weathertight performance in vertical surfaces.
   7. Perimeters of frames of doors, windows, louvers, and other openings where bonding is critical to airtight performance.
   8. Expansion and control joints in masonry vertical surfaces.

D. Synthetic rubber sealing compound, self-leveling Type I:
   1. Use where indicated on the Drawings.
   2. Expansion and control joints in masonry, concrete horizontal surfaces, and metal panels in horizontal surfaces.

3. Small voids between materials requiring filling for weathertight performance in horizontal surfaces.
4. Pavement joints.
5. Perimeters of frames of doors, windows, louvers, and other openings in horizontal surfaces where bonding is critical to airtight performance.

3.06 FIELD QUALITY CONTROL

A. Adhesion testing:
   1. Perform adhesion tests in accordance with ASTM C1521 per the following criteria:
      a. Water bearing structures: 1 test per every 1,000 LF of joint sealed.
      b. Exterior precast concrete wall panels: 1 test per every 2,000 LF of joint sealed.
      c. Chemical containment areas: 1 test per every 1,000 LF of joint sealed.
      d. Building expansion joints: 1 test per every 500 LF of joint sealed.
      e. All other type of joints except butt glazing joints: 1 test per every 3,000 LF of joint sealed.
      f. Manufacturer's authorized factory representative provide written recommendations for remedial measures on failing tests.

END OF SECTION

SECTION 09960

HIGH-PERFORMANCE COATINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Coatings, including coating systems, surface preparation, application requirements, and quality control requirements.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
   2. D2200 - Standard Practice for Use of Pictorial Surface Preparation Standards and Guides for Painting Steel Surfaces.
   3. D3359 - Standard Test Methods for Rating Adhesion by Tape Test.
   4. D3960 - Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings.
   5. D4262 - Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces.
   6. D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
   7. D4285 - Standard Test Method for Indicating Oil or Water in Compressed Air.
   8. D4414 - Standard Practice for Measurement of Wet Film Thickness by Notch Gages.
   9. D4417 - Standard Test Methods for Field Measurement of Surface Profile of Blast-Cleaned Steel.
   10. D4541 - Standard Test Methods for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
   11. D4787 - Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.
   12. D5162 - Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates.
   13. D7234 - Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.
   14. E337 - Standard Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures).
   15. F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
   16. F2170 - Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In-situ Probes.

B. International Concrete Repair Institute (ICRI):
   1. 310.2 - Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

C. NACE International (NACE):
   1. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.
   2. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

D. National Association of Pipe Fabricators (NAPF):
   1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

E. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

F. Occupational Safety and Health Administration (OSHA).

G. Society of Protective Coatings (SSPC):
   1. Glossary - SSPC Protective Coatings Glossary.
   2. Guide 6 - Guide for Containing Surface Preparation Debris Generated during Paint Removal Operations.
   3. Guide 15 - Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates.
   4. PA 1 - Shop, Field, and Maintenance Painting of Steel.
   5. PA 2 - Procedure for Determining Conformance to Dry Coating Thickness Requirements.
   6. PA 9 - Measurement of Dry Coating Thickness Using Ultrasonic Gages.
   7. QP 1 - Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors.
   8. SP 1 - Solvent Cleaning.
   9. SP 3 - Power Tool Cleaning.
   10. SP 5 - White Metal Blast Cleaning.
   11. SP 10 - Near-White Metal Blast Cleaning.
   12. SP 11 - Power Tools Cleaning to Bare Metal.
   13. SP 13 - Surface Preparation of Concrete.
   14. SP 16 - Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
   15. SP COM - Surface Preparation Commentary.
   16. SP VIS 1 - Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.
   17. SP WJ-1 - Waterjet Cleaning of Metals -- Clean to Bare Substrate.
   18. SP WJ-2 - Waterjet Cleaning of Metals -- Very Thorough Cleaning.
   19. SP WJ-3 - Waterjet Cleaning of Metals -- Thorough Cleaning.
   20. SP WJ-4 - Waterjet Cleaning of Metals -- Light Cleaning.

1.03 DEFINITIONS

A. Definitions used in this Section are in accordance with definitions referenced in ASTM D16, ASTM D3960, and SSPC Glossary of Definitions.

B. Specific definitions:
   1. Abrasive: Material used for blast cleaning, such as sand, grit, or shot.
   2. Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed.

3. Anchor Pattern: Profile or texture of prepared surface(s).
4. Biogenic Sulfide Corrosion: Corrosion caused by sulfuric acid formed when *Thiobacillus* bacteria metabolizes hydrogen sulfide.
5. Bug Holes: Small cavities resulting when air bubbles are entrapped in the surface of formed concrete during placement and consolidation.
6. System: Protective film with 1 or more coats applied in a predetermined order, including surface preparation and quality control requirements.
7. Coating/Paint/Lining Thickness: Total thickness of primer, intermediate, and/or finish coats after drying or curing.
8. Dew point: Temperature a given air/water vapor mixture starts to condense.
9. Drying Time: Time interval between application and material curing.
10. Dry to Recoat: Time interval between material application and its ability to receive the next coat.
11. Dry to Touch: Time interval between material application and its ability to tolerate a light ouch without coating damage.
12. Exposed Surface: Any indoor or outdoor surface not buried or encased.
13. Feather Edging: Reducing coating thickness at its edge to blend with existing surrounding coating.
14. Feathering: Tapering off a wet edge with a comparatively dry brush.
15. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.
16. Field Coat: Application of a surface coating system at the work site.
17. Finish Coat: Final coat in a paint system, including texture, color, smoothness of surface, and other properties affecting appearance.
18. Hold Point: A defined point, specified in this Section, at which work shall be halted for inspection.
19. Holiday: A discontinuity, skip, void, or pinhole in coating or coating system film that exposes the substrate.
20. Honeycomb: Segregated and porous surface of hardened concrete due to insufficient consolidation.
21. Hydroblast: High or ultra-high-pressure water jet surface preparation.
22. Incompatibility: One coating's inability to overlay another coating or surface as evidenced by bleeding, poor bonding, or lifting of old coating; inability of a coating to bond to a substrate.
23. Immersed/Immersion: A service condition in which substrate is submerged, is immediately above liquids, or is subject to frequent wetting, splashing, or washdown.
24. Laitance: A thin, weak, brittle layer of cement and aggregate fines on a concrete surface.
25. Mil: 0.001 inch.
26. Overspray: Dry spray, particularly paint bonded to an unintended surface.
27. Pinhole: A small diameter discontinuity in a coating or coating system film, created by offgassing from a void in a concrete or masonry substrate causing a void between coats or exposing the substrate. Usually caused by coating application while temperature is rising.
28. Pot Life: Time interval after components are mixed and coating can be satisfactorily applied.
29. Prime Coat: First full paint coat applied to a surface when using a multicoat system. Primers adhere to a new substrate, protect the substrate, and promote adhesion of subsequent coats of paint. The prime coat on metal surfaces is the first full coat and does not include solvent wash, grease emulsifiers, or other pretreatment applications.

30. Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-based material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces.
31. Shelf Life: Maximum storage time a material may be stored without losing its usefulness.
32. Shop Coat: 1 or more coats applied in an off-site shop or plant before shipment to work site where field or finishing coat(s) are applied.
33. Spreading Rate: Area covered by a unit volume of paint at a specific thickness.
34. Stripe Coat: A separate brush coat of paint applied to all weld seams, pits, nuts/bolts/washers, and edges. This coat shall not be applied until previous coats have cured. Once applied, the coat shall be allowed to cure before subsequent coats are applied.
35. Tie Coat: An intermediate coat that bonds different types of paint material, improving succeeding coat adhesion.
36. Thick Film Coating System: A coating system applied with a minimum dry film thickness of 25 mils.
37. Touchup Painting: Application of paint on previously painted surfaces to repair marks, scratches, and deteriorated or damaged areas to restore the appearance and performance of the coating.
38. Water Blast: An alternative to air abrasive blast cleaning that can be used with or without abrasive injection. Water cleaning at pressures up to 5,000 pounds per square inch is called low-pressure water cleaning or power washing. High-pressure water cleaning uses water pressures between 5,000 and 10,000 pounds per square inch. Water jetting is water blasting with added abrasive at pressures between 10,000 and 25,000 pounds per square inch. Ultra-high-pressure water jetting is water blasting at pressures above 25,000 pounds per square inch.
39. Weld Splatter: Beads of non-structural weld metal that adhere to the surrounding surface, removed as part of surface preparation.

1.04 ABBREVIATIONS

A. CSM - Coating System Manufacturer.

B. CMU - Concrete Masonry Units.

C. CSA - Coating System Applicator. Specialty subcontractor retained by the Contractor to install the coating systems specified in this Section.

D. CTR - Coating System Manufacturer's Technical Representative.

E. DFT - Dry-Film Thickness. Thickness of cured film, usually expressed in mils (0.001 inch).

F. SSD - Surface Saturated Dry. Refers to concrete surface condition where the surface is saturated (damp) without the presence of standing water.

G. TPC - Technical Practice Committee.

H. VOC - Volatile Organic Compound. Portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing; expressed in grams per liter (g/l) or pounds per gallon (lb/gal). VOC is determined by EPA Method 24.

I. WFT - Wet Film Thickness. Coating thickness as measured immediately after application. Usually expressed in mils (0.001 inch).

1.05 PERFORMANCE REQUIREMENTS

A. Coating materials shall be formulated for environments encountered in water and wastewater treatment processes.

B. Coating materials that come in contact with water distributed as potable water shall be certified in accordance with NSF 61.

1.06 SUBMITTALS

A. As specified in Section 01330 - Submittal Procedures, submit the following:
   1. Schedule of proposed coating materials.
   2. Schedule of surfaces to be coated with each coating material.
   3. Dehumidification and heating plan.
   4. Product data:
      a. Physical properties of coatings, including the following:
         1) Solids content.
         2) Ingredient analysis.
         3) VOC content.
         4) Temperature resistance.
         5) Typical exposures and limitations.
         6) Manufacturer's standard color chips.
      b. Compliance with regulatory requirements:
         1) VOC limitations.
         2) Lead compounds and polychlorinated biphenyls.
         3) Abrasives and abrasive blast cleaning techniques and disposal.
         4) Methods for tenting blasting areas and methods to protect existing equipment from dust and debris.
         5) NSF certification of coatings for potable water supply systems.
      c. CSM's current printed recommendations and product data sheets for coating systems, including:
         1) Surface preparation recommendations.
         2) Primer type.
         3) Maximum dry and wet-mil thickness per coat and number of coats.
            a) Coating Coverage Worksheets.
         4) Minimum and maximum curing time between coats, including atmospheric conditions for each.
         5) Curing time before submergence in liquid.
         6) Thinner to be used for each coating.
         7) Ventilation requirements.
         8) Minimum and maximum atmospheric conditions during which the paint shall be applied.
         9) Allowable application methods.
         10) Maximum allowable substrate moisture content.
         11) Maximum shelf life.
         12) Requirements for transportation and storage.
         13) Mixing instructions.
         14) Shelf life.
         15) Material Pot life.

16) Precautions for applications free of defects.
17) Method of application.
18) Drying time of each coat, including prime coat.
19) Compatible prime coats.
20) Limits of ambient conditions during and after application.
21) Required protection from sun, wind, and other conditions.
22) Touchup requirements and limitations.
23) Minimum adhesion of each system submitted in accordance with ASTM D4541 and ASTM D7234.

d. Samples: Include 8-inch square drawdowns or brushouts of topcoat finish when requested. Identify each sample as to finish, formula, color name and number, sheen name, and gloss units.
e. Affidavits signed by an officer of the CSM's corporation attesting to full compliance of each coating system component with current federal, state, and local air pollution control regulations and requirements.
f. List of cleaning and thinner solutions allowed by the CSMs.
g. Storage requirements, including temperature, humidity, and ventilation for Coating System Materials as recommended by the CSMs.
h. Thick film coating systems (greater than 25 mils):
1) CSM's detailed written instructions for coating system treatment and graphic details for coating system terminations in coated structures, including pipe penetrations, metal embedments, gate frames, and other terminations encountered.
2) Include detail treatment for coating system at concrete joints.
3) Manufacturer's Representative's (CTR) Field Reports.

5. Quality assurance submittals:
a. Quality assurance plan.
b. Qualifications of CSA, including:
1) List of Similar Projects.
a) Name and address of project.
b) Year of installation.
c) Year placed in operation.
d) Point of contact: Name and phone number.
2) Provide a minimum of 5 project references, each including contact name, address, and telephone number where similar coating work has been performed by their company in the past 5 years.
c. CSA Reports:
1) Written daily quality control inspection reports.
d. CTR Reports:
1) Reports on visits to project site to view and approve surface preparation of structures to be coated.
2) Reports on visits to project site to observe and approve coating application procedures.
3) Reports on visits to coating plants to observe and approve surface preparation and coating application on shop-coated items.

1.07 QUALITY ASSURANCE

A. CSA qualifications:
   1. Minimum of 5 years of experience applying specified type or types of coatings under conditions similar to those of the Work:
      a. Provide qualifications of applicator and references listing 5 similar projects completed in the past 5 years.
   2. SSPC QP 1 certified.
   3. Manufacturer-approved applicator when manufacturer has approved applicator program or when required in these specifications.

B. CTR qualifications:
   1. Certification, one of the following:
      a. NACE Level 2 or 3 Certified Coating Inspector.
      b. SSPC Level 3 Protective Coatings Inspector.
   2. Minimum of 5 years of experience evaluating application of manufacturer's coatings under conditions similar to those of the Work:
      a. Provide CTR qualifications and references listing 5 similar projects completed in the past 5 years.

C. Regulatory requirements: Comply with governing agencies' regulations by using coatings conforming to their VOC limits.
   1. Lead-based coatings are not permitted.
   2. Do not use coal-tar epoxy in contact with drinking water or exposed to ultraviolet radiation.

D. Pre-installation conference: Conduct as specified in Section 01312 - Project Meetings.
   1. Coordinate Hold Point schedule

E. Field samples:
   1. Prepare and coat a minimum 100-square-foot area of each system between corners or limits such as control or construction joints.
   2. Approved field sample may be part of the Work.

F. Obtain approval before coating other surfaces. Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.

G. CSM services:
   1. CSA shall arrange for CTR to attend pre-installation conferences.
   2. Visit the project site periodically to consult on and inspect specified surface preparation and application Hold Points.
   3. Visit coating plants to observe and approve surface preparation procedures and coating application of items to be shop primed and coated.
   4. CTR shall provide written inspection reports.

H. Quality control requirements:
   1. Contractor shall be responsible for the workmanship and quality of the coating system installation.
      a. Inspections by Owner, Engineer, CSA, or CTR will not relieve or limit Contractor’s responsibilities.

2. Conform to this specification's requirements and the standards referenced in this Section. Changes in the coating system application requirements will be allowed only with the Engineer's written acceptance.
3. Specially trained crews with experience applying the specified coating system coating are required for:
    a. Coating application using plural component spray equipment or other specialty equipment.
    b. Coating with specialty linings for severe service conditions, including floor coatings, and with linings for corrosive headspaces or secondary containment areas.
4. CTR shall specially train personnel for coating systems as specified in Appendix B Coating Detail Sheets.
    a. CSM shall approve personnel in writing applying the coating system.
5. Do not use contaminated, outdated, diluted materials, and/or materials from previously opened containers.
6. Identify inspection access points used by Owners or Engineers.
7. Provide ventilation, ingress, egress, or other means as necessary for Owner's or Engineer’s personnel to safely access the work areas.
8. Conduct and continually inspect work so the coating system is installed as specified. The CSM shall provide written directions to correct coating work not conforming to the specifications or is otherwise unacceptable.
9. Provide written daily reports summarizing test data, work progress, surfaces covered, ambient conditions, quality control inspection test findings, and other information pertinent to the coating system application.
    a. Determine relative humidity in accordance with ASTM E337. Confirm other conditions, such as proper protective measures for surfaces not to be coated and safety requirements for personnel.
        1) Measure daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
        2) Determine the acceptability of weather and/or environmental conditions within the structure in accordance with the CSM's requirements.
    b. Monitoring surface preparation: Spot check cleanliness, surface profile, and surface pH testing at least 3 times daily. Check each surface at least once. In accordance with:
        1) ASTM D4262.
        2) ASTM D4263.
        3) ASTM D4417.
        4) ICRI 310.2 requirements.
        5) SSPC Surface Preparation Standards.
    c. Confirm that compressed air used for surface preparation or blow-down cleaning is free of oil and moisture.
    d. Monitor surface preparation daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
    e. Do not apply coatings when environmental conditions are outside of the CSM's published limits.
    f. Monitoring coatings application: Continuously inspect, measure, and record the wet film thickness and general film quality (visual inspection) for runs, sags, pinholes, holidays, etc. during coating.
        1) Perform WFT measurements in accordance with ASTM D4414.
    g. Post cure evaluation: Measure and inspect the overall dry film thickness on all surfaces. Conduct a DFT survey and perform adhesion testing,

holiday detection, or cure testing as required in this Section and/or the CSM's written instructions. Perform all applicable tests in accordance with ASTM D4541, ASTM D4787, ASTM D5162, ASTM D7234, SSPC-PA 1, SSPC-PA 2, SSPC-PA 9, and other pertinent standards and recommended practices.

I. Inspection at Hold Points:
   1. Conduct inspections at Hold Points during the coating system application and record the results.
   2. Coordinate Hold Points with the Engineer so the Engineer can observe Contractor's inspections on a scheduled basis.
   3. Provide the Engineer a minimum of 24 hours of notice before conducting Hold Point Inspections.
   4. Hold Points shall be as follows:
      a. Conditions before surface preparation: Before starting surface preparation, observe, record, and confirm that oil, grease, and/or soluble salts are gone from the surface.
      b. Post surface preparation: After completing surface preparation, measure and inspect for cleanliness and proper surface profile as specified in this Section and in the CSM's written instructions.
      c. Coatings application: At the beginning of any coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.

      d. Coatings application: At the beginning of coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.
         1) Observe conditions during the Pre-application Meeting.

1.08 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products as specified in Section 01600 - Product Requirements.

B. Immediately remove unspecified and unapproved coatings from Project site.

C. Deliver new labeled, unopened containers:
   1. Do not deliver materials after manufacturer's expiration date or over 12 months from manufacturing date, whichever is more stringent. Store materials in well-ventilated enclosed structures and protect from weather and excessive heat or cold in accordance with the CSM's recommendations.
      a. Store flammable materials in accordance with federal, state, and local requirements.
      b. Store rags and cleanup materials appropriately to prevent fire and spontaneous combustion.
   2. Store and dispose of hazardous waste in accordance with federal, state, and local requirements. This requirement specifically applies to waste solvents and coatings.
   3. Container labels shall show the following:
      a. Brand name or product title.

b. CSM's batch number.
c. CSM's manufacture date.
d. CSM's name.
e. Generic material type.
f. Application and mixing instructions.
g. Hazardous material identification label.
h. Shelf life expiration date.
i. Color.
j. Mixing and reducing instructions.

4. Clearly mark containers to indicate safety hazards associated with the use of or exposure to materials.

1.09 PROJECT CONDITIONS

A. Apply coatings to dry surfaces.
1. Surface moisture: Comply with manufacturer's requirements or as specified in this Section.
a. Plaster and gypsum wallboard: 12 percent.
b. Masonry and concrete block: 12 percent.
c. Interior located wood: 15 percent.
d. Concrete floors: Moisture vapor transmission rate of no more than 3.0 pounds per 1,000 square feet per 24 hours in accordance with ASTM F1869 or relative humidity no greater than 80 percent if tested in accordance with ASTM F2170 unless the CSM's recommendations are more restrictive.
e. Concrete structures: Negative results from Plastic Sheet Test in accordance with ASTM D4263, and maximum of 80 percent relative humidity in accordance with ASTM F2170.

B. Do not apply coatings when the following conditions exist. If such conditions exist, provide containment, covers, environmental controls, and other necessary measures.
1. During rainy, misty, or damp weather, or to surfaces with frost or condensation.
2. When the surface temperature is below 10 degrees Fahrenheit above the dew point.
3. When ambient or surface temperature:
a. Is less than 55 degrees Fahrenheit unless manufacturer allows a lower temperature.
b. Is less than 65 degrees Fahrenheit for clear finishes, unless manufacturer allows a lower temperature.
c. Exceeds 90 degrees Fahrenheit, unless manufacturer allows a higher temperature.
d. Exceeds manufacturer's recommendation.
4. When relative humidity is higher than 85 percent.
5. Under dusty or adverse environmental conditions.
6. When light on surfaces measures less than 15 foot-candles.
7. When wind speed exceeds 15 miles per hour.

C. Apply coating only under evaporation conditions rather than condensation.

1. Use dehumidification equipment, fans, and/or heaters inside enclosed areas to maintain required atmospheric and surface temperature requirements for proper coating application and cure.
2. Measure and record relative humidity and air and surface temperatures at the start and end of each shift to confirm proper humidity and temperature levels inside the work area.
    a. Submit test results.

D. Continuously ventilate, dehumidify, and heat enclosed spaces with high humidity during surface preparation, coating application, and curing.
    1. Maintain minimum air temperature of 55 degrees Fahrenheit and 10 degrees Fahrenheit above the dew point.
    2. Maintain dew point of at least 10 degrees Fahrenheit less than the temperature of the coldest part of the structure where work is performed.
    3. Reduce dew point temperature in conditioned space by at least 10 degrees Fahrenheit within 20 minutes.
    4. Seal work areas and maintain positive pressure per dehumidification equipment supplier's recommendations.
    5. Maintain these conditions before, during, and after application to ensure proper adhesion and cure of coatings for no less than:
        a. Entire curing period.
        b. 8 hours after coating.

E. Systems:
    1. Site electrical power availability as specified in Section 01500 - Temporary Facilities and Controls.
    2. Internal combustion engine generators may be used.
        a. Obtain required permits and provide air pollution and noise control devices on equipment as required by permitting agencies require.
        b. Comply with state, federal, and local fire and explosion protection measures when locating and operating generator.
        c. Locate engine generator outside hazardous classified areas per NFPA 820.
        d. Provide daily fuel service for generator for duration of use.
    3. Dehumidification:
        a. Provide desiccant or refrigeration drying.
        b. Use only desiccant types with a rotary desiccant wheel capable of continuous operation.
        c. Liquid, granular, or loose lithium chloride drying systems are not acceptable.
    4. Heating:
        a. Use electric, indirect combustion, or steam coil.
        b. Direct-fired combustion heaters are not acceptable heat sources during abrasive blasting, coating application, or coating cure.
    5. Filters:
        a. Use a filtration system for dust removal designed to not interfere with dehumidification equipment’s ability to control dew point and relative humidity inside the reservoir.
        b. Do not allow air from the working area or dust filtration equipment to recirculate through thein dehumidifier during coating application or when solvent vapors are present.

6. Design and submittals:
    a. Prepare and submit dehumidification and heating plan, including all equipment and operating procedures.
    b. Suppliers of services and equipment shall have at least 3 years of experience in similar applications.

F. Provide containment and ventilation system components in accordance with SSPC-Guide 6, Level 3 and as required for hazardous materials.

1.10 MAINTENANCE

A. Provide table of products applied organized by surface type. List coating manufacturer, color, color formulation, distributor name, telephone number, and address.

1.11 CTR RESPONSIBILITIES

A. General:
    1. Attend pre-installation conference.
    2. Perform onsite application training.
    3. Periodically inspect coating system application.

B. Coating system installation training:
    1. Provide a minimum of 8 hours of classroom and off-site training for application personnel and supervisory personnel in one of the following ways:
        a. Train a minimum of 2 supervisory personnel and 2 application personnel.
        b. Submit a letter from the CSM stating that CSM approves the supervisory and application personnel, listed by name and responsibility, and no additional training is required.
    2. CTR can train up to 14 application personnel and 3 supervisory personnel at a time.
    3. Minimum training requirements:
        a. Explain in detail the mixing, application, curing, and termination requirements.
        b. Provide hands-on demonstration of coating system mixing.
        c. Explain in detail the ambient condition requirements for temperature and humidity.
        d. Explain in detail the surface preparation requirements.
        e. Explain in detail the re-coat times, cure times, and related ambient condition requirements.
        f. Write a letter stating that training was satisfactorily completed by the personnel, listed by name and responsibility.
    4. Provide special training as specified in the Coating Detail Sheets.

C. Coating system inspection:
    1. CTR inspection is in addition to the CSA's inspection as specified in this Section.
    2. Be on-site to oversee:
        a. Coating application at least once a week.
        b. End of surface preparation.
        c. During coating application.
        d. Post-cure inspection.

3. Routinely inspect and verify in writing that application personnel have successfully performed surface preparation, filler/surfacer application, coating system application, and Quality Control Inspection in accordance with this Section and to warrantable quality.
4. Perform the following activities to confirm conformance with the specifications:
    a. Inspect ambient conditions during coating system installation at Hold Points for conformance with the specified requirements.
    b. Inspect each coated surface type and coating system applied to verify the following:
        1) Cleanliness.
        2) Surface pH for concrete substrates.
        3) Confirm surface preparation of substrates where coating system will terminate or will be applied for conformance to the specified application criteria.
    c. Verify surface profile of substrates by completing the following:
        1) Inspect preparation and application of coating detail treatment at terminations, transitions, metal embedments in concrete, and joints and cracks in substrates.
        2) Inspect application of filler/surfacer materials for concrete and masonry substrates.
        3) Verify proper mixing of coating materials.
        4) Inspect application of primers and finish coats, including wet and dry film thickness.
        5) Inspect coating systems for proper cure times and conditions.
    d. Review adhesion testing of cured coating systems.
    e. Review coating system continuity testing.
    f. Inspect and record representative-localized repairs.
    g. Conduct final review of completed coating system installation.
    h. Prepare and submit site visit reports after each site visit to document that the coating work is in accordance with the CSM’s Recommendations.

D. Final report:
1. Prepare a final report, after coating work ends, summarizing each day's test data, observations, drawings, and photographs. Include substrate conditions, ambient conditions, and application procedures observed during the CTR's site visits. Include a statement that completed work was performed in accordance with the requirements of the CSM’s recommendations.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
1. Product requirements as specified in Section 01600 - Product Requirements.

2.02 COATING SYSTEMS IDENTIFICATION

A. Naming Conventions: Coating Systems Identifications contain the elements defined in Table 1.

Table 1 Coating System Identification Elements						
First Element	-	Second Element	-	Third Element	-	Fourth Element (optional)
3 or 4 alpha characters		1-3 alpha characters		1 number		3 or 4 alpha characters
Coating Type		Substrate		System Number		Additional Substrate or Special Condition
Example: EPX	-	C	-	6	-	BSC

1) First element identifies the coating type using the following abbreviations:
   a) ACR: acrylic.
   b) CTE: coal tar epoxy.
   c) ELA: elastomeric acrylic.
   d) EPU: epoxy-polyurethane.
   e) EPX: epoxy.
   f) POL: polyurethane.
   g) SIL: silicone.
   h) SILX: siloxane or silane.
   i) VE: vinyl ester.
2) Second element identifies the substrate using the following abbreviations:
   a) C: concrete or masonry.
   b) F: concrete flooring.
   c) FRP: fiber-reinforced plastic.
   d) GM: galvanized metal.
   e) M: metal.
   f) PVC: polyvinyl chloride, chlorinated polyvinyl chloride.
3) Third element identifies the sequential system number.
   a) For example, EPX-C-2 is the second standard epoxy coating system for concrete substrates.
4) Fourth element is optional and identifies the additional substrate or special condition with the following abbreviations:
   a) PWS: Potable water service applications (NSF-61 approved).
   b) BSC: Biogenic sulfide corrosion-resistant applications in wastewater.
   c) BG: Below grade or buried.
   d) OZ: Organic zinc primer, epoxy polyurethane system.
   e) SC: Secondary containment.

2.03 PRODUCTS FOR COATING SYSTEMS

A. Products: As specified in Appendix B Coating Detail Sheets.

B. Cleaning solvents:
   1. Requirements for solvent wash, solvent wipe, or cleaner used, including, but not limited to, those used for surface preparation in accordance with SSPC-SP 1:
      a. Emulsifying type.
      b. Containing no phosphates.
      c. Biodegradable.
      d. Does not damage zinc.

e. Compatible with the specified primer.
f. Complying with applicable air-quality control board requirements.

2. Use clean white cloths and clean fluids in solvent cleaning.

PART 3 EXECUTION

3.01 GENERAL PROTECTION REQUIREMENTS

A. Protect adjacent coated surfaces from coatings and damage associated with coating work. Repair damage resulting from inadequate or unsuitable protection.

B. Use drop cloths and other coverings to protect adjacent surfaces not to be coated against spatter and droppings.

C. Mask off surfaces of items not to be coated or remove items from area.

D. Furnish and deploy sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being coated and, in particular, surfaces within storage and preparation areas.

E. Place coating waste, cloths, and material that may pose a fire hazard in closed metal containers and remove daily from site.

F. Remove electrical plates, surface hardware, fittings, and fasteners before coating application. Carefully store, clean, and replace items after completing coating in each area. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finishes.

G. Erect and maintain protective enclosures in accordance with SSPC- Guide 6.

H. Protect the following surfaces from abrasive blasting by masking or by other means:
1. Threaded portions of valve and gate stems, grease fittings, and identification plates.
2. Machined surfaces for sliding contact.
3. Surfaces to be assembled against gaskets.
4. Surfaces of shafting where sprockets will be fit.
5. Surfaces of shafting where bearings will be fit.
6. Machined bronze surfaces, including slide gates.
7. Cadmium-plated items, except cadmium-plated, zinc-plated, or sherardized fasteners used to assemble equipment requiring abrasive blasting.
8. Galvanized items, unless scheduled to be coated.

I. Protect installed equipment, mechanical drives, and adjacent coated equipment from abrasive blasting to prevent damage caused by spent abrasive blast media, dust, or dirt entering such equipment.

J. Schedule cleaning and coating to keep dust and spray from the cleaning process from falling on wet, newly coated surfaces.
1. Whenever possible, coordinate with other trades and complete surface preparation and coating work before installing hardware, hardware accessories, nameplates, data tags, electrical fixtures, and similar uncoated

items that will be in contact with coated surfaces. Mask machined surfaces, sprinkler heads, and other small items that will not be coated.
2. After completing coating, reinstall removed items.
3. Disconnect and move equipment adjacent to walls to clean and coat equipment and walls. Replace and reconnect equipment after coating.

3.02 GENERAL SURFACE PREPARATION REQUIREMENTS

A. Prepare surfaces in accordance with CSM's instructions unless more stringent requirements are specified in this Section.

B. Coating detail sheets in Appendix B include additional surface preparation requirements.

C. Follow more stringent requirement if information conflicts.

D. Where required by the Owner's representative, a NACE International certified coatings inspector, provided by the Owner, will inspect and approve surfaces to be coated before applying a coating.
1. CSA shall coordinate coating inspections.
   a. Identify coating inspection Hold Points during the pre-installation conference.
   b. Provide at least 2 days' notice before inspection.
2. Contractor shall correct surface defects identified by the inspector at no additional cost to Owner.

3.03 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION

A. Identify equipment, ducting, piping, and conduit as specified in Section 15075 - Equipment Identification, Section 15076 - Pipe Identification, and Section 16075 - Identification for Electrical Systems.

B. Remove grilles, covers, and access panels for mechanical and electrical system and coat separately.

C. Prepare and finish coat equipment primed by the manufacturer using specified intermediate and topcoats, as applicable, and color selected by the Owner.

D. Prepare, prime, and coat both insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are covered with material not requiring coating, or with a prefinished coating.

E. Replace identification markings on mechanical or electrical equipment when coated over or spattered.

F. Prepare and coat interior surfaces of air ducts and convector and baseboard heating cabinets visible through grilles and louvers with 1 coat of flat black paint to limit of sight line.

G. Prepare and coat dampers exposed immediately behind louvers, grilles, and convector and baseboard heating cabinets to match face panels.

H. Prepare and coat exposed conduit and appurtenances occurring in finished areas with color and texture to match adjacent surfaces.

I. Prepare and coat sides' front, back, and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.

J. Color code equipment, piping, conduit, and exposed ductwork and apply color banding and identification, such as flow arrows, naming, and numbering, in accordance with the Contract Documents.

3.04 CLEANING OF NEW AND PREVIOUSLY COATED OR NEW SURFACES

A. Utilize cleaning agent to remove soluble salts, such as chlorides, from concrete and metal surfaces:
   1. Cleaning agent: Biodegradable non-flammable and containing no VOC.
   2. Manufacturers: The following or equal:
      a. CHLOR*RID International, Inc.
         1) Complete soluble salt removal with steam or warm water cleaning.
   3. Steam clean and degrease surfaces to be coated to remove oils and grease.
   4. Clean surfaces with decontamination agent in conjunction with abrasive blast cleaning, steam cleaning, high-pressure washing, or hand washing, as approved by the CTR and the Engineer.
   5. Test cleaned surfaces to ensure removal of soluble salts. Carry out additional cleaning as needed.
   6. Complete final surface preparation before applying new coating system in strict accordance with CSM's printed instructions.

3.05 BLAST CLEANING

A. Surface preparation requirements:
   1. Do not reuse spent blast abrasive.
   2. Ensure that filter compressed air used for blast cleaning is free of condensed water and oil. Clean moisture traps at least once every 4 hours or more frequently, as required, to prevent moisture from entering the abrasive blasting equipment air supply. Check blast air for moisture and oil after each cleaning in accordance with ASTM D4285.
   3. Install oil separators just downstream of compressor discharge valves and at the discharge point of blast pot discharges. Check separators on the same frequency as the moisture traps.
   4. Keep regulators, gauges, filters, and separators on compressor air lines to blasting nozzles operational at all times.
   5. Install an air dryer or desiccant filter drying unit to dry the compressed air before blast pot connections. Use and maintain the dryer throughout surface preparation work.
   6. Use a venturi-type, or other high velocity-type, abrasive blast nozzles supplied with at least 100 pounds per square inch gauge air pressure at the nozzle and enough volume to obtain appropriate blast cleaning production rates and surface cleanliness.
   7. Provide airborne particulate evacuation and filtering that meets OSHA safety standards. Maintain optimal visibility both to clean and provide the specified surface profile and to allow inspection of the substrate during surface preparation work.

8. If prepared and cleaned metallic substrates become contaminated between final surface preparation work and coating system application, or if the prepared substrate darkens or changes color, re-clean by water blasting, or abrasive blast cleaning as appropriate until the specified degree of cleanliness is restored.

B. Water jetting or water blasting:
   1. Use water jetting or water blasting for recoating or relining where an adequate surface profile exists.
   2. Perform water jetting or water blasting in accordance with SP 13 and SSPC-WJ-1, WJ-2, WJ-3, WJ-4.

3.06 PREPARATION REQUIREMENTS FOR CONCRETE SURFACES

A. Cure for at least 28 days before coating.

B. Remove degraded concrete using abrasive blast cleaning or high or ultrahigh pressure water jetting, chipping, or other abrading tools until achieving a sound, clean substrate. Remove all bruised or cracked concrete.

C. Prepare substrate cracks and areas requiring resurfacing; perform detail treatment, including, but not limited to, terminating edges per the CSM's recommendations and as indicated on the Drawings.
   1. Prepare concrete surfaces in accordance with SSPC-SP 13.

D. Prepare concrete surfaces in accordance with SSPC-SP 13.
   1. Inspect concrete surfaces to select appropriate surface preparation method to provide a suitable substrate for the specified coating system.
   2. Use blast cleaning or other means to expose the complete perimeter of air voids or bug holes. Do not leave shelled over, hidden air voids beneath the exposed concrete surface.
   3. Repair concrete defects and physical damage.
   4. Clean concrete surfaces of dust, mortar, formwork, fins, loose concrete particles, form release materials, oil, and grease.
   5. Fill voids to provide surface as specified in Section 03366 - Tooled Concrete Finishing.

E. Provide clean substrate visually free of calcium sulfate, loose, coarse, or fine aggregate, laitance, loose hydrated cement paste, and otherwise harmful substances.
   1. Confirm concrete surface minimum pH of 9.0 with surface pH testing.
   2. If after surface preparation the surface pH remains below 9.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.

F. Prepare concrete surface for coating in accordance with SSPC-SP 13.
   1. Provide ICRI 310.2 minimum No. 3 concrete surface profile (CSP) or as specified on Coating Detail Sheets.
   2. Evaluate profile of the prepared concrete using ICRI 310.2 surface profile replicas.

G. Blast clean cementitious repair mortars or grouts to the same profile and degree of cleanliness requirements required for concrete substrates.

H. Blast clean polymer-based surfacers or waterborne modified cementitious surfaces only if they have exceeded the CSM's recommended recoat time.

I. Vacuum all concrete surfaces before coating application, leaving a dust free, sound concrete substrate.
   1. Thoroughly clean concrete surfaces to be coated to remove loose dirt and spent abrasive.
   2. Remove debris produced by blast cleaning from the structures to be coated, and legally dispose of it off-site.

J. Test moisture content of concrete to be coated:
   1. Conduct ASTM D4263 plastic sheet test at least once for every 500 square feet of surface area to be coated.
      a. Any moisture on plastic sheet after test period constitutes a non-acceptable test, and the concrete must be dried further.
   2. Conduct ASTM F1869 test at least once for every 1,000 square feet of concrete floor surface area to be coated.
   3. Conduct ASTM F2170 one relative humidity moisture test at least once for each 500 square feet of non-floor concrete surface area where the opposite side is exposed to soil or water.
   4. Comply with specified minimum moisture content and CSM’s written recommendations for moisture vapor transmission rates or relative humidity values.

K. Masonry surfaces:
   1. Cure for at least 28 days before coating.
   2. Prepare masonry surfaces to remove chalk, laitance, loose dirt, dried mortar splatter, dust, peeling, or loose existing coatings, or otherwise deleterious substances to leave a clean, sound substrate.
   3. Wash and scrub masonry surfaces with clear water. Do not use muriatic acid.
   4. Seal or fill masonry surfaces with a sealer or block filler compatible with the specified primer after cleaning.
   5. Confirm that masonry surfaces are dry before coating application.
      a. If using pressure washing or low-pressure water blast cleaning for preparation, allow the masonry to dry for at least 5 days under dry weather conditions or until the minimum ambient temperature is 70 degrees Fahrenheit before coating.

3.07 GENERAL PREPARATION REQUIREMENTS FOR METALLIC SURFACES

A. Remove rust, scale, and welding slag and spatter.
   1. Remove and grind smooth all excessive weld material and weld spatter on metal surfaces before blast cleaning in accordance with NACE SP0178, Appendix C, Level C.
   2. Grind sharp edges on metal substrate to approximately 1/16-inch radius before abrasive blast cleaning.

B. Prepare metallic surfaces in accordance with applicable portions of surface preparation specifications of the SSPC specified for each coating system.
   1. Remove grease and oil in accordance with SSPC-SP 1.
   2. Use solvent as recommended by the CSM.

3. Measure profile depth of the surface to be coated in accordance with Method C of ASTM D4417. Contractor shall select blast particle size and gradation to produce the specified surface profile.
4. Constantly monitor and maintain ambient environmental conditions to ensure cleanliness and that no “rust back” occurs before coating material application.

C. Prepare metallic surfaces by blast cleaning in accordance with SSPC-VIS 1 (ASTM D2200). Prepare abrasive blast representative areas for the Owner's representative to inspect on the first day of cleaning.

D. Unless otherwise specified, the requirements for blast cleaning steel, ductile iron, and stainless steel substrates are as follows:
1. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC-SP 10 unless blasting may damage adjacent surfaces, is prohibited, or is specified otherwise. Where abrasive blasting is not possible, clean surfaces to bare metal with power tools in accordance with SSPC-SP 11.
2. Ferrous metal surfaces to be submerged: Abrasive blast in accordance with SSPC-SP 5, unless specified otherwise, to clean and provide roughened surface profile with a depth between 2 and 4 mils.
3. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products, or embedded abrasive from substrate before coating application.
4. When abrasive blasted surfaces rust or discolor before coating, abrasive blast clean surfaces again.

E. Field preparation of shop-primed surfaces:
1. Smooth welds and prominences with power tools before applying field-applied coatings.
2. Clean and dry shop-primed ferrous metal surfaces and fabricated assemblies before applying field coats.
3. Prepare shop epoxy primed surfaces with light abrasive blasting or abrading and then vacuum before applying finish coats.
    a. Follow CSM instructions for surface preparation when the primer recoat limit has been exceeded.
4. Non-immersion service: Clean in accordance with SSPC-SP 2 (Hand Tool Cleaning) or SSPC-SP 3 (Power Tool Cleaning) and uniformly roughen.
5. Immersion, BSC, and SC service: Remove shop primer in accordance with SSPC-SP 5 (Near-White Blast Cleaning).

F. Damaged shop primer or rust bleeding:
1. Ferrous metals: Clean in accordance with SSPC-SP 1 (Solvent Cleaning) and spot blast in accordance with SSPC-SP 10 (Near-White Metal Blast Cleaning) to achieve a uniform surface profile between 2.0 and 2.5 mils before recoating.
2. Reject galvanized steel with rust bleeding.

G. Damaged coating: Repair by abrasive blast cleaning surfaces as specified for the coating system; feather to a smooth transition before touching up.

3.08 PREPARATION REQUIREMENTS BY SURFACE TYPE

A. Galvanized steel and non-ferrous metal surfaces:
1. Degrease or solvent clean (SSPC-SP 1) to remove oily residue.
2. Abrasive blast clean in accordance with SSPC-SP 16.

a. If abrasive blast cannot be performed, abrade in accordance with SSPC-SP 3 (Power Tool Cleaning).
3. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded, such as bolts, nuts, or preformed channels.
4. Test surface for contaminants using copper sulfate solution.

B. Stainless-steel surfaces:
1. Abrasive blast clean in accordance with SSPC-SP 16 to leave a clean, uniform appearance with surface profile between 1.5 and 2.5 mils.

C. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPF 500-03.

D. Sherardized, aluminum, copper, and bronze surfaces:
1. Abrasive blast clean in accordance with SSPC-SP 16.
2. Prepare in accordance with CSM's instructions.

E. Cadmium-plated, zinc-plated, or sherardized fasteners:
1. Abrasive blast in the same manner as uncoated metal when assembling equipment designated for abrasive blasting.

F. PVC and FRP surfaces:
1. Lightly sand surfaces to be coated.
a. Sand to remove gloss and establish uniform surface profile.
2. Vacuum to remove loose dust, dirt, and other materials.
3. Solvent clean with clean white rags and allow solvent to evaporate completely before applying coating materials.

3.09 APPLICATION REQUIREMENTS

A. Apply coatings in accordance with manufacturer's instructions.

B. Empty aboveground piping to be coated of contents when applying coatings.

C. Mechanical equipment shop primed by the manufacturer.
1. Pumps and valves: Shop coat with manufacturer's highest quality coating system meeting the project specifications.
a. Contractor shall provide CTR shop coating reports.
2. Non-immersed equipment: Touch up shop primer, and coat in the field with specified coating system after installation.
a. If project requires equipment removal and reinstallation, complete touchup coating after final installation.
3. Immersed equipment not shop coated: Remove shop primer before surface preparation and field apply coating.

D. Verify surface preparation immediately before applying coating in accordance with SSPC SP COM and the SSPC visual standard for the specified surface preparation method.

E. Allow surfaces to dry, except where coating manufacturer requires surface wetting before coating.

F. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with manufacturer's recommended special primer.

G. Do not apply coatings to a surface until it has been prepared as specified.

H. Use equipment designed to apply materials specified.
   1. Use compressors with moisture traps and filters that remove water and oils from the air.
      a. Perform a paper blotter test at the Engineer's request to verify air is sufficiently free of oil and moisture. Do not allow the amount of oil and moisture to exceed CSM-recommended amount.
   2. Equip spray equipment with properly sized mechanical agitators, pressure gauges, pressure regulators, and spray nozzles.

I. Where 2 or more coats are required, tint prime coat intermediate coats as necessary to distinguish each coating and to help indicate coverage.
   1. Do not use color additives with chromium, lead or lead compounds that hydrogen sulfide, other corrosive gases, might destroy or alter. Apply the specified number of coats.

J. Apply coating by brush, roller, trowel, or spray unless a specific application method is required by coating manufacturer's instructions or these Specifications.
   1. Apply primer or first coat by brush to power tool cleaned ferrous surfaces.
   2. Brush or spray-apply coats for blast-cleaned ferrous surfaces and subsequent coats for non-blast cleaned ferrous surfaces.
   3. After prime coat dries, mark, repair, and retest pinholes and holidays before intermediate or topcoats are applied.

K. Spray application:
   1. With a brush, stripe coat edges, welds, corners, nuts, bolts, and difficult-to-reach areas, as necessary, before spray application to ensure specified coating thickness along edges.
   2. When using spray application, apply each coat to thickness no greater than recommended in coating manufacturer's instructions.
   3. Use airless spray method unless air spray method is required by CSM's instruction or these Specifications.
   4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.

L. Lightly sand and thoroughly clean surfaces to receive high gloss finishes unless CSM instructs otherwise.

M. Remove all dust on coatings between coats.

N. Shop and field coats:
   1. Prime coat: Shop-apply or field-apply prime coats as specified. Use shop-applied primer compatible with the specified field coating system and apply at the minimum dry film thickness recommended by the finish coat CSM.
      a. Provide data sheets identifying the shop primer to on-site coating application personnel.
      b. Perform adhesion tests on the shop primer.
      c. Remove and recoat damaged, deteriorated, and poorly applied shop coatings.

d. If shop primer coat meets this Section's requirements, spot prime exposed metal of shop-primed surfaces before spray applying primer over the entire surface.

2. Field coats: Apply field coats with 1 or more prime coats and finish coats to build up coating to dry film thickness specified for the coating system.
   a. Do not apply finish coats until other work in the area is complete and previous coats are inspected.
3. Adhesion confirmation: Perform adhesion tests after proper coating cure in accordance with ASTM D3359. Demonstrate that:
   a. Prime coat adheres to the substrate.
   b. Coatings adhere to the prime and intermediate coats.
      1) Coating 5 mils or more DFT: Achieve adhesion test result of 5A on immersed surfaces and 4A or better on other surfaces.
      2) Coating less than 5 mils DFT: Achieve adhesion test results of 5B on immersed surfaces and 4B or better on other surfaces.

O. Brush, roll, trowel, or spray and back roll coats for concrete and masonry.

P. Plural component coating application:
1. Premix contents of component drums if required by the CSM each day.
2. Before starting application:
   a. Verify gauges are working properly.
   b. Complete ratio checks.
   c. Sample the mix on plastic sheeting to ensure set time is appropriate and complete.
   d. Label and retain all spray samples. Submit to Engineer when requested.

Q. Drying and recoating:
1. Provide fans, heating devices, or other means to prevent condensate or dew on substrate surface or between coats and during curing after applying the last coat.
2. Allow each coat to cure or dry thoroughly, in accordance with if required in CSM’s printed instructions, before recoating.
3. Use CSM's printed instructions and the requirements specified in this Section to determine minimum required drying time.
   a. Do not allow excessive drying time or exposure, which may impair bond between coats.
   b. Recoat all coatings within time limits recommended by CSM.
   c. If time limits are exceeded, abrasive blast clean and de-gloss clean before applying another coat.
4. If limitations on time between abrasive blasting and coating are not met before attaching components to surfaces that cannot be abrasive blasted, coat components before attachment.
5. Ensure primer and intermediate coats of coating are unscarred and completely integral when applying each succeeding coat.
6. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
7. Leave no holidays. Repair all holidays in accordance with the requirements on pertinent Coating Detail Sheets or as recommended by the CSM.
8. Sand and feather in to a smooth transition and recoat scratched, contaminated, or otherwise damaged coating surfaces so repairs are invisible to the naked eye.

9. For submerged service or highly corrosive headspace service, provide a letter to the Engineer stating that the lining system is fully cured and ready to be placed into service.

R. Workmanship:
   1. Ensure that coated surfaces are free from runs, drips, ridges, waves, laps, and brush marks. Coats shall be applied to produce a smooth, even film of uniform thickness completely coating corners and crevices.
   2. Coat surfaces without drops, overspray, dry spray, excessive runs, ridges, waves, holidays, laps, or brush marks.
   3. Remove splatter and droppings after coating work is completed.
   4. Evenly apply each coat of material and sharply cut to a line created with masking tape or other suitable materials.
   5. Avoid over spraying or spattering paint on surfaces not to be coated. Protect glass, hardware, floors, roofs, vehicles, and other adjacent areas and installations by taping, drop cloths, or other suitable measures.
   6. When coating complex steel shapes, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces with the primer before overall coating system application.
      a. Brush apply stripe coat to ensure proper coverage.
      b. Do not stripe coat with spray or roller.
   7. Ensure that finish coat, including repairs, has a uniform color and gloss.

S. Coating properties, mixing, and thinning:
   1. Thin prime coat and apply as recommended by the CSM. Thinned coating must comply with prevailing air pollution control regulations.
   2. If maximum recoat time is exceeded, prepare surface with solvent washing, light abrasive blasting, or other procedures per CSM’s instructions.
   3. Allow adequate drying time between coats as instructed by the CSM, adjusted as necessary for the site conditions.
   4. Ensure that coatings, when applied, provide a satisfactory film and a smooth even surface. Lightly sand glossy undercoats to provide a surface suitable for proper application and adhesion of subsequent coats. Thoroughly stir and strain coating materials during application and maintain uniform consistency.
   5. Mix coatings with 2 or more components in accordance with CSM’s instructions.
   6. Where necessary to suit conditions of the surface, temperature, weather and method of application, thin the coating per CSM's recommendations.
      a. Ensure that volatile organic content (VOC) of the thinned coating complies with prevailing air pollution control regulations.
      b. Thin coatings to only what is necessary to obtain proper application characteristics.
      c. Use a thinner recommended by the CSM.

T. Film thickness and continuity:
   1. Apply coating to the specified thicknesses.
      a. Apply additional coats when necessary to achieve specified thicknesses, especially at edges and corners.
   2. Verify WFT of the coating system first coat and after applying each subsequent coat.
   3. Do not allow the minimum thickness at any point to deviate more than 25 percent from the required average.

4. Do not allow the surface area covered per gallon of coating for various types of surfaces to exceed those recommended by the CSM.
    a. Provide coating coverage worksheets listing the maximum and minimum coverage for each unit volume of coating for concrete surfaces.
5. Apply additional coats to achieve the specified dry film thickness if brush or roller application methods cannot achieve the specified film thicknesses per coat.

U. Protecting coated surfaces:
1. Do not handle, work on, or otherwise disturb coated items until the coating is completely dry and hard.
2. After installation, recoat shop-coated surfaces with specified coating system as necessary to match surrounding surfaces, and to coordinate with the specified color identification requirements.

V. Special requirements:
1. Before erection, apply all but the final finish coat to interior surfaces of roof plates, roof rafters and supports, pipe hangers, piping in contact with hangers, and contact surfaces inaccessible after assembly. Apply final coat after erection.
2. Coat structural slip-critical connections and high strength bolts and nuts after erection.
3. Areas damaged during erection:
    a. Prepare surface for spot repairs as specified for the coating system.
    b. Recoat with prime coat before applying subsequent coats.
    c. Touch up surfaces after installation.
    d. Clean and dry surfaces to be coated at time of application.
4. Coat underside of equipment bases and supports not galvanized with at least 2 coats of primer specified before setting the equipment in place.
5. Coat aluminum in contact with concrete.

3.10 APPLICATION REQUIREMENTS FOR CONCRETE COATING SYSTEMS

A. Apply filler/surfacer as recommended by CSM to fill bug holes and air voids in concrete or block texture in CMU, leaving a uniformly filled surface that does not produce blowholes or outgassing causing the coating system to pinhole.
1. Allow filler/surfacers to cure sufficiently before applying prime coat as required by the CSM. Use the CSM-recommended drying time between coats.

B. Apply surfacer or filler and let dry before coating application.
1. Use the drying time between filler/surfacer and coating system specified by the CSM for the site conditions.
    a. Let concrete substrate dry before applying filler/surfacers or coating system materials.
2. If the maximum recoat time is exceeded, prepare surfaces by solvent washing, light abrasive blasting, and other procedures per CSM's instructions.
3. Apply a complete parge coat of the specified filler/surfacer material over the entire substrate before applying the coating system.
    a. Scrub filler/surfacer into the substrate to completely fill open air voids and bug holes.
    b. Completely cover the substrate, unless otherwise specified, above such filled voids by 1/8 inch of thickness.

c. Provide relatively flat, uniformly even surface before coating application.

4. Secondary containment: Place surfacer or filler 1/16 inch thick above concrete plane to create a monolithic surface free of pinholes.
   a. Floor surfaces: Broadcast with aggregate to create a non-slip surface texture.
   b. Remove excess aggregates and apply base coat to encapsulate embedded non-slip aggregate.

C. Concrete substrate temperatures:
   1. Apply filler/surfacers and the coating system when temperatures are falling, typically late afternoon or evening.
      a. Do not coat concrete with rising concrete substrate surface temperatures or substrates in direct sunlight, to minimize outgassing from the substrate and formation of pinholes, and/or blistering.
   2. Should bubbles, pinholes, or other discontinuities form in the applied coating system material, they shall be repaired.
      a. Should discontinuities develop in the filler/surfacer material or in the first coat of the coating material, repair them before the next coat.
      b. When discontinuities occur, open the air void behind or beneath the discontinuities and completely fill with specified coating material. Then, abrade the coated area around the discontinuities repair reapply coating over that area.

D. Perform application detail work in accordance with these Specifications, the CSM's current written recommendations, and drawings, whichever is stricter.

E. Concrete coating systems application requirements:
   1. Concrete coating minimum dry film thickness excludes parge coat, block filler, and sealer.

3.11 COATING SYSTEM SCHEDULE

A. Appendix A specifies surfaces to be coated in the field with the coating systems required.

3.12 SURFACES NOT REQUIRING COATING

A. Stainless steel piping, valves, pipe supports, instrument sunshades.

B. Sliding surfaces on expansion joints, motor and pump shafts, machined surfaces at bearings and seals, grease fittings, etc.

C. Galvanized structural steel framing, galvanized roof decking, galvanized pipe supports.

D. Copper and brass pipe, fittings, valves, etc.

E. Bronze valves, bearings, bushings, and fasteners.

F. Corrosion resistant special alloys: Inconel, Alloy 20, Hastelloy, etc.

G. Exterior Concrete.

H. Plastic surfaces except coat PVC, CPVC, and other plastic piping system exposed to sunlight.

I. Buried Piping that is encased in concrete or cement mortar.

3.13 QUALITY CONTROL

A. Owner-provided inspection or inspection by others does not limit the Contractor's or CSA's responsibilities for quality workmanship or quality control as specified or as required by the CSM's instructions. Owner inspection is in addition to any inspection required of the Contractor.

B. Owner may perform, or contract with an inspection agency to perform, quality control inspection and testing of the coating work covered by this Section. These inspections may include the following:
   1. Inspect materials upon receipt to ensure that the CSM supplied them.
   2. Verify that specified storage conditions for the coating system materials, solvents, and abrasives are provided.
   3. Inspect and record findings for substrate cleanliness.
   4. Inspect and record pH of concrete and metal substrates.
   5. Inspect and record substrate profile (anchor pattern).
   6. Measure and record ambient air and substrate temperature.
   7. Measure and record relative humidity.
   8. Check for substrate moisture in concrete.
   9. Verify that mixing of coating system materials is in accordance with CSM's instructions.
   10. Inspect, confirm, and record that coating system materials' "pot life" is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.
   11. Perform adhesion testing.
   12. Measure and record the coating system's thickness.
   13. Verify proper curing of the coating system in accordance with the CSM's instructions.
   14. Holiday or continuity testing in accordance with NACE SP0188 for coatings that will be immersed or exposed to aggressively corrosive conditions.

C. Contractor shall perform holiday testing in accordance with NACE SP0188 to identify holidays or pinholes needing repair for coating over 100 percent of surfaces:
   1. Coated steel that will be immersed or exposed to aggressively corrosive conditions.
   2. Coated concrete.
   3. Perform holiday tests after proper application and coating system cure.

3.14 CORRECTIVE MEASURES

A. Repair pinholes or holidays identified by Holiday Testing as follows:
   1. Remove the coating system with a grinder or other suitable power tool.
   2. Remove coating system at all pinholes and holidays at least 2 inches diameter around the defect back to expose substrate.
   3. Concrete voids: chip back to expose entire cavity in all directions.
      a. Completely fill void with approved filler/surfacer material using a putty knife or other suitable tool, and strike off. Cure per CSM's recommendations.

4. Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system.
5. Vacuum the prepared area to remove all dust, dirt, etc., leaving clean, sound surfaces.
6. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.
7. Apply the coating system with enough coats to achieve the specified finish coat thickness over the defect and coating removal area. Feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline.
8. Follow curing time between coats as specified by CSM for the site conditions. Solvent wash and abrasive blast per CSM's instructions, if the maximum recoat time is exceeded.
9. Apply coating at specified dry film thickness.

3.15 CLEANUP

A. Remove surplus materials, protective coverings, and accumulated rubbish after completing coating. Thoroughly clean surfaces and repair overspray or other coating-related damage.

3.16 FINAL INSPECTION

A. Conduct final inspection of coating system work to determine whether it meets specifications requirements.

B. Conduct subsequent final inspection with Engineer to ensure work conforms to contract documents requirements.

C. Mark any rework required.
   1. Re-clean and repair, as specified, at no additional cost to the Owner.

END OF SECTION

APPENDIX A
Schedule of Surfaces to be Coated

A. The following schedule is incomplete. Coat unlisted surfaces with same coating system as similar listed surfaces. Contact Engineer for clarification.

EPU-M-1	Metals, exterior, non-immersed
EPX-M-2	Metals, interior, non-immersed
EPX-M-3	Metals, immersed
EPX-C-2	Concrete
ACR-PVC-1	PVC

Notes:

1: Non-immersed ferrous metal surfaces include:
- a. Doors, doorframes, ventilators, louvers, grilles, exposed sheet metal, and flashing.
- b. Pipe, valves, pipe hangers, supports and saddles, conduit, cable tray hangers, and supports.
- c. Motors and motor accessory equipment.
- d. Drive gear, drive housing, coupling housings, and miscellaneous gear drive equipment.
- e. Valve and gate operators and stands.
- f. Structural steel.
- g. Crane and hoist rails.
- h. Exterior of tanks and other containment vessels.
- i. Mechanical equipment supports, drive units, and accessories.
- j. Bare electrical equipment: boxes, exposed conduit, and accessories.
- k. Pumps not submerged.
- l. Other miscellaneous metals.

2: Immersed ferrous metal surfaces include:
- a. Interior surfaces of ferrous metal tanks.
- b. Field priming of ferrous metal surfaces with defective shop-prime coat; including non-submerged service.
- c. Bell rings, underside of manhole covers and frames.
- d. Sump pumps, including underside of base plates and submerged suction and discharge piping.
- e. Exterior of submerged piping and valves other than stainless steel or PVC piping.
- f. Submerged pipe supports and hangers.
- g. Stem guides.
- h. Other submerged iron and steel metal unless specified otherwise.

Appendix B			
Coating Detail Sheet			
Coating System	EPU-M-1		
Coating Material	Two coats epoxy with polyurethane finish coat		
Substrate	Metal		
Products	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 890	Carboguard 890	Carbothane 134 VOC
International Paint	Devran 224V	Devran 224V	Devthane 379
PPG	Amercoat 385	Amercoat 385	Amercoat 450H
Sherwin Williams	Macropoxy 646	Macropoxy 646	Hi Solids Polyurethane
Tnemec	Series 66HS	Series 66HS	Series 1095
Service Condition	Interior or Exterior, subject to direct sunlight. Non-immersion.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP10, Near-White Blast Cleaning. Shop primed surfaces: SSPC-SP2, Hand Tool Cleaning or SSPC-SP3, Power Tool Cleaning. Damaged primer or rust: SSPC-SP10, Near White Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush Blast Cleaning. Test for surface contaminants.		
Surface profile			
Ferrous Metal	2.5 to 3.0 mils		
Nonferrous Metal	1.5 to 2.0 mils		
Galvanized Metal	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	10 to 13 mils		
Primer	4 to 5 mils		
Intermediate Coat	4 to 5 mils		
Finish Coat	2 to 3 mils		
Application			
Special CTR Training	Not required.		

Appendix B			
Coating Detail Sheet			
Coating System	EPX-M-2		
Coating Material	Epoxy		
Substrate	Metal		
Products	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 890	Carboguard 890	Carboguard 890
International Paint	Bar-Rust 236	Bar-Rust 236	Bar-Rust 236
PPG	Amerlock 2/400 Series	Amerlock 2/400 Series	Amerlock 2/400 Series
Sherwin Williams	Macropoxy 80	Macropoxy 80	Macropoxy 80
Tnemec	Series 66HS	Series 66HS	Series 66HS
Service Condition	Immersed, non-immersed, moderately corrosive environment.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP5, White Metal Blast Cleaning. Shop primed surfaces: SSPC-SP7, Brush-Off Blast Cleaning. Damaged primer or rust: SSPC-SP5, White Metal Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Surface profile			
Ferrous Metal	2 to 4 mils		
Nonferrous Metal	1.0 to 1.5 mils		
Galvanized Metal	1.0 to 1.5 mils		
System Thickness (Dry Film)			
Total	12 to 16 mils		
Primer	4 to 6 mils		
Intermediate Coat	4 to 6 mils		
Finish Coat	4 to 6 mils		
Application			
Special CTR Training	Not required.		

Appendix B			
Coating Detail Sheet			
Coating System	EPX-M-3		
Coating Material	Epoxy		
Substrate	Metal		
Products	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 891	Carboguard 891	Carboguard 891
International Paint	Bar-Rust 236	Bar-Rust 236	Bar-Rust 236
PPG	Amercoat 240	Amercoat 240	Amercoat 240
Sherwin Williams	Macropoxy 80	Macropoxy 80	Macropoxy 80
Tnemec	Series 104	Series 104	Series 104
Service Condition	Immersed; non-immersed, corrosive environment. Not for Biogenic Sulfide Corrosion areas in wastewater.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP5, White Metal Blast Cleaning. Shop primed surfaces: SSPC-SP7, Brush-Off Blast Cleaning. Damaged primer or rust: SSPC-SP5, White Metal Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Surface profile			
Ferrous Metal	2.5 to 3.0 mils		
Nonferrous Metal	1.5 to 2.0 mils		
Galvanized Metal	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	16 to 20 mils		
Primer	4 to 8 mils		
Intermediate Coat	4 to 8 mils		
Finish Coat	4 to 8 mils		
Application			
Special CTR Training	Not required.		

Appendix B			
Coating Detail Sheet			
Coating System	EPX-C-2		
Coating Material	Epoxy		
Substrate	Concrete or masonry		
Products	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 890	Carboguard 890	Carboguard 890
International Paint	Bar-Rust 236	Bar-Rust 236	Bar-Rust 236
PPG	Amerlock 2/400 Series	Amerlock 2/400 Series	Amerlock 2/400 Series
Sherwin Williams	Macropoxy 646	Macropoxy 646	Macropoxy 646
Tnemec	Series 66HS	Series 66HS	Series 66HS
Service Condition	Interior, Non-Immersion, Moderately Corrosive.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Concrete	Cure at least 28 days and dry to the CSM's recommended moisture content. Remove loose concrete and laitance from surfaces, and repair voids and cracks as specified in this Section.		
Existing Coated Concrete	Remove all existing coating to a sound substrate or intact, well-adhered coating. Abrade all surfaces to achieve required surface profile and vacuum to remove all loose dirt, paint chips, and dirt.		
Masonry	Cure at least 28 days and dry to CSM's recommended moisture content. Fill holes or other joint defects with mortar and repoint. Scrape or chip to remove loose or splattered motar. Wash and scrub masonry surfaces with clear water to remove foreign and deleterious substances. Do not use muriatic acid. Fill surfaces with block filler compatible with the specified primer after cleaning.		
Surface profile			
Concrete	0.5 to 1.5 mils		
Existing Coated Concrete	0.5 to 1.5 mils		
Masonry	0.5 to 1.5 mils		
System Thickness (Dry Film)			
Total	10 mils, excluding block filler and sealer.		
Application			
General	Let sealer or filler dry at least 48 hours before primer application. Use CSM's recommended drying time between coats.		
Special CTR Training	Not Required.		

Appendix B			
Coating Detail Sheet			
Coating System	ACR-PVC-1		
Coating Material	Acrylic		
Substrate	PVC and CPVC pipe		
Products	Primer	Intermediate Coat	Finish Coat
Carboline	Carbocrylic 120	None Applied	Carbocrylic 3359
International Paint	Devcryl 1440	None Applied	Devcryl 1448
PPG	Pitt Tech Primer	None Applied	Pitt Tech
Sherwin Williams	Sher Cryl HPA	None Applied	Sher Cryl HPA
Tnemec	Series 1028 or 1029	None Applied	Series 1028 or 1029
Service Condition	Exterior, exposed to direct sunlight, non-immersed.		
Surface Preparation	Prepare surfaces as specified in this Section and as follows.		
General	Clean to remove loose dirt, dust, or other contaminants. Sand surfaces to achieve a uniform, roughened surface profile. Solvent clean and vacuum to remove loose debris.		
Surface profile	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	3 mils		
Primer	2 to 4 mils		
Finish Coat	2 to 4 mils		
Application			
Special CTR Training	Not Required.		

SECTION 09997

PIPELINE COATINGS AND LININGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pipeline coatings and linings.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. B1000 - Standard Practices for Casting Preparation and Test Procedure of Porcelain Enamel-lined Pipe, Fittings, and Valves for Use in the Municipal Wastewater, Sewage, and Water Treatment Industry.
   2. C33 - Standard Specification for Concrete Aggregates.
   3. C150 - Standard Specification for Portland Cement.
   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.
   6. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.

B. American Water Works Association (AWWA):
   1. C104 - Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
   2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
   3. C203 - Coal-Tar Protective Coatings and Linings for Steel Water Pipes.
   4. C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe 4 In, and Larger-Shop Applied.
   5. C210 - Liquid Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   6. C214 - Tape Coatings for Steel Water Pipelines.
   7. C216 - Heat-Shrinkable Cross-Linked Polyolefin Coatings for Steel Water Pipe and Fittings.
   8. C217 - Microcrystalline Wax and Petrolatum Tape Coating Systems for Steel Water Pipe and Fittings (PDF).
   9. C222 - Bolted, Split-Sleeve Restrained and Nonrestrained Couplings for Plain-End Pipe.
   10. C225 - Fused Polyolefin Coatings for Steel Water Pipelines
   11. C301 - Prestressed Concrete Pressure Pipe, Steel-Cylinder Type.
   12. C303 - Concrete Pressure Pipe, Bar-Wrapped, Steel-Cylinder Type.

C. National Association of Pipe Fabricators (NAPF):
   1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

D. International Organization for Standardization (ISO):
   1. 8179-1 - Ductile iron pipe, fittings, accessories and their joints - External zinc-based coating - Part 1: Metallic zinc with finishing layer.

E. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

F. Society for Protective Coatings (SSPC):
   1. PA 2 - Procedure for Determining Conformance to Dry Coating Thickness Requirements.
   2. SP 1 - Solvent Cleaning.
   3. SP 3 - Power Tool Cleaning.
   4. SP 5 - White Metal Blast Cleaning.
   5. SP 6 - Commercial Blast Cleaning.
   6. SP 10 - Near-White Metal Blast Cleaning.
   7. SP 11 - Power Tool Cleaning to Bare Metal.
   8. SP 13 - Surface Prep of Concrete.

1.03 SUBMITTALS

A. Manufacturer's qualifications.
   1. Manufacturer qualifications and list of projects using the specified material: 5 years minimum.

B. Manufacturer's Quality Assurance Manual.
   1. Submit manufacturer's coating and lining application quality assurance manual to Engineer prior to beginning coating application.
      a. Strict conformance to the requirements of the manual will be required.
      b. Deviation from the requirements of the manual will be grounds for the Engineer to reject the applied coating.

C. Product information.

1.04 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. Store piping, fittings, and other accessories such that they do not accumulate and hold rainwater, dirt, and debris.

PART 2 PRODUCTS

2.01 COATING AND LINING MATERIALS

A. As specified in Section 01600 - Product Requirements.

B. Prepare, install, and repair in accordance with manufacturer's requirements.

C. Contractor is responsible for:
   1. That coating selected is suitable for the application conditions anticipated, such as temperature, humidity, etc.
   2. Managing the project schedule to allow adequate cure time before backfill or immersion based on surface temperatures at the time of application.

2.02 CEMENT MORTAR

A. Cement mortar mixture in accordance with AWWA C205 and as specified in this Section.
   1. Cement: Type II.

B. Water for cement mortar in accordance with AWWA C205 and as specified in this Section.

C. Provide silica sand or other aggregate that is not subject to leaching in accordance with ASTM C33.

D. Shop apply cement mortar in uniform thickness over the full length of the pipe.

2.03 HEAT SHRINK SLEEVES

A. In accordance with AWWA C216 and as specified in this Section.
   1. Manufacturers: One of the following or equal:
      a. Canusa.
      b. Covalence.
   2. Engineer may approve use of "Weld After Backfill.
   3. Sleeve width:
      a. Contractor to consider sleeve shrinkage and joint profile in determining sleeve width required.
      b. Overlapping of 2 or more heat shrink sleeves to achieve the necessary width on pipe joints will not be permitted without Engineer approval.
   4. Sleeve overlap:
      a. Minimum of 3 inches or as indicated on the Drawings.
   5. Heat shrink sleeve material:
      a. Cross-linked polyolefin wrap with a mastic sealant.
      b. Nominal thickness: 85-mil.
      c. Suitable for pipeline operating temperature.
      d. Sleeve material recovery in accordance with sleeve manufacturer’s requirements.
   6. Filler mastic:
      a. Adhere filler material to the pipe and heat shrink sleeve.
      b. Size and type in accordance with sleeve manufacturer’s requirements.
      c. Provide filler material at step changes greater than 1/4-inch.
   7. Apply filler material in a manner and of sufficient thickness that no tenting or voids remain under the heat shrink sleeve.
      a. Joints subject to weld after backfill: Filler mastic melt temperature minimum of 500 degrees Fahrenheit.

2.04 LIQUID APPLIED EPOXY LINING

A. In accordance with AWWA C210 and as specified in this Section.

B. Manufacturers: One of the following or equal:
   1. Carboline.
   2. ICI Devoe.
   3. Tnemec.
   4. Sherwin Williams.

C. Steel pipe lining:
   1. Where epoxy lining is specified or indicated on the Drawings, apply epoxy lining directly to the steel surface as follows:
      a. Surface preparation: SSPC-SP 5.
      b. Epoxy lining: Polyamine or polyamide high build epoxy, NSF 61 approved, suitable for continuous immersion, and capable of achieving full cure before placement in service or exposing to water.
      c. Application: Apply in 3 coats at 5 mils minimum dry film thickness per coat with separate stripe coat at welds.

D. Epoxy overcoat of cement mortar lining:
   1. Provide liquid epoxy primer and lining in cement mortar lined metallic pipe at insulating joints for a minimum of 2 pipe diameters on each side of the insulated joint. If other side of joint is an existing pipe, apply epoxy lining for 2 pipe diameters in fabricated pipe.
   2. Cure epoxy lining with NSF 61 polyamine or polyamide approved for potable water contact and capable of achieving full cure prior to placement in service or exposure to water.
   3. Application:
      a. Cement mortar preparation:
         1) Prior to surface preparation and coating application, cure cement mortar for a minimum of 15 days or steam cure a minimum of 7 days.
         2) Prepare cement mortar lining by abrasive blasting to remove laitance and provide a surface profile equivalent to 80 grit sandpaper.
         3) Mortar lining must be dry prior to epoxy lining application.
      b. Epoxy overcoat application:
         1) Apply in 2 coats at equivalent spread rate for 6 mils dry film thickness per coat.
         2) Apply epoxy over the cement mortar lining where specified for the pipeline lining material.

E. Application:
   1. Apply epoxy lining directly to the steel surface after abrasively blasting to SSPC-SP 5.
   2. Cement mortar preparation:
      a. Prior to surface preparation and coating application, cure cement mortar for a minimum of 15 days or steam cure a minimum of 7 days.
         1) Cure hand applied mortar lining a minimum of 15 days or in accordance with coating manufacturer's requirements for application on cement or concrete, whichever is greater.
      b. Prepared cement mortar lining by abrasive blasting to remove laitance and create a suitable anchor profile equivalent to 80 grit sandpaper.
      c. Mortar lining must be dry during epoxy lining application.
   3. Epoxy application:
      a. Clean the interior of cement mortar lined pipe at insulating joints.
      b. Coat the interior of cement mortar lined pipe at insulating joints.

1) Apply 2 coats of epoxy coating.
2) Applied in a manner that will minimize gassing and pinholes in the completed lining.
3) Provide total coating thickness of 16 mils dry film thickness.
4) Apply to both sides of the insulating joint for a minimum of 1 pipe diameter.
    a) If only 1 side of the joint can be coated, apply coating for a minimum of 2 pipe diameters.

2.05 PLURAL COMPONENT EPOXY

A. Plural component, 100 percent solids, non-extended in accordance with AWWA C210 and as specified in this Section.

B. Surface preparation: SSPC-SP 10 or SSPC-SP 11.

C. Primer: In accordance with coating manufacturer's requirements.

D. High build epoxy coating:
    1. 2 component, high build polyamide or polyamine cured epoxy coating, suitable for direct burial or immersion, dries to touch in 2 or more hours, suitable for immersion or burial after full cure of coating.
    2. Manufacturers: One of the following or equal:
        a. Carboline.
        b. ICI Devoe.
        c. Sherwin Williams.
        d. Warren Environmental.

E. Fast cure epoxy coating:
    1. 2 component, 100 percent solids by volume, fast cure epoxy coating suitable for direct burial or immersion, dry to touch in less than 1 hour at 72 degrees Fahrenheit, capable of curing while immersed or buried.
    2. Manufacturers: One of the following or equal:
        a. North American Denso, Protal 7125 or Protal 7200.
        b. Tapecoat Inc., TC 7010.

F. Application:
    1. Apply coating using plural component spray equipment by a manufacturer certified coating applicator.
    2. Perform coating application in an environmentally controlled shop area that meets or exceeds the written environmental application requirements of the coating manufacturer.
        a. It is not acceptable to apply coating in outdoor conditions without adequate environmental shelter, environmental controls, and/or dehumidification.
    3. In potable water applications, provide epoxy lining suitable for potable water contact in accordance with NSF 61, unless otherwise approved by Engineer.
    4. Concrete embedded pipe penetrations: Extend epoxy coating a minimum of: 6 inches outside of interior and exterior surfaces of concrete walls or floors.
    5. Concrete penetrations minimum dry film thickness: 12 mils.
    6. Apply heat shrink sleeves to buried transitions from epoxy to tape wrap or extruded polyolefin coating systems.

a. Backfill as soon as practical to limit exposure to direct sun or heat and potential thermal creep of sleeve.

G. Self-priming, plural component, 100 percent solids, suitable for burial or immersion, and in accordance with AWWA C210 and the following, whichever is more stringent:
   1. Non-NSF certified: Ceramic fill.
   2. NSF certified: Poly amine epoxy or poly amide epoxy.
   3. Shop applied coating thickness:
      a. Minimum: 1 coat, 35 mils total dry film thickness.
   4. Shop applied lining thickness:
      a. Minimum: 1 coat, 35 mils total dry film thickness.

H. Adhesion test procedures:
   1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A except as modified in this Section.
      a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
      b. Use automatic adhesion test equipment.
      c. Perform tests to coating or glue failure or maximum test load, whichever is happens first.
      d. In accordance with ASTM D4541 using standard 20-millimeter dollies.
      e. Base adhesion testing on 3 tests.
         1) Conduct the tests by the same person, test equipment, and test procedure.
         2) Complete the tests within a 30-minute period.
      f. Conduct adhesion tests within an area not to exceed 6 inches by 6-inches.
      g. Score coatings with more than 10 percent elongation or 25 mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.
   2. Attach dollies for adhesion testing to the coating surface using a 2-part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater.
      a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
   3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with coating manufacturer’s requirements.
      a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with coating manufacturer’s requirements and Engineer‘s approval.
   4. Epoxy coating and lining adhesion criteria:
      a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
      b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.

5. Pipe lot performance criteria:
    a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
    b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion.
        1) Reject each pipe that fails the coating adhesion criteria.
6. Adhesion test evaluation and records:
    a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.
    b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.
    c. Adhesion test failure:
        1) Adhesive or substrate failure.
            a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
        2) Cohesive test failure.
            a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
    d. Retest coating adhesion tests:
        1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the Acceptance Criteria or the Minimum Criteria.
        2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
        3) Retest disputed adhesion tests.
            a) Owner's representative will witness dolly attachment and adhesion retesting.
    e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.
    f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
        1) Pipe identification.
        2) Pipe coating date.
        3) Adhesion test date.
        4) Surface tested (interior or exterior).
        5) Surface temperature at time of test.
        6) Coating thickness.
        7) Tensile force applied.
        8) Applied load rate per second.
        9) Mode of failure.
        10) Percentage of failure types, previously defined, relative to dolly surface area.
        11) Dolly size and attachment glue used.
        12) If different coatings are tested, include coating manufacturer and product number.
7. Adhesion test repairs:
    a. Fabricator or contractor to complete adhesion repairs as specified this Section.
    b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

I. Long term adhesion test:
   1. Acceptance criteria:
      a. Not more than 10 percent loss of adhesion over duration of test.
      b. Differential based on the highest average adhesion result to the lowest average adhesion result.
   2. Test durations, cumulative:
      a. 1 day.
      b. 7 days.
      c. 3 weeks.
      d. 2 months.
   3. Sample preparation:
      a. SSPC-SP 5, 3.00 mils profile, minimum.
      b. Test area minimum: 18 inches by 18 inches.
      c. Curved steel plate.
         1) Minimum radius of 15 inches.
         2) Inclined between 30 and 45 degrees.
   4. Test procedure:
      a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.
   5. Adhesion test results:
      a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
      b. Based an average of the 5 highest pulls and identify the values used.
   6. Record adhesion pulls and their failure mode.
   7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

2.06 PLURAL COMPONENT POLYURETHANE

A. Plural component, polyurethane coating system (referred to as a polyurethane system) applied in accordance with AWWA C222 and as specified in this Section.

B. Manufacturers: One of the following or equal:
   1. Chemline, Chemthane 2265.
   2. Lifelast, Equivalent product.

C. Adhesion test procedures:
   1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A except as modified in this Section.
      a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
      b. Use automatic adhesion test equipment.
      c. Perform tests to coating or glue failure or maximum test load, whichever is happens first.
      d. In accordance with ASTM D4541 using standard 20-millimeter dollies.
      e. Base adhesion testing on 3 tests.
         1) Conduct the tests by the same person, test equipment, and test procedure.
         2) Complete the tests within a 30-minute period.
      f. Conduct adhesion tests within an area not to exceed 6 inches by 6-inches.

g. Score coatings with more than 10 percent elongation or 25 mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.

2. Attach dollies for adhesion testing to the coating surface using a 2-part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater.
   a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with coating manufacturer's requirements.
   a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with coating manufacturer's requirements and Engineer‘s approval.
4. Epoxy coating and lining adhesion criteria:
   a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
   b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.
5. Pipe lot performance criteria:
   a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
   b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion.
      1) Reject each pipe that fails the coating adhesion criteria.
6. Adhesion test evaluation and records:
   a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.
   b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.
   c. Adhesion test failure:
      1) Adhesive or substrate failure.
         a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
      2) Cohesive test failure.
         a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
   d. Retest coating adhesion tests:
      1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the Acceptance Criteria or the Minimum Criteria.
      2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
      3) Retest disputed adhesion tests.
         a) Owner's representative will witness dolly attachment and adhesion retesting.
   e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.

f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
    1) Pipe identification.
    2) Pipe coating date.
    3) Adhesion test date.
    4) Surface tested (interior or exterior).
    5) Surface temperature at time of test.
    6) Coating thickness.
    7) Tensile force applied.
    8) Applied load rate per second.
    9) Mode of failure.
    10) Percentage of failure types, previously defined, relative to dolly surface area.
    11) Dolly size and attachment glue used.
    12) If different coatings are tested, include coating manufacturer and product number.

7. Adhesion test repairs:
    a. Fabricator or contractor to complete adhesion repairs as specified this Section.
    b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

D. Long term adhesion test:
1. Acceptance criteria:
    a. Not more than 10 percent loss of adhesion over duration of test.
    b. Differential based on the highest average adhesion result to the lowest average adhesion result.
2. Test durations, cumulative:
    a. 1 day.
    b. 7 days.
    c. 3 weeks.
    d. 2 months.
3. Sample preparation:
    a. SSPC-SP 5, 3.00 mils profile, minimum.
    b. Test area minimum: 18-inches by 18-inches.
    c. Curved steel plate.
        1) Minimum radius of 15-inches.
        2) Inclined between 30 and 45 degrees.
4. Test procedure:
    a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.
5. Adhesion test results:
    a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
    b. Based an average of the 5 highest pulls and identify the values used.
6. Record adhesion pulls and their failure mode.
7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

2.07 POLYETHYLENE ENCASEMENT

A. General:
   1. Polyethylene encasement: Supplied by pipe manufacturer.

B. Materials: Supply one of the following polyethylene encasements in accordance with AWWA C105 and as specified in this Section.
   1. Linear low-density polyethylene (LLDPE) film:
      a. Minimum thickness: 8 mils.
      b. Minimum layers: 2.
   2. High-density, cross-laminated polyethylene (HDCLPE) film:
      a. Minimum thickness: 4 mils.
      b. Minimum layers: 1.
   3. V-Bio® enhanced polyethylene encasement:
      a. Product description: 3 layers of co-extruded LLDPE film with anti-microbial additive and volatile corrosion inhibitor infused on the inside surface.
      b. Minimum thickness: 8 mils.
      c. Minimum layers: 1.

2.08 TAPE WRAP

A. In accordance with AWWA C214 and as specified in this Section.

B. Manufacturers: The following or equal:
   1. Liquid adhesive: Polyken 1019, 1027, 1029, or in accordance with coating manufacturer's requirements.
   2. Weld stripe tape: Polyken 931 (no backing), 4-inches wide minimum.
   3. Corrosion layer (Inner wrap): Polyken, 989.
   4. Mechanical layer of tape wrap: Polyken, 955.
   5. Mechanical layer **(**Outer wrap): Polyken 956.

C. Ultraviolet resistance:
   1. Able to resist above grade exposure for a minimum of 12 months or the proposed storage and construction time, whichever is greater.

D. Tape width maximum: 12 inches.
   1. Engineer can approve conditional use of wider tape will be if the coating applicator can demonstrate that proper tensioning can be maintained, and mechanical wrinkling prevented throughout the coating application.
      a. If at any time during the pipe fabrication, tape quality becomes inconsistent, the Engineer can require the remainder of the pipe to be coated using the maximum specified tape width.

E. Manufacturing requirements:
   1. Monitoring system:
      a. Provided by applicator.
      b. Approved by the tape manufacturer that constantly records pipe and tape conditions during coating application.
      c. Recorded monitoring parameters include, but not be limited to the following: Pipe temperature; line speed, primer and tape roll body temperature, and tape tension.
   2. Pipe surface temperature: Between 45 and 120 degrees Fahrenheit and 5 degrees Fahrenheit above dew point, whichever is greater.

3. Apply a uniform liquid adhesive layer in accordance with manufacturer's requirements.
    a. Rug type application is not acceptable.
    b. Finish with skips, runs, or sags is not acceptable.
4. Weld seams stripping tape:
    a. In accordance with AWWA C214 and as specified in this Section.
    b. Corrosion layer adherence to pipe surface.
        1) 100 percent adhering to the metal surface.
        2) No visible damage, wrinkles, voids, contamination, or holidays.
        3) Perform tape coating adhesion test.

F. Tape-coating system thickness:
1. Pipe 24-inch diameter and larger: 80 mil (nominal).
    a. Liquid adhesive layer.
    b. Corrosion layer:
        1) Layer 1 of 20 mil (nominal), black colored tape.
    c. Mechanical layer:
        1) Layer 1 of 30 mil (nominal), grey color tape.
        2) Layer 2 (outer layer) of 30 mil (nominal), white color tape.
2. Pipe less than 24-inch diameter: 50 mil (nominal).
    a. Adhesive layer.
    b. Corrosion layer:
        1) Layer 1 of 20 mil (nominal), black colored tape.
    c. Mechanical layer:
        1) Layer 1 (outer layer) of 30 mil (nominal), white color tape.

G. Overcoat: Cement mortar.

H. Adhesion testing:
1. Apply continuous pulling tension without stopping.
    a. Monitor throughout at least 12-inches length of the pull.
2. Sample preparation:
    a. Conduct on pipe in either of the following conditions:
        1) Prior to application of the cement mortar overcoat, where applicable.
        2) Pipe that has been mortar coated prior to adhesion testing.
            a) Contractor remove mortar coating of sufficient dimensional area to permit the adhesion test to be conducted as directed by the Engineer.
3. Adhesion pull evaluation:
    a. Adhesive failure, defined as separation of the adhesive from the metal substrate, will be rejected.
    b. Failure: Cohesive failure of the adhesive only.
    c. Delamination failure, defined as separation of the adhesive from the backing material, requires the following additional testing:
        1) Pipe that fails the test by delamination will be retested on 2 other pipes within the same lot of coated pipe.
        2) Failure of any 2 pipes within the tape lot will result in rejection of each pipe coated with the rejected tape lot.

2.09 WAX TAPE SYSTEM

A. In accordance with AWWA C217 and as specified in this Section.

B. Manufacturers: One of the following or equal:
   1. Filler mastic:
      a. Denso North America, Denso Densyl Mastic.
      b. The Trenton Corp., Trenton Fill-Pro PM-GP.
   2. Primer:
      a. Denso North America, Denso Paste.
      b. The Trenton Corp., Trenton Wax-Tape Primer.
   3. Wax tape for buried applications:
      a. Denso North America, Densyl Tape.
      b. The Trenton Corp., Trenton Wax-Tape #1.

C. Wax tape for above ground applications:
      a. Denso North America, Densyl Tape.
      b. The Trenton Corp., Trenton Wax-Tape #2.
   2. Tape outerwrap:
      a. Denso North America, Denso Poly-Wrap.
      b. The Trenton Corp., Trenton Poly-Ply.

D. Wax tape properties:
   1. Color:
      a. Potable water pipe: Brown.
      b. Reuse water pipe: Purple.
   2. Saturant pour point: 115 to 125 degrees Fahrenheit.
   3. Thickness minimum: 70 mils.
   4. Tape width: 6 inches.
   5. Dielectric strength: 170 volts per mil.
   6. Coverages: 1 gallon per 100 square feet.

2.10 DUCTILE IRON PIPE

A. Coating:
   1. Polyethylene encasement.
   2. Plural component epoxy:
      a. Ductile iron pipe: SSPC-SP 10 as specified in ductile iron surface preparation, this Section.
         1) Blast profile in accordance with coating manufacturer’s requirements.

B. Lining:
   1. Cement mortar:
      a. In accordance with AWWA C104 and as specified in this Section.
      b. Extend to faces of flanges and ends of spigots.
      c. Provide cement mortar lining of uniform thickness.
      d. Finish to a smooth dense surface.
      e. Cement: In accordance with ASTM C150, Type II.
   2. Cement mortar with seal coat:
      a. In accordance with AWWA C104 and as specified in this Section.
      b. Apply seal coat.
      c. Provide cement mortar lining of uniform thickness.
      d. Finish to a smooth dense surface.

2.11 STEEL PIPE

A. Coating:
   1. Cement mortar:
      a. Apply cement mortar coating:
         1) In accordance with AWWA C205 and as specified in this Section.
         2) As indicated on the Drawings.
      b. Thickness minimum: 1 inch.
      c. Cement: In accordance with ASTM C150, Type II.
      d. Reinforcement:
         1) Steel plate specials: Reinforced with 2-inch by 4-inch, No. 13 gauge welded wire mesh in lieu of steel wire reinforcing wire.
            a) 1 layer of mesh positioned approximately in center of mortar coating.
            b) Lap ends of reinforcement strips 4 inches and tie or loop free ends to assure continuity of reinforcement.
         2) Pipe and specials smaller than 48 inches in diameter: Reinforce coating with spirally-wound steel wire positioned approximately in center of mortar coating:
            a) No. 12 gauge spaced at maximum 1-inch centers.
            b) No. 14 gauge steel wire at maximum 1/2-inch centers.
         3) Pipe and specials 48 inches in diameter and larger: Reinforce coating with 2 layers spirally-wound steel wire positioned approximately in center of mortar coating positioned approximately at the third points of mortar coating:
            a) No. 12 gauge spaced at maximum 1-inch centers.
            b) No. 14 gauge steel wire at maximum 1/2-inch centers.
   2. Polyolefin:
      a. In accordance with AWWA C225 and as specified in this Section.
   3. Coal tar enamels:
      a. In accordance with AWWA C203 and as specified in this Section.
   4. Plural component epoxy:
      a. In accordance with AWWA C210 and as specified in this Section.
      b. Surface preparation by material type:
         1) In accordance with AWWA C210 and as specified in this Section.
         2) Steel pipe: SSPC-SP 5, 3.00 mil profile, minimum, or in accordance with manufacturer’s requirements, whichever is greater.
   5. Plural component polyurethane:
      a. In accordance with AWWA C222 and as specified in this Section.
      b. Surface preparation by material type:
         1) In accordance with AWWA C222 and as specified in this Section.
         2) Steel pipe: SSPC-SP 5, 3.00 mil profile, minimum, or in accordance with manufacturer’s requirements, whichever is greater.
   6. Fusion bonded epoxy:
      a. In accordance with AWWA C213 and as specified in this Section.
   7. Heat shrink sleeve:
      a. Heat shrink sleeve locations as indicated on the Drawings.
      b. Heat shrink sleeves are restricted to pipeline joints and couplings under buried or concrete encased applications only.
         1) Application inside vaults or where exposed to the weather will not be allowed.

c. Store, handle, and apply field heat shrink sleeve coatings in accordance with AWWA C216 and as specified in this Section.
   1) Store sleeves in shipping box until use is required.
   2) Keep dry and sheltered from exposure to direct sunlight.
   3) Store off the ground or concrete floors.
   4) Maintain at a temperature between 60 and 100 degrees Fahrenheit in accordance with sleeve manufacturer's requirements.
   5) Acceptable types of heat shrink sleeves: Type I or II.
d. Shop prepare pipe joints for heat shrink sleeves with holdback primer as specified this Section.

8. Tape wrap:
   a. Surface preparation by material type: SSPC-SP 6, 1 to 3 mils blast profile.

B. Lining:
1. Cement mortar:
   a. In accordance with AWWA C205 and as specified in this Section.
   b. Cement: In accordance with ASTM C150, Type II.
   c. Provide cement mortar lining of uniform thickness.
   d. Finish to a smooth dense surface.
   e. Line special pieces or fittings by mechanical, pneumatic, or hand placement.
      1) Extend to faces of flanges and ends of spigots.
      2) Less than 12 inches in width: Coat with epoxy bonding agent prior to applying cement mortar.
      3) Larger than 12 inches in width: Reinforced with 2-inch by 4-inch No. 13 gauge welded steel wire mesh prior to applying cement mortar.
   f. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
   g. Repair damage to the cement mortar lining, including disbondment, or cracking caused by improper curing, shipping, handling, or installation in accordance with AWWA C205 and approved by the Engineer.
2. Plural component epoxy:
   a. In accordance with AWWA C210 and as specified in this Section.
3. Plural component polyurethane:
   a. In accordance with AWWA C222 and as specified in this Section.

2.12 CONCRETE CYLINDER PIPE (CCP)

A. Coating:
1. Plural component polyurethane.
2. Plural component epoxy.

PART 3 EXECUTION

3.01 GENERAL

A. Apply coating or lining and repair in accordance with manufacturer's requirements and as specified in this Section.

B. Inspect coating prior to backfilling of pipe and associated items.

3.02 DEFECTS IN COATINGS EXCEPT TAPE WRAP AND CEMENT MORTAR COATING

A. Engineer will identify defective coating to be field repaired in accordance with the applicable AWWA standard.
   1. Pipe joints exceeding the following defect maximum will be rejected.
      a. Minor defects:
         1) No more than 1.5 per 100 square feet of surface area.
         2) 2 or more minor repairs within an 8-inches diameter circle will be considered a single repair.
         3) Repairs for adhesion testing will not be included in the total number of repairs.
         4) Repair in accordance with manufacturer's requirements.
      b. Major defects:
         1) No more than 3 major repairs on each pipe joint.
         2) No more than 30 percent repairs on the pipe surface area with defects.
   2. Minor repairs:
      a. Repairs less than 8-inches in the greatest dimension.
      b. Repair in accordance with manufacturer's requirements.
   3. Major repairs:
      a. Repairs that exceed 8-inches in the greatest dimension.
      b. Repair in accordance with manufacturer's requirements.

3.03 HEAT SHRINK SLEEVES

A. Apply heat shrink sleeve joint coating system as indicated on the Drawings.
   1. No cement mortar coating is required.
   2. Do not use heat shrink sleeves on complex shapes like couplings, valves, flanges, and other similar shapes.
   3. Field prepare pipe joints in accordance with SSPC-SP 1 and SSPC-SP 3 to remove dirt, mud, oil, and grease prior to application of heat shrink sleeve.
   4. Temperature requirements:
      a. Preheat pipe uniformly in accordance with sleeve manufacturer’s requirements.
         1) Monitor pipe temperature using a surface temperature gauge, infrared thermometer, or color changing crayons.
         2) Protect preheated pipe from rain, snow, frost, or moisture with tenting or shields and do not permit the joint to cool.
   5. Fill cracks, crevices, gaps, and step-downs greater than 1/8 inch with filler mastic.
      a. Apply filler material in accordance with the manufacturer's requirements.
   6. Overlap on a 1-inch wide step from outer wrap to middle wrap to inner wrap.
   7. Completed joint sleeve fully adhered to the pipe and existing coating surface without voids.
      a. Provide visible mastic beading along the full circumference of the sleeve.
      b. Wrinkling or excessive burns on the sleeves are not acceptable.
      c. Reject sleeves that do not meet requirements.
      d. Make minor repairs using heat applied patch material specified for minor coating repairs.
   8. Allow the sleeve to cool before backfilling.
      a. In hot climates, provide shading from direct sunlight.
      b. Use water quenching only when permitted by the sleeve manufacturer.

9. Bury heat shrink sleeves as soon as practical after installation. Limit exposure to direct sunlight in accordance with manufacturer's requirements.
10. Reject heat shrink joint coatings which have become wrinkled or disbonded because of prolonged exposure to UV light or thermal cycling.
11. Double coating of defective heat shrink coatings will be permitted if the second sleeve is wider to adhere directly to the pipe.

3.04 TAPE WRAP

A. Engineer will identify defective tape wrap coating to be field repaired in accordance with AWWA C214.
   1. Pipe joints exceeding the defect maximum will be rejected.
      a. No more than 5 repairs.
      b. No more than 2 areas of coating damage greater than 5 square feet.

B. Minor repairs:
   1. Repairs less than 8 inches in the greatest dimension.
   2. Complete minor repairs using a heat applied coating patch material.
   3. Limit material removal to only damaged layers:
      a. Carefully remove damaged layers by cutting the coating with a sharp knife without cutting undamaged layers.
      b. Cut in a stepped fashion to expose 1-inch or more of the underlying tape layer for the circumference of the repair.
   4. Cut patch material to overlap onto the undamaged coating a minimum of 2 inches on each side with 1-inch radius on each corner of the patch.
   5. Apply patch material in accordance with manufacturer's requirements.

C. Major repairs:
   1. Repairs that exceed 8-inches in the greatest dimension.
   2. Complete major repairs:
      a. With heat shrink sleeves as specified for joints.
   3. Limit material removal to only damaged layers.
      a. Carefully remove damaged layers by cutting the coating with a sharp knife without cutting undamaged layers.
      b. Cut in a stepped fashion to expose 1-inch or more of the underlying tape layer for the circumference of the repair.
      c. If corrosion layer is exposed:
         1) Holiday test.
            a) If a holiday is detected:
               (1) Cut outer layers back to fully expose the holiday(s).
               (2) Retest for holidays.
   4. Apply repair material in accordance with manufacturer's requirements or as specified in this Section.
      a. Clean surfaces by solvent wiping and applying primer over the inner tape layer for a minimum of 6-inches onto the outer wrap in all directions.
      b. Cigarette wrap coating:
         1) Apply first layer of repair coating, over lapping 1-inch or more onto undamaged coating in all directions.
            a) On larger areas, lap the repair tape within a minimum of 1-inch overlap, offsetting the overlap from the previous layer overlap, until the area is properly covered.

b) If corrosion layer is repaired:
(1) Holiday test.
(a) If a holiday is detected.
(b) Cut outer layers back to fully expose the holiday(s).
(c) Retest for holidays.
2) Repeat for each tape layer damaged with each succeeding layer applied at 90 degrees to the preceding layers and overlapping onto the undamaged coating a minimum of 2-inches.
3) Apply the last tape layer, use the cigarette wrap method for the full pipeline circumference covering any previous repair layers and overlapping a minimum of 2-inches onto undamaged coating.
a) Point ends of the cigarette wrap downward.

c. Heat shrink sleeves:
1) Width of sleeve: Equal to width of the damaged area plus 4-inch overlap.
2) Multiple sleeves may be used for larger repairs, but must be overlapped a minimum of 2 inches.

3.05 WAX TAPE COATING

A. Apply wax tap coating system in accordance with AWWA C217 and manufacturer's requirements.

B. Filler mastic:
1. Irregular shapes: Apply filler mastic between primer and wax tape.
2. Apply filler mastic by hand, working material on to metal to displace moisture to maximize adhesion.
3. Build up an even surface.

3.06 DUCTILE IRON PIPE

A. Coating:
1. Polyethylene encasement:
a. Wrap buried ductile iron pipe and fittings in accordance with AWWA C105 and as specified in this Section.
b. Wrap polyethylene encasement to be continuous and terminated neatly at connections to below grade equipment or structures.
c. At wall penetrations, extend encasement to the wall and neatly terminate.
d. At slab penetrations, extend encasement to 2 inches below the top of slab and neatly terminate.
e. When rising vertically in unimproved areas, extend encasement on pipe 6 inches above existing grade and neatly terminate.

B. Lining:
1. Cement mortar:
a. Cement mortar with seal coat.

3.07 STEEL PIPE

A. Coating:
1. Cement mortar:
a. Engineer will identify defective cement mortar coating to be field repaired in accordance with AWWA C205.

1) Reject pipe with mortar coating defects on greater than 25 percent of the pipe surface.

2. Heat shrink sleeve:
   a. Dielectric coating with or without overcoat:
      1) Protect welded or bell and spigot steel pipe joints with heat shrink sleeve in accordance with AWWA C216.
3. Wax tape:
   a. Apply wax tape to flange joints and coupling style joints.

B. Lining:
1. Cement mortar:
   a. Field applied interior joint lining:
      1) After the backfill has been completed to final grade, fill interior joint recess with tightly packed cement mortar.
         a) Trowel flush with the interior surface with no indentation or projection of the mortar exceeding 1/16-inch.
         b) Remove excess cement mortar.
2. Plural component epoxy:
   a. Provide same coating system on shop-applied lining and surface preparation and field lining of pipe joints.
   b. Comply with same application requirements on shop-applied and field lining of pipe joints.
      1) Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.
3. Plural component polyurethane:
   a. Provide same coating system on shop-applied lining and surface preparation and field lining of pipe joints.
   b. Comply with same application requirements on shop- applied lining and field lining of pipe joints.
      1) Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.08 CONCRETE CYLINDER PIPE (CCP)

A. Coating:
1. Plural component polyurethane:
   a. Surface preparation:
      1) Concrete Soundness:
         a) In accordance with SSPC SP-13 using scratching or hammer impact methods.
      2) Moisture content:
         a) In accordance with SSPC SP-13 and manufacturer's requirements.
2. Plural component epoxy:
   a. Surface preparation:
      1) Concrete soundness:
         a) In accordance with SSPC SP 13 using scratching or hammer impact methods.

2) Moisture content:
   a) In accordance with SSPC SP 13 and manufacturer's requirements.

END OF SECTION

SECTION 11312D

VERTICAL TURBINE SHORT SETTING CENTRIFUGAL PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pump systems including vertical turbine pumps with radial, mixed flow, or axial (propeller) type impellers and drivers as scheduled.

B. Tag numbers: As specified in Pump Schedule.

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.
   3. PTC 8.2 - Centrifugal Pumps.

C. American Water Works Association (AWWA):
   1. C205 - Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe, 4 In. (100 mm) and Larger-Shop Applied.

D. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished.
   4. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   5. A278 - Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650°F (350°C).
   6. A283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
   7. A516- Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate-and Lower-Temperature Service.
   8. A582 - Standard Specification for Free-Machining Stainless Steel Bars.
   9. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
   10. B30 - Standard Specification for Copper Alloys in Ingot Form.
   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):
   1. 2.1-2.2 - Rotodynamic (Vertical) Pumps for Nomenclature and Definitions.
   2. 2.3 - Rotodynamic (Vertical) Pumps for Design and Application.
   3. 2.4 - Rotodynamic (Vertical) Pumps for Manuals Describing Installation, Operation 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.

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, 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 head, and intake basket or strainer (when specified).

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, Hydraulic Institute Standards 2.1-2.2, 2.3, 2.4, and 9.1-9.5 shall apply.

E. Allowable Operating Region (AOR): The region over which the service life of the pump is not seriously compromised by hydraulic loads, vibration, or flow separation where the pump’s vibration, noise, and cavitation are within acceptable limits.

F. Preferred Operating Region (POR): The region over which the service life of the pump will not be significantly affected by hydraulic loads, vibration, or flow separation where the pump’s vibration, noise, and cavitation are within acceptable limits.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15050 - Common Work Results for Mechanical Equipment:
   a. Pump certification as specified in Section 01600 - Product Requirements.
   b. Weighted average lead calculations as specified in Section 01600 - Product Requirements.

C. Shop drawings: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

D. Calculations: As specified in Section 15050 - Common Work Results for Mechanical Equipment:
   1. Torsional analysis: Submit as specified in Section 15050 - Common Work Results for Mechanical Equipment when scheduled.

E. Vendor operation and maintenance manuals: As specified in Section 01782 - Operation and Maintenance Data.

F. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.05 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Flowserve; model as scheduled.
   2. Sulzer/Johnston Pumps; similar to scheduled model.
   3. Peerless Pump; similar to scheduled model.
   4. Weir/Floway; similar to scheduled model.
   5. National Pump Co.; similar to scheduled model.

2.02 SYSTEM DESCRIPTION

A. Components: Pumps, drivers, motors, and drive arrangements as specified or as scheduled with shafts, columns, barrels, 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. All required conditions (flow/head) shall be within the pump manufacturer's Allowable Operating Range (AOR).
      c. Performance tolerances shall be the same as the test tolerances specified in Section 15958 - Mechanical Equipment Testing.
      d. 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 01600 - Product Requirements and Section 15050 - Common Work Results for Mechanical Equipment.

2.03 MATERIALS

A. General:
   1. Pump Schedule materials: As specified in this Section.
   2. Drinking water pumps: Provide materials as specified in Section 15050 - Common Work Results for Mechanical Equipment.

B. Cast iron: ASTM A48, Class 30 minimum.

C. Nickel cast iron: ASTM A48, minimum Class 30, cast iron with 3 percent nickel.

D. Gray iron casting: ASTM A278, Class 30.

E. Iron-chromium alloy: ASTM A743, Grade CA40; ASTM A276, Type 420 Stainless Steel may be substituted; Brinell Hardness Number of 350 to 380.

F. Lead-free bronze except for bearings that require lead for lubricity: ASTM B584.

G. Leaded tin bronze: ASTM B505, Alloy C92700.

H. Bronze or high lead tin bronze: ASTM B584, Alloy 93800.

I. Leaded red brass: ASTM B584, Alloy C83600, leaded red brass.

J. Type 416 stainless: ASTM A582, Type 416 Stainless Steel.

K. Neoprene: Polychloroprene rubber.

L. Steel: ASTM A283, Grade D or ASTM A516 Gr. 70.

M. Steel pipe: ASTM A53, Grade B.

N. Aluminum bronze meeting the requirements of Section 15050 - Common Work Results for Mechanical Equipment.

O. Lead-free aluminum bronze: ASTM B30.

2.04 GENERAL PUMP CONSTRUCTION

A. Type: Industrial, heavy duty, vertical turbine, centrifugal type 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. Discharge nozzles: Provide 1/2-inch NPT taps for pressure gauges; install nipple and gauge with block valve.

D. Bearings:
   1. 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.

2. Design motor to withstand continuous duty full load thrust and momentary up thrust that may occur during pump on/off or other operations.

E. Fasteners: Provide Type 316 stainless steel fasteners in accordance with ASTM F593 or ASTM F594.

F. Match existing pump installation.
   1. Pumps must fit through existing 16” slab penetrations.

2.05 PUMP SUCTION ASSEMBLY

A. Pump suction assembly: Provide suction bell. Provide anti-vortex baffles and strainer when scheduled.

B. Design suction bells and provide strainers and anti-vortex baffles to minimize solids plugging and vortexing. Screens to have a flow area at least 4 times the suction pipe area.

C. Materials:
   1. Pump suction bell: As scheduled.
   2. Anti-vortex baffles: Same material as scheduled for pump suction bell.
   3. Pump suction bell bearing: As scheduled.
   4. Pump suction strainer: When strainer scheduled, provide Type 316 stainless steel.

2.06 PUMP IMPELLER BOWL ASSEMBLIES

A. Pump impeller assembly:
   1. Type: As scheduled.
   2. Maximum number of vanes: As scheduled.
   3. Number of stages: As scheduled.
   4. Required balance: As specified in Section 15050 - Common Work Results for Mechanical Equipment to meet vibration criteria as specified in Section 15958 - Mechanical Equipment Testing.
   5. Method of securing impellers to shafts: Keyed and secured by a bronze nut locked in place or locked by other methods acceptable to the Engineer. Provide any special tools required for removal and installation of pump impellers.
   6. Provisions for adjustment of axial clearance: Make such adjustment through use of motor adjusting nut or adjustable coupling.
   7. Impeller thrust: When appropriate for the specified impeller type, provide hydraulically balanced impeller to minimize down thrust.

B. Intermediate and discharge impeller cases:
   1. Material: As scheduled.
   2. Attached with bolting.

C. Pump impeller bowl bearings: Provide bearing for each impeller; material as scheduled.

D. Diffusion vanes: Provide vanes cast into bowl.

E. Suction bowl bearings:
   1. Provide bronze sleeved 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.

F. Design with smooth water passages to reduce clogging by stringy or fibrous materials on impellers or shafting.

G. Design replaceable wear rings for both the bowl and impeller on each impeller bowl.

H. Design capable of passing solids with a sphere size as scheduled or larger.

I. Design impellers capable of working on pumps that may be abnormally started against closed manual valve or normally against a closed pump control valve.

2.07 LINE SHAFTS

A. Provide line shaft type and lubrication type as scheduled and as specified in this Section.

B. Open line shaft, product lubricated:
   1. Shaft and couplings:
      a. Provide keyed shaft type mechanical couplings with key or set screw locking of shaft couplings.
      b. Shaft threaded connections are not allowed.
   2. Bearings and bearing retainers: Provide bearings and retainers spaced as scheduled, but not to exceed 10 feet; provide at least 1 bearing for each line shaft length; provide grease fitting for top bearing extended to outside any guards when grease lubrication specified.
   3. Materials:
      a. Shaft and couplings: As scheduled; where hard-faced steel shaft is specified, hard face at sleeve bearings to 550 Brinell minimum.
      b. Bearings and bearing retainers: As scheduled; when not scheduled, Neoprene rubber bearings with bronze retainers.

C. Enclosed line shaft, oil lubricated:
   1. Shaft and couplings: Provide flanged shaft couplings with key or set screw locking of shaft couplings.
   2. Shaft bearings and spiders: Provide bearings and retainers as scheduled, but not to exceed 10 feet and enclosing tube spiders spaced at 30 feet maximum; provide oil reservoir volume for 3 days continuous use.
   3. Enclosing tube: Pipe, thickness as scheduled.
   4. Materials: As scheduled; when not scheduled provide:
      a. Shaft and couplings: ASTM A108, Grade 1045 steel with ASTM A276, Type 316 hardened stainless steel journal or sleeve at each bearing.
      b. Shaft bearings and spiders: ASTM B584, Alloy C83600 leaded red brass bearings; Neoprene rubber spider on enclosing tube.
      c. Enclosing tube: Steel pipe, ASTM A53, Grade B unless scheduled otherwise.

D. Design strength: Able to withstand minimum 1.5 times maximum operating torque and other loads.

E. Resonant frequency: As specified in Sections 15050 - Common Work Results for Mechanical Equipment and 15958 - Mechanical Equipment Testing.

F. Sleeves: Provide shafting with Type 316 stainless steel sleeve or hardened sleeves where shafts pass through bearings or stuffing boxes as scheduled; Brinell 550 or higher for hardened shaft; when the specified mechanical seals cannot be installed on a hardened shaft, hardened shafts are not required in the area of the mechanical seal.

G. Design pump line shafting in interchangeable lengths as scheduled, but not to exceed 10 feet; shaft lengths to match scheduled pump column lengths.

H. Coupling strength: Design driver to pump line shaft coupling of sufficient length and strength to maintain line shaft alignment.

I. Adjustment:
   1. Design a means to adjust shaft position to adjust impeller position.
   2. For motor driven units with solid shaft motors, design driver to pump line shaft coupling to allow adjustment of the impeller position.
   3. For motor driven units with hollow shafts, an adjusting nut may be provided at the top of the motor shaft.

J. Spacer coupling: When mechanical seals are scheduled, provide an adjustable spacer coupling to allow removal of the seal without driver removal.

2.08 PUMP COLUMN PIPE

A. Pump column pipe: Thickness and material as scheduled.

B. Head connection: Design with flanged and bolted connection to discharge head and flanged and bolted connection to impeller assembly to permit removal of impeller bowl assembly without disturbing the column or discharge connections.

C. 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.

D. 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.

E. Lengths and connections: Design with maximum 10-foot length, or less if scheduled, interchangeable column sections with flanged or threaded with registered fit screwed connections as scheduled.

F. Diameter: Design column inside diameter for no more than 4 feet of fluid friction loss per 100 feet of column length.

G. Column pipe 14 inch and smaller shall use bronze “drop-in” spiders retainers with rubber or neoprene “pop-in” bearings.

H. Column lining and coating: As scheduled

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. Stuffing box and seal:
   1. Design the discharge head with a stuffing box to accommodate packing or mechanical seals as scheduled.
   2. Packing: When packing scheduled, provide stuffing box arranged for packing (sized for bronze lantern ring and 6 packing rings minimum); provide hollow shaft motor with top adjusting nut.
   3. Mechanical seal: When scheduled, provide stuffing box suitable for the specified seal and provide solid shaft motor with spacer coupling.
   4. Additional seal or packing requirements: As specified in Section 15050 - Common Work Results for Mechanical Equipment.
   5. Drain: Provide drain, minimum 3/4-inch size, for pump stuffing box leakage, together with drain line to the pump can or wet well or to nearest equipment drain as indicated on the Drawings.

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: Bronze.
   3. Stuffing box and seal: Container and gland, cast iron, ASTM A48, Class 30 minimum; Neoprene top shaft seal.

2.10 EQUIPMENT GUARDS

A. Provide equipment safety guards as specified in Section 15050 - Common Work Results for Mechanical Equipment.

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 16222 - Low Voltage Motors up to 500 Horsepower and as specified in this Section:
1. RPM: As scheduled:
2. Enclosure: As scheduled.
3. Electrical characteristics: As scheduled.
4. Efficiency, service factor, insulation, and other motor characteristics: As specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.
5. Motor accessories: As specified in Section 16222 - Low Voltage Motors up to 500 Horsepower 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 Schedule.

D. Non-reverse ratchets: When scheduled, provide driver with non-reverse ratchets 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 15958 - Mechanical Equipment Testing.

C. Coordinate pump and drive system supports with the foundation designs as indicated on the Drawings.

D. Anchor bolts: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.13 SPARE PARTS AND SPECIAL TOOLS

A. Spare parts:
1. Line shaft rubber bearings: 1 set for each type pump.
2. Line shaft bronze bearings: 1 set for each type pump.
3. Impeller and bowl wear rings: 1 set for each type of pump.
4. Mechanical seal: 1 complete seal of each type.
5. Motor/gear thrust bearing set: 1 for each type of pump.
6. Motor radial bearing set: 1 for each size of motor (if specified).
7. Pump impeller/bowl assembly: 1 of each type supplied.
8. Line shaft: 1 length of each size and type.

B. Special tools: Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.

PART 3 EXECUTION

3.01 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Source Testing.
      b. Manufacturer's Certificate of Installation and Functionality Compliance.
   2. Manufacturer's Representative onsite requirements:
      a. Installation: 1 trip, 2-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 the Pump Schedule.

D. Functional testing: As specified in the Pump Schedule.

3.02 PUMP SCHEDULE

Tag Numbers	**WWP-4431, WWP-4432**
General Characteristics:	
Application	Backwash Washwater
Service	Decant Return Pumps
Quantity	2
First Named Manufacturer's Model Number	14EBL
Maximum Noise, dBA at 3 feet	85
Torsional Analysis	Required
Minimum Pumped Fluid Degrees Fahrenheit	34
Normal Pumped Fluid Degrees Fahrenheit	70
Maximum Pumped Fluid Degrees Fahrenheit	85
Pump Characteristics:	
Number of Stages	Per Manufacturer
Impeller Type	Enclosed
Impeller, Maximum Number of Vanes	Per Manufacturer

Tag Numbers	WWP-4431, WWP-4432
Pass Minimum Sphere Size, Inch	Per Manufacturer
Pump Impeller Bowl Bearing Lubrication	Product Lubricated
Suction Bowl Bearing Lubrication	Grease
Suction Strainer	Required
Anti-Vortex Baffle	Required
Line Shaft Type	Open
Minimum Line Shaft Bearing Spacing, Feet	10
Line Shaft Lubrication	Product
Discharge Shaft Seal Type	Single Mechanical
Column Connection Type	Flanged
Maximum Column Section Lengths, Feet	10
Pump Barrel or Can	None Required
Discharge Arrangement	Above Base
Coupling Type	Spacer
Speed Control	Fixed
Maximum Pump rpm	1,800
Rated Design Point (at Maximum Revolutions per Minute):	
Flow, gpm	1,400
Head, Feet	50
Minimum Efficiency, Percent	75
Required Condition 2 (at Maximum Revolutions per Minute):	
Flow, gpm	1,000
Head Range, Feet	55 to 70
Minimum Efficiency, Percent	70
Required Condition 3 (at Maximum Revolutions per Minute):	
Flow Range, gpm	1,600 to 1,900
Head, Feet	28
Minimum Efficiency, Percent	60
Other Conditions:	
Maximum Shut Off Head, Feet	110
Maximum NPSHr at every Specified Flow, Feet	24
Minimum NPSHa at every Specified Flow, Feet	29
Minimum Suction Static Head, Feet	3

Tag Numbers	WWP-4431, WWP-4432
Maximum Suction Static Head, Feet	24
Pump Materials:	
Suction Bell	Cast Iron
Suction Bell Bearing	Bronze
Impeller Cases	Cast Iron
Impeller	Bronze
Impeller Bearing	Bronze
Impeller Shaft Key	Steel
Line Shaft and Coupling	Type 416 Stainless Steel
Line Shaft Bearings	Neoprene
Shaft Enclosing Tube	N/A
Shaft Sleeve	Hardened
Column Material and Thickness, Inch or Schedule	Steel Pipe, 0.25
Discharge Head/Driver Stand	Steel
Discharge Head Bearing	Bronze
Discharge Stuffing Box	Cast Iron
Discharge Head & Column Interior Lining	Epoxy
Discharge Head & Column Exterior Coating	Epoxy
Driver Characteristics:	
Driver Type	Motor
Drive Arrangement	Vertical, Coupled
Non-Reverse Ratchets	Required
Minimum Driver Horsepower	30
Maximum Driver rpm	1,800
Motor Characteristics (when motor is driver type):	
Inverter Duty Rated	No
Motor Voltage/Phases/Hertz	460/3/60
Enclosure Type	TEFC
Source Testing:	
Test Witnessing	Not Witnessed
Performance Test Level	2
Vibration Test Level	1

Tag Numbers	WWP-4431, WWP-4432
Noise Test Level	1
Functional Testing:	
Performance Test Level	2
Vibration Test Level	1
Noise Test Level	1

END OF SECTION

SECTION 13446

MANUAL ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Valve and gate actuators.
   2. Handwheel actuators.
   3. Hand-cranked geared actuators.
   4. Floor Boxes.
   5. Floor stands.
   6. Key operated valves.
   7. Bench stands.
   8. Accessory equipment and floor boxes.

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 or gate, except for valve actuators utilizing T-wrenches or keys, and portable gate 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 AND GATE ACTUATORS

A. Valve actuators:
   1. Motorized actuators are specified in Section 13447 - Electric Motorized Actuators.
   2. 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.
   3. Stem and cover:
      a. For submerged valves, provide extension stem as indicated on the Drawings.
   4. 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. Provide switch with NEMA Type 7 enclosure when switch is located within areas with NEC Class 1, Division 1 or Class 1, Division 2 designations as indicated on the Drawings.

B. Stem covers:
   1. Aluminum pipe:
      a. Threaded cap on top.
      b. Bolted aluminum flange on bottom.
      c. Slots cut 1- by 12-inch at 18 inches on center in front and back of pipe.
      d. Capable of covering threaded portion of greased stems that project above actuators when gates or valves are opened or closed.
   2. 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.

3. 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 HANDWHEEL ACTUATORS

A. Manufacturers: One of the following or equal:
   1. Rodney Hunt Co.
   2. Waterman Industries, Inc.

B. Coating: Handwheel as specified in Section 09960 - High-Performance Coatings.

C. Mounting: Floor stand or bench stand. Unless otherwise indicated on the Drawings position actuator 36 inches (nominal) above top of walkway surface.

D. Bearings above and below finished threaded bronze operating nut: Ball or roller.

E. Wheel diameter: Minimum 24 inches.

F. Indicator: Counterclockwise opening with arrow, and word OPEN cast on top of handwheel indicating direction for opening.

G. Pull to operate: Maximum 40 pounds pull at most adverse design condition.

H. Stem travel limiting device: Setscrew locked stop nuts above and below lift nut.

I. Grease fittings: Suitable for lubrication of bearings.

2.03 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 gate 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.

2.04 FLOOR BOXES

A. Manufacturers: 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.

2.05 FLOOR STAND

A. Manufacturers: One of the following or equal:
   1. Rodney Hunt Co.
   2. Waterman Industries, Inc.

B. Floor stand assemblies: Heavy-duty cast-iron, suitable for mounting specified actuator.

2.06 BENCH STANDS

A. Manufacturers: One of the following or equal:
   1. Rodney Hunt Co.
   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.

2.07 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 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry 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 13447

ELECTRIC ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Electric motor-driven actuators for valves and gates as identified in the valves and gates schedule as EAM, EDM, or EDR.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C504 - Standard for Rubber-Seated Butterfly Valves.
   2. C542 - Standard for Electric Motor Actuators for Valves and Slide Gates.

B. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 DEFINITIONS

A. NEMA:
   1. Type 4 enclosure in accordance with NEMA 250.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures and Section 15050 - Common Work Results for Mechanical Equipment.

B. Provide a complete list/schedule of all actuators being provided with their associated tag names as indicated on the design drawings and/or specifications, service process area and the size of the valve they are actuating.

C. Product data:
   1. Electrical ratings:
      a. Voltage and number of phases.
      b. Starting and running current.
      c. Voltage levels and source for control and status.
   2. Description of integral control interface.
   3. Environmental ratings, including NEMA enclosure rating and submergence capabilities.
   4. Gear ratios for both manual and motorized actuation.
   5. Opening and closing directions.
   6. Allowable starts per hour.
   7. List of all included options and accessories.
   8. Full travel times.
   9. Gearbox data including gear ratio, and gearbox efficiency.

D. Shop drawings:
   1. Wiring diagrams:
      a. Include all options and expansion cards furnished with each actuator.
   2. Dimensioned drawings of each valve and actuator combination.
   3. Dimensioned drawings of each valve gearbox.
   4. Electric motor data.

E. Calculations:
   1. Operating torque.
   2. Maximum torque calculations for seating and unseating.
   3. Maximum operating torque at starting and normal operation.
   4. Signed by Professional Engineer.

F. Provide draft vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data:
   1. Include a list of all configurable parameters, and the final values for each.
   2. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

G. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.
      a. Affidavit in accordance with AWWA C542.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

H. Project closeout documents:
   1. Provide final vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data.

1.05 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers for lines 4 inches and larger:
   1. One of following or equal:
      a. Limitorque Corp.:
         1) L120.

2.02 CHARACTERISTICS FOR ACTUATORS ON LINES 4 INCHES AND LARGER

A. Provide actuators complete and operable with all components and accessories required for operation.

B. Power supply:
   1. Voltage and phases as indicated in the Motorized Actuator Schedule.
   2. Valve or gate motion independent of power supply phase rotation.

3. Provide an internal backup power source or mechanical indicator to maintain settings and track valve position when main power is off.
4. The actuators shall incorporate all major components such as the motor, starter, local controls, terminals, etc. housed within a self-contained, sealed enclosure.

C. Size actuator to move gates or valves from full open to closed position within the time indicated in the Motorized Actuator Schedule:
   1. If an operating time is not indicated on the Motorized Actuator Schedule, size the actuator to move gates or valves at minimum 12 inches per minute under maximum load. Measure rate of closure for valves at maximum diameter of disc, plug, or ball.
   2. Size actuators so that gear boxes are not required where possible.

D. Control interface:
   1. Local interface, integral to actuator:
      a. Selector switches:
         1) LOCAL-OFF-REMOTE:
            a) Motor actuator operation is prevented with the switch in OFF.
         2) OPEN-STOP-CLOSE:
            a) Controls the valve when LOCAL-OFF-REMOTE is in LOCAL.
            b) Spring return to center.
            c) Configurable between maintained (actuator runs until end of travel, high torque, or a LOCAL-OFF-REMOTE is switched to STOP) and momentary (actuator stops when lever is released).
      b. Local display:
         1) Valve fully open and fully closed indicators.
         2) Continuous position indication.
   2. Control inputs:
      a. Capable of using 120 VAC or 24 VDC inputs.
      b. Controls the valve when LOCAL-OFF-REMOTE is in REMOTE.
      c. Isolated inputs capable of operating from external control voltage source or internal power supply:
         1) Furnish 120 VAC or 24 VDC control power supplies within the actuator.
      d. Provide the following inputs:
         1) OPEN.
         2) CLOSE.
         3) STOP.
      e. OPEN and CLOSE inputs configurable between maintained (actuator runs until end of travel, high torque, or a STOP input) and momentary (actuator stops when command is removed).
   3. Status outputs:
      a. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
         1) Fully closed.
         2) Fully open.
         3) LOCAL-OFF-REMOTE in REMOTE position.
      b. All output contacts rated for 5 amps, 120 VAC, and 24 VDC.

E. Features:
   1. Time delay on reversal: Incorporate time delay between stopping actuator and starting in opposite direction to limit excessive current, torque, and heating from instantaneous reversal.

F. Materials:
   1. Construct motorized actuators of materials suitable for the environment in which the valve or gate is to be installed.

G. Components:
   1. Motors:
   2. Specifically designed for valve actuator service with high starting torque, totally enclosed non-ventilated construction.
   3. Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety.
      a. Design requirements for rubber seated AWWA butterfly valves:
         1) Design actuators for maximum gate or valve operating torque, in accordance with and using safety factors required in AWWA C504 and AWWA C542.
            a) Valve actuator torque requirement for open-close service: Not less than the required valve-seating and dynamic torques under design operating conditions in accordance with AWWA C504.
            b) Valve actuator torque requirement for modulating service: Not less than twice the required valve dynamic torque under design operating conditions in accordance with AWWA C504.
      b. Design requirements for slide gates, gate valves, knife gate valves, globe valves, and diaphragm valves:
         1) Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C542.
         2) Design for the maximum torque and thrust running load over the full cycle.
         3) Maximum torque or thrust rating: The actuator stall torque or maximum thrust output shall not exceed the torque or thrust capability of the valve or gate, as determined by the valve or gate manufacturer.
   4. Capable of being removed and replaced without draining the actuator gear case.
   5. Motor bearings shall be amply proportioned of the anti-friction type and permanently lubricated.
   6. Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius.
      a. Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
      b. 60 starts per hour for open/close service or 1,200 starts per hour for modulating service.
   7. Provide the following motor protection features:
      a. High motor temperature (sensed by an embedded thermostats).
      b. High torque.

H. Enclosures:
   1. Actuator housing ratings as indicated in the Motorized Actuator Schedule.

2. Cast iron or cast aluminum.
3. Stainless steel external fasteners.
4. Provide O-ring seals for each of the following areas:
    a. Between the terminal compartment and the internal electrical elements.
    b. Between the mechanical and electrical portions to protect from the ingress of oil, and to protect the mechanical components of oil from dust and moisture when the electrical terminal is open.
5. Provide the following minimum enclosure ratings:
    a. NEMA Type 4 enclosure for general applications.

I. Position sensing:
1. Limit switches shall be an integral part of the valve actuator.
2. Valve range and position switch outputs field adjustable.

J. Torque sensing:
1. Capable of interrupting control circuit during both opening and closing and when valve torque overload occurs.
2. Independent of variations in frequency, voltage, or temperature.
3. Provide a temporary inhibit of the torque sensing system during unseating or during starting in mid-travel against high inertia loads.
4. Provide visible verification of torque switch status without any housing disassembly.

K. Manual actuators:
1. Hand wheel for manual operation.
    a. Maximum 80-pound pull on rim when operating gate or valve under maximum load.
    b. Provide pull chain when motorized actuator is located more than 6 feet above floor surface.
        1) Chain shall be of sufficient length to reach approximately 4 feet above the operating level.
        2) Where the chain obstructs an aisle or walkway, provide holdback or other means to ensure chain does not create a nuisance or hazard to operating personnel.
2. Declutch lever: Padlockable, capable of mechanically disengaging motor and related gearing and freeing hand wheel for manual operation.

L. Gearing: Hardened alloy steel spur or helical gears and self-locking, alloy bronze worm gear set.
1. Accurately cut to ensure minimum backlash.

M. Bearings:
1. Anti-friction bearing with caged balls or rollers throughout.
2. Sealed-for-life type thrust bearings housed in a separate thrust base.

N. Drive bushing:
1. Easily detachable for machining to suit the valve stem or gearbox input shaft.
2. Positioned in a detachable base of the actuator.

O. Lubrication:
1. Provide totally enclosed actuator gearing with oil or grease filled gear case suitable for operation at any angle.
2. Actuators requiring special or exotic lubricants are not acceptable.

2.03 ACCESSORIES (NOT USED)

2.04 SPARE PARTS AND SPECIAL TOOLS

A. As specified in Section 01600 - Product Requirements.

B. Spare parts:
   1. Provide the following (minimum 10 percent of total number of actuators of each model type furnished, but not less than 1 for each model of actuator furnished):
      a. Stem nut.
      b. Worm shaft subassembly.
      c. Drive sleeve subassembly.
      d. Complete actuator seal kit.
      e. Actuator gearbox oil (sufficient quantity to fill 4 gearboxes).
   2. Provide 1 spare motor for each size motor furnished.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 15050 - Common Work Results for Mechanical Equipment.

B. Position visual indicators so that they are most easily visible.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning, Section 15958 - Mechanical Equipment Testing, and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Source Testing:
         1) Proof-of-Design and Performance Test Reports in accordance with AWWA C542.
      b. Manufacturer's Certificate of Installation and Functionality Compliance.
   2. Manufacturer's Representative on-site requirements:
      a. Installation: 2 trips, 2-day minimum each.
      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.

C. Source testing:
   1. Design and Performance Test Reports in accordance with AWWA C542.
   2. Test each actuator with a simulated load.
      a. Simulate a typical valve load.
   3. Electrical Instrumentation and Controls:
      a. Test witnessing: not witnessed.
      b. Conduct testing as specified in Section 17950 - Commissioning for Instrumentation and Controls.

D. Functional testing:
   1. Installed actuator:
      a. Test witnessing: Witnessed.
      b. Conduct Level 2 General Equipment Performance Tests.
      c. Conduct Level 2 Vibration Tests.
      d. Conduct Level 2 Noise Tests.
   2. Electrical Instrumentation and Controls:
      a. Test witnessing: Witnessed.
      b. Conduct testing as specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.03 MOTORIZED ACTUATOR SCHEDULE

A. Provide all actuators indicated on the Drawings:
   1. Actuators are listed in the Motorized Actuator Schedule in this Section.

B. Abbreviations relating to type:
   1. BFV = Butterfly Valve.
   2. BV = Ball Valve.
   3. PV = Plug Valve.
   4. SG = Slide Gate.

C. Abbreviations relating to actuator type:
   1. O/C = Open and Close Service.
   2. MOD = Modulating Service.

D. Abbreviations relating to controls:
   1. A = Analog (4-20 mA) control, modulating duty.
   2. D = Discrete control, modulating duty.
   3. D-O/C = Discrete Open/Close.

END OF SECTION

MOTOR ACTUATOR SCHEDULE

Item	Reference DWG	Type	Size	Actuator Type	NEMA Rating	Voltage/ Phase/ Hz	Open Time	Controls
Weir Box Discharge Valve	N01	BFV	48”	O/C	4	480/3/60	30 s	D-O/C

SECTION 15050

COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic design and performance requirements for building mechanical equipment and process mechanical equipment.

1.02 REFERENCES

A. American Gear Manufacturer's Association (AGMA) Standards:
   1. 6001-E08 - Design and Selection of Components for Enclosed Gear Drives.

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

C. American Petroleum Institute (API):
   1. 682 - Shaft Sealing Systems for Centrifugal and Rotary Pumps.

D. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A48 - Standard Specification for Gray Iron Castings.
   3. A125 - Standard Specification for Steel Springs, Helical, Heat-Treated.
   4. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   6. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
   7. A536 - Standard Specification for Ductile Iron Castings.
   8. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   9. B61 - Standard Specification for Steam or Valve Bronze Castings.
   10. B62 - Standard specification for Composition Bronze or Ounce Metal Castings.
   11. B505 - Standard Specification for Copper Alloy Continuous Castings.
   12. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
   13. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   14. F594 - Standard Specification for Stainless Steel Nuts.

E. Hydraulic Institute (HI).

F. Occupational Safety and Health Administration (OSHA).

G. Unified Numbering System (UNS).

1.03 DEFINITIONS

A. Resonant frequency: That frequency at which a small driving force produces an ever-larger vibration if no dampening exists.

B. Rotational frequency: The revolutions per unit of time usually expressed as revolutions per minute.

C. Critical frequency: Same as resonant frequency for the rotating elements or the installed machine and base.

D. Peak vibration velocity: The root mean square average of the peak velocity of the vibrational movement times the square root of 2 in inches per second.

E. Rotational speed: Same as rotational frequency.

F. Maximum excitation frequency: The excitation frequency with the highest vibration velocity of several excitation frequencies that are a function of the design of a particular machine.

G. Critical speed: Same as critical frequency.

H. Free field noise level: Noise measured without any reflective surfaces (an idealized situation); sound pressure levels at 3 feet from the source unless specified otherwise.

I. Operating weight: The weight of unit plus weight of fluids or solids normally contained in unit during operation.

1.04 DESIGN REQUIREMENTS

A. General:
   1. Product requirements as specified in Section 01600 - Product Requirements.
   2. Project conditions as specified in Section 01610 - Project Design Criteria.
   3. Provisions specified under each technical equipment specification prevail over and supersede conflicting provisions specified in this Section.
   4. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries required for proper operation.
   5. Vibration considerations:
      a. Resonant frequency:
         1) For single-speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the operating rotational frequencies or multiples of the operating rotational frequencies that may be excited by the equipment design.
         2) For variable-speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the range of operating frequencies.
      b. Design, balance, and align equipment to meet the vibration criteria specified in Section 15958 - Mechanical Equipment Testing.
   6. Equipment units weighing 50 pounds or more: Provide with lifting lugs or eyes to allow removal with hoist or other lifting device.

B. Power transmission systems:
   1. V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, variable frequency drives, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints are to be rated for 24 hour-a-day continuous service or frequent stops-and-starts intermittent service, whichever is most severe, and sized with a service factor of 1.5 or greater in accordance with manufacturer recommendations:
      a. Apply service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
      b. Apply service factors in accordance with AGMA 6001-E08, other applicable AGMA standards, or other applicable referenced standards.

C. Equipment mounting and anchoring:
   1. Mount equipment on cast-iron or welded-steel bases with structural steel support frames.
      a. Utilize continuous welds to seal seams and contact edges between steel members.
      b. Grind welds smooth.
   2. Provide bases and supports with machined support pads, dowels for alignment of mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits.
   3. Provide jacking screws in bases and supports for equipment weighing over 1,000 pounds.
   4. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load specified in Section 01612 - Seismic Design Criteria, and other loads as required for proper operation of equipment.
      a. For equipment with an operating weight of 400 pounds or greater and all equipment that is supported higher than 4 feet above the floor, provide calculations for:
         1) The operating weight and location of the centroid of mass for the equipment.
         2) Forces and overturning moments.
         3) Shear and tension forces in equipment anchorages, supports, and connections.
         4) The design of equipment anchorage, supports, and connections based on calculated shear and tension forces.
   5. Anchorage of equipment to concrete or masonry:
      a. Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
      b. Unless otherwise indicated on the Drawings, select and provide anchors from the types specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
      c. Provide bolt sleeves around cast-in anchor bolts for 400 pounds or greater equipment.
         1) Adjust bolts to final location and secure the sleeve.
   6. Anchorage of equipment to metal supports:
      a. Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.
   7. Unless otherwise indicated on the Drawings, install equipment supported on concrete over non-shrink grout pads as specified in this Section.

1.05 SUBMITTALS

A. As specified in Section 01600 - Product Requirements.

B. Product data:
   1. For each item of equipment:
      a. Design features.
      b. Load capacities.
      c. Efficiency ratings.
      d. Material designations by UNS alloy number or ASTM Specification and Grade.
      e. Data needed to verify compliance with the Specifications.
      f. Catalog data.
      g. Nameplate data.
      h. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
   2. Gear reduction units:
      a. Engineering information in accordance with applicable AGMA standards.
      b. Gear mesh frequencies.

C. Shop drawings:
   1. Drawings for equipment:
      a. Drawings that include cut-away drawings, parts lists, material specification lists, and other information required to substantiate that proposed equipment complies with specified requirements.
   2. Outline drawings showing equipment, driver, driven equipment, pumps, seal, motor(s) or other specified drivers, variable frequency drive, shafting, U-joints, couplings, drive arrangement, gears, base plate or support dimensions, anchor bolt sizes and locations, bearings, and other furnished components.
   3. Installation instructions including leveling and alignment tolerances, grouting, lubrication requirements, and initial Installation Testing procedures.
   4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
   5. Recommended or normal operating parameters such as temperatures and pressures.
   6. Alarm and shutdown setpoints for all controls furnished.

D. Calculations:
   1. Structural:
      a. Substantiate equipment base plates, supports, bolts, anchor bolts, and other connections meet minimum design requirements specified and seismic design criteria as specified in Section 01612 - Seismic Design Criteria.
   2. Mechanical:
      a. ABMA 9 or ABMA 11 L10 life for bearings calculation methods for drivers, pumps, gears, shafts, motors, and other driveline components with bearings.
      b. Substantiate that operating rotational frequencies meet the requirements of this Section.

c. Torsional analysis of power transmission systems: When torsional analysis specified in the equipment sections, provide:
1) Sketch of system components identifying physical characteristics including mass, diameter, thickness, and stiffness.
2) Results of analysis including first and second critical frequencies of system components and complete system.
d. Calculations shall be signed and stamped by a licensed engineer.

3. Drinking water:
a. If applicable, conform to the requirements of Section 01600 - Product Requirements for materials in contact with drinking water.

E. Operation and maintenance manuals:
1. As specified in Section 01782 - Operating and Maintenance Data.
2. Equipment with bearings:
a. Include manufacturer and model number of every bearing.
b. Include calculated ball pass frequencies of the installed equipment for both the inner and outer raceways.

F. Commissioning submittals: As specified in Section 01756 - Commissioning.

G. Project closeout documents: As specified in Section 01770 - Closeout Procedures.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials as specified in Section 01600 - Product Requirements including special requirements for materials in contact with drinking water.

B. Ferrous materials:
1. Steel for members used in fabrication of assemblies: ASTM A36.
2. Iron castings: ASTM A48, tough, close-grained gray iron, free from blowholes, flaws, and other imperfections.
3. Ductile iron castings: ASTM A536, Grade 65-45-12, free from flaws and imperfections.
4. Galvanized steel sheet: ASTM A653, minimum 0.0635-inch (16-gauge).
5. Expanded metal: ASTM A36, 13-gauge, 1/2-inch flat pattern expanded metal.
6. Stainless steel:
a. As specified in Section 05120 - Structural Steel.
b. In contact or within 36 inches of water: Type 316 or 316L.
c. In sea air environment: Type 316 or 316L.
d. Other locations: Type 304 or 304L.
e. Source cleaning and passivation as specified in Section 05120 - Structural Steel.

C. Non-ferrous materials:
1. Bronze in contact with drinking water: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C89833, C89520, or C92200 in accordance with ASTM B61, B62, B505, or B584, when not specified otherwise.
2. Bronze in contact with wastewater: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C83600, C89833, C89520,

C92200, or C93700 in accordance with ASTM B61, B62, B505, or B584, when not specified otherwise.
3. Aluminum: As specified in Section 05140 - Structural Aluminum.

D. Dielectric materials for separation of dissimilar metals:
1. Neoprene, bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other materials as specified.

E. Non-shrink grout and epoxy non-shrink grout: As specified in Section 03600 - Grouting.

2.02 ANCHORS AND FASTENERS

A. Mechanical anchoring to concrete and masonry:
1. As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry:
a. Type 316 stainless steel.
2. Design as specified in Section 01612 - Seismic Design Criteria.

B. High-strength fasteners:
1. As specified in Section 05120 - Structural Steel.

C. Flange bolts:
1. As specified in Section 15052 - Common Work Results for General Piping.

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:
    a. Manufacturers: One of the following or equal:
        1) Chesterton, S10.
        2) John Crane, 5610 Series.
3. Cartridge-type double mechanical: Manufacturers:
    a. One of the following or equal:
        1) Chesterton, S20.
        2) John Crane, 5620 Series.

4. Split-face single mechanical: Manufacturers:
    a. One of the following or equal:
        1) Chesterton, 442.
        2) John Crane, 3740.

2.05 GEAR REDUCTION UNITS

A. Type: Helical or herringbone, unless otherwise specified.

B. Design:
1. Made of alloys treated for hardness and for severe service.
2. AGMA Class II service:
    a. Use more severe service condition when such is recommended by unit's manufacturer.
3. Cast-iron housing with gears running in oil.
4. Anti-friction bearings.
5. Thermal horsepower rating based on maximum horsepower rating of prime mover, not actual load.
6. Manufactured in accordance with applicable AGMA standards.

C. Planetary gear units are not to be used.

2.06 BELT DRIVES

A. Sheaves:
1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap tightening screws.
2. When 2 sheave sizes are specified, provide separate belts sized for each set of sheaves.
3. Statically balanced for all; dynamically balanced for sheaves that operate at a peripheral speed of more than 5,500 feet per minute.
4. Key bushings to drive shaft.

B. Belts: Anti-static type when explosion-proof equipment or environment is specified.
1. When spare belts are specified, furnish 1 spare belt for every different type and size of belt-driven unit:
    a. Where 2 or more belts are involved, furnish matched sets.
    b. Identify as to equipment, design, horsepower, speed, length, sheave size, and use.
    c. Package in boxes labeled with identification of contents.

C. Manufacturers: One of the following or equal:
1. Dodge, Dyna-V belts with matching Dyna-V sheaves and Taper-Lock bushings.
2. T.B. Woods, Ultra-V belts with matching Sure-Grip sheaves and Sure-Grip bushings.

2.07 BEARINGS

A. Type: Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.

B. Oil-lubricated bearings: Provide either pressure lubricating system or separate oil reservoir splash-type system:
   1. Size oil-lubrication systems to safely absorb heat energy generated in bearings when equipment is operating under normal conditions and with the temperature 15 degrees Fahrenheit above the maximum design temperature as specified in Section 01610 - Project Design Criteria.
   2. Provide an external oil cooler when required to satisfy the specified operating conditions:
      a. Provide air-cooled system if a water-cooling source is not indicated on the Drawings.
      b. Equip oil cooler with a filler pipe and external level gauge.

C. Grease lubricated bearings, except those specified to be factory sealed: Fit with easily accessible grease supply, flush, drain, and relief fittings.
   1. Lubrication lines and fittings:
      a. Lines: Minimum 1/4-inch diameter stainless steel tubing.
      b. Multiple fitting assemblies: Mount fittings together in easily accessible location.
      c. Use standard hydraulic-type grease supply fittings:
         1) Manufacturers: One of the following or equal:
            a) Alemite.
            b) Zerk.

D. Ratings: Rated in accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours.

2.08 MOTORS

A. As specified in Section 16222 - Low Voltage Motors Up to 500 Horsepower.

2.09 GEAR MOTORS

A. Motors as specified in Section 16222 - Low Voltage Motors Up to 500 Horsepower.

B. Helical gearing for parallel shaft drives and worm gearing for right-angle drives.

C. Manufactures: One of the following or equal:
   1. Baldor Electric Company.
   2. Bodine Electric Company.

2.10 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.

2.11 PIPING AND VALVES

A. Piping as specified in Section 15052 - Common Work Results for General Piping.

B. Valves as specified in Section 15110 - Common Work Results for Valves.

2.12 SAFETY EQUIPMENT

A. Safety guards:
   1. Provide guards that protect personnel from rotating shafts or components within 7.5 feet of floors or operating platforms.
   2. Requirements:
      a. Allow visual inspection of moving parts without removal.
      b. Allow access to lubrication fittings.
      c. Prevent entrance of rain or dripping water for outdoor locations.
      d. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.
   3. Materials:
      a. Sheet metal: Carbon steel, 12-gauge minimum thickness, hot-dip galvanized after fabrication.
      b. Fasteners: Type 304 stainless steel.

B. Insulation:
   1. Insulate all surfaces with normal operating temperatures above 120 degrees Fahrenheit when surface is within 7.5 feet height from any operating floor or level.
   2. Insulation thickness such that temperature is below 120 degrees Fahrenheit.

C. Warning signs:
   1. Provide warning signs in accordance with OSHA requirements for equipment that starts automatically or remotely.
   2. Mount warning signs with stainless steel fasteners at equipment.

2.13 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.

2.14 SHOP FINISHES

A. Provide appropriate factory coatings as specified in Section 09960 - High-Performance Coatings.
   1. Motors and gear reducers: Shop finish paint with manufacturer's standard coating, unless otherwise specified in the individual equipment specification.

2.15 SPECIAL TOOLS

A. Supply 1 set of special tools as specified in Section 01600 - Product Requirements.

2.16 SOURCE TESTING

A. Testing requirements unless specified otherwise in the individual equipment specifications:
   1. Mechanical equipment: Level 1 General Equipment Performance Test as specified in Section 15958 - Mechanical Equipment Testing.
   2. Motors: As specified in Section 16222 - Low Voltage Motors Up to 500 Horsepower.
   3. Vendor control panels: As specified in Section 17950 - Commissioning for Instrumentation and Controls.

2.17 SHIPPING

A. As specified in Section 01600 - Product Requirements.

B. Prior to shipment of equipment:
   1. Bearings (and similar items):
      a. Pack separately or provide other protection during transport.
      b. Greased and lubricated.
   2. Gear boxes:
      a. Oil filled or sprayed with rust preventive protective coating.
   3. Fasteners:
      a. Inspect for proper torques and tightness.

PART 3 EXECUTION

3.01 DELIVERY, HANDLING, STORAGE, AND PROTECTION

A. As specified in Section 01600 - Product Requirements.

B. Inspect fasteners for proper torques and tightness.

C. Storage:
   1. Bearings:
      a. Rotate units at least once per month or more often as recommended by the manufacturer to protect rotating elements and bearings.
   2. Gear boxes:
      a. Inspect to verify integrity of protection from rust.

D. Protection:
   1. Equipment Log shall include description of rotation performed as part of maintenance activities.

3.02 INSTALLATION

A. Field measurements:
   1. Prior to shop drawings preparation, take measurements and verify dimensions indicated on the Drawings.
   2. Ensure equipment and ancillary appurtenances fit within available space.

B. Sequencing and scheduling:
   1. Equipment anchoring: Obtain anchoring material and templates or setting drawings from equipment manufacturers in adequate time for anchors to be cast-in-place.
   2. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.

C. Metal work embedded in concrete:
   1. Accurately place and hold in correct position while concrete is being placed.
   2. Clean surface of metal in contact with concrete immediately before concrete is placed.

D. Concrete surfaces designated to receive non-shrink grout:
   1. Heavy sandblast concrete surface in contact with non-shrink grout.
   2. Clean concrete surfaces of sandblasting sand, grease, oil, dirt, and other foreign material that may reduce bond to non-shrink grout.
   3. Saturate concrete with water. Concrete shall be saturated surface damp at time non-shrink grout is placed.

E. Install equipment in accordance with manufacturer's installation instructions and recommendations.

F. Lubrication lines and fittings:
   1. Support and protect lines from source to point of use.
   2. Fittings:
      a. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
      b. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
      c. Fittings for underwater bearings: Bring fittings above water surface and mount on edge of structure above.

G. Alignment of drivers and equipment:
   1. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after complete unit has been leveled on its foundation.

2. Comply with procedures of appropriate HI, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
    a. Maximum total coupling offset (not the per-plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).
    b. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.
3. Use reverse-indicator arrangement dial-type or laser-type alignment indicators: Mount indicators on the driver/coupling flange and equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.
4. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.
5. When alignment satisfies most stringent tolerance of system components, grout between base and foundation.
    a. Allow minimum 48 hours for grout to harden.
    b. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
    c. Correct alignment as required.
6. After functional testing is complete, dowel motor or drivers and driven equipment:
    a. Comply with manufacturer's instructions.

H. Grouting under equipment bases, baseplates, soleplates, and skids:
1. Unless otherwise indicated on the Drawings, grout with non-shrink grout as specified in Section 03600 - Grouting.
    a. Non-shrink epoxy grout required only when indicated on the Drawings.
2. Comply with equipment manufacturer's installation instructions for grouting spaces, and tolerances for level and vertical and horizontal alignment.
3. Install grout only after:
    a. Equipment is leveled and in proper alignment.
    b. Piping connections are complete and in alignment with no strain transmitted to equipment.
4. Do not use leveling nuts on equipment anchors for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting.
5. Use jack screws for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting following the procedure defined below:
    a. Drill and tap equipment base plates, sole plates, and skids for jack screws.
    b. Use suitable number and size of jack screws.
    c. End of jack screws shall bear on circular steel plates epoxy bonded to equipment foundation.
    d. Jack screw threads that will be in contact with grout: Wrap with multiple layers of tape or other material, acceptable to Engineer, to prevent grout from bonding to threads.
    e. Place and cure grout as specified in Section 03600 - Grouting.
    f. After grout is cured, remove jack screws and material used to prevent bonding to grout.
        1) Provide jack screws to Owner for future use.

g. Tighten equipment anchors in accordance with equipment manufacturer requirements.
h. Fill holes where jack screws have been removed with grout.
i. Cure as specified in Section 03600 - Grouting.

6. For equipment bases, baseplates, soleplates, and skids where it is not practical to use jack screws, use steel wedges and shims.
   a. Wrap wedges and shims that contact grout with multiple layers of tape or other material, acceptable to Engineer, to prevent grout from bonding.
   b. Place and cure grout as specified in Section 03600 - Grouting.
   c. Remove wedges or shims.
   d. Tighten equipment anchors to in accordance with equipment manufacturer requirements.
   e. Fill voids where wedges and shims have been removed with grout.
   f. Cure as specified in Section 03600 - Grouting.
7. Preparation of equipment bases, baseplates, soleplates, and skids for grouting:
   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 03600 - Grouting.

I. Field welding:
   1. Use welding procedures, welders, and welding operators qualified and certified in accordance with AWS D1.1.
   2. Shielded arc welding.

J. Field finishes:
   1. Protect motors.
   2. Clean equipment.
   3. Apply primer and coating systems as specified in Section 09960 - High-Performance Coatings requirements.

K. Special techniques:
   1. Use applicable special tools and equipment, including precision machinist levels, dial indicators, and gauges as required in equipment installations.

L. Tolerances:
   1. Completed equipment installations: Comply with requirements for intended use and specified vibration and noise tolerances.

M. Warning signs:
   1. Mount securely with stainless fasteners at equipment that can be started automatically or from remote locations.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Functional testing requirements unless specified otherwise in the individual equipment specifications:
   1. Mechanical equipment: Level 1 tests as specified in Section 15958 - Mechanical Equipment Testing.
   2. Motors: As specified in Sections 16222 - Low Voltage Motors Up to 500 Horsepower and 16950 - Field Electrical Acceptance Tests.
   3. Vendor control panels: As specified in Section 17950 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 15052

COMMON WORK RESULTS FOR GENERAL PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic materials and methods for metallic and plastic piping systems.

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. 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 for High Temperature or High Pressure Service and Other Special Purpose Applications.
   2. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   3. A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 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.
   6. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements of Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

D. NSF International (NSF).

1.03 DEFINITIONS

A. Buried pipes: Pipes that are buried in the soil with or without a concrete pipe encasement.

B. Exposed pipe: Pipes that are located above ground, or located inside a structure, supported by a structure, or cast into a concrete structure.

C. Underground pipes: Buried pipes - see A. above.

D. Underwater pipes: Pipes below the top of walls in basins or tanks containing water.

E. Wet wall: A wall with water on at least 1 side.

PART 2 PRODUCTS

2.01 GENERAL

A. Materials as specified in Section 01600 - Product Requirements including special requirements for materials in contact with drinking water.

2.02 ESCUTCHEONS

A. Material: Chrome-plated steel plate.

B. Manufacturers: One of the following or equal:
   1. Dearborn Brass Co., Model Number 5358.
   2. Keeney Manufacturing Co., 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. Links 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.
   4. Hardware to be Type 316 stainless steel.
      a. Provide anti-galling lubricant for threads.

B. One of the following or equal:
   1. Link-Seal.
   2. Pipe Linx.

2.04 FLANGE BOLTS AND NUTS

A. General:
   1. Washer:
      a. Provide a washer for each nut.
      b. Washer shall be of the same material as the nut.
   2. Nuts: Heavy hex-head.
   3. Cut and finish flange bolts to project a maximum of 1/4-inch beyond outside face of nut after assembly.
   4. Tap holes for cap screws or stud bolts when used.
   5. Lubricant for stainless steel bolts and nuts:
      a. Chloride-free.
      b. Manufacturers: One of the following or equal:
         1) Huskey FG-1800 Anti-Seize.
         2) Weicon Anti-Seize High-Tech.

B. Plastic pipe:
   1. On exposed pipes:
      a. Bolts: ASTM A307, Grade B.
      b. Nuts: ASTM A563, Grade A.
      c. Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.

2. On underwater pipes and pipes adjacent to wet walls:
    a. Bolts: ASTM A193, Grade B8M.
    b. Nuts: ASTM A194, Grade 8M.

C. Steel pipe:
1. On exposed pipes:
    a. For ASME B16.5 Class 150 flanges and AWWA C207 Class D flanges:
        1) Bolts: ASTM A307, Grade B.
        2) Nuts: ASTM A563, Grade A.
        3) Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.
    b. For ASME B16.5 and B16.47 Class 300 flanges and AWWA C207 Class E and F flanges:
        1) Bolts: ASTM A193, Grade B7.
        2) Nuts: ASTM A194, Grade 2H.
2. On underwater pipes and pipes adjacent to wet walls:
    a. Bolts: ASTM A193, Grade B8M.
    b. Nuts: ASTM A194, Grade 8M.

2.05 GASKETS

A. General.
1. Gaskets shall be suitable for the specific fluids, pressure, and temperature conditions.
2. Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure.

B. Gaskets for flanged joints in polyvinyl chloride and polyethylene piping:
1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal to 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:
    a. Chemical systems: 0.125-inch thick Viton rubber.
    b. Sewer and water: 0.125-inch thick SBR.
3. Manufacturers: One of the following or equal:
    a. Garlock.
    b. John Crane, similar product.

C. Gaskets for flanged joints in ductile iron or steel water piping:
1. Suitable for hot or cold water, pressures equal to and less than 150 pounds per square inch gauge, and temperatures equal to and less than 160 degrees Fahrenheit.
2. Material:
    a. SBR or neoprene elastomer, compressed, with non-asbestos fiber reinforcement.
3. Manufacturers: One of the following or equal:
    a. Garlock, Bluegard 3300.
    b. John Crane, similar product.

D. Gaskets for flanged joints in ductile iron or steel 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. EPDM material with 80 Shore A durometer rating.
   3. Manufacturers: One of the following or equal:
      a. Garlock, 98206.
      b. John Crane, similar product.

2.06 REPAIR BANDS

A. Design requirements:
   1. In accordance with AWWA C230.

B. Materials:
   1. Shells: Type 304 stainless steel.
   2. Lugs: Removable epoxy coated ductile iron in accordance with ASTM A536.
   3. Bolts and nuts: 304 Stainless Steel with fluorpolymer coated nuts.
   4. Gaskets: Compounded for water and sewer service.

C. Manufacturers: One of the following or equal:
   1. Romac Industries, Inc.
   2. Smith-Blair Inc.

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. Grooved joints: Use couplings, flange adapters, and fittings of the same manufacturer.
    1) Manufacturer's factory trained representative:
        a) Provide on-site training for Contractor's field personnel.
        b) Periodically visit the jobsite to verify Contractor is following best recommended practices.
    2) Distributor's representative is not considered qualified to conduct the training or jobsite visits.
e. 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.
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. Install exposed piping after installing equipment and after piping and fitting locations have been determined.

3. Support piping: As specified in Sections 15061 - Pipe Supports and 15062 - Preformed Channel Pipe Support System:
    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 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 09960 - High-Performance Coatings.

F. Restraining buried 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.
   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. Restraining above ground piping:
   1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
      a. When piping is aboveground or underwater, use mechanical or structural restraints.
   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.

H. 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.

I. Connections to in-service piping:
   1. As specified in Section 01140 - Work Restrictions.

J. 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.

K. 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. Conduct pressure and leak test, as specified.

3.03 PIPING SCHEDULE

A. As indicated on the Drawings.

END OF SECTION

SECTION 15061

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Supports for pipe, fittings, valves, and appurtenances.

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 01330 - Submittal Procedures

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 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

2.02 MATERIALS

A. General:
   1. Hot dip galvanized:
      a. Fabricate as specified in Section 05120 - Structural Steel.
      b. Hot dip after fabrication of support in accordance with ASTM A123.
      c. Repair galvanized surface as specified in Section 05120 - Structural Steel.
   2. Stainless steel.
      a. Fabricate as specified in Section 05120 - Structural Steel.
      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. Type 304 Stainless Steel.

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 316 Stainless Steel.

E. Fasteners:
   1. As specified in Section 05120 - Structural Steel.

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. Brackets: MSS SP-58, Type 32 with back plate; rated for 1,500 pounds:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 30M.
         2) Cooper B-Line Systems, Inc., Figure B3066.
         3) FM Stainless Fasteners, Figure 98.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 195.
         2) Cooper B-Line Systems, Inc., Figure B3066.

D. Standard U-bolt: MSS SP-58, Type 24:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 110.
         2) Cooper B-Line Systems, Inc., Figure B3188.
         3) FM Stainless Fasteners, Figure 37.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 137.
         2) Bergen-Power, Figure 283.
         3) Cooper B-Line Systems, Inc., Figure B3188.

E. Riser clamps: MSS SP-58, Type 8:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc., Figure B3373.
         2) FM Stainless Fasteners, Figure 61.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 261.
         2) Bergen-Power, Figure 126.
         3) Cooper B-Line Systems, Inc., Figure B3373.

F. Pipe clamps: MSS SP-58, Type 4:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 4.
         2) Cooper B-Line Systems, Inc., Figure 3140.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 212.
         2) Bergen-Power, Figure 175.
         3) Cooper B-Line Systems, Inc., Figure B3140.

G. 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 stainless steel piping:
         1) Nibco-Tolco, Figure 318.
         2) FM Stainless Fasteners, Figure 59.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 259.
         2) Bergen-Power, Figure 125.
         3) Cooper B-Line Systems, Inc., Figure B3090.
      c. 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.

H. Welded beam attachment: MSS SP-58, Type 22:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 304.
2) Cooper B-Line Systems, Inc., Figure 3083.
b. For all other 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.

I. Anchor bolts, concrete anchors, concrete inserts, powder-actuated fasteners, and sleeve anchors: As specified in Section 05120 - Structural Steel.

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 01410 - Regulatory Requirements.

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 09960 - High-Performance Coatings.

END OF SECTION

SECTION 15062

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.

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.

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 01612 - Seismic Design Criteria 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 01330 - Submittal Procedures.

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 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 Ind., 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 Ind., 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 Ind., 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 Ind., B-Line Series B297.

E. Touch-up paint for galvanized surfaces:
   1. Manufacturers: The following or equal:
      a. Galvinox, Galvo-Weld.

F. Touch-up paint for painted surfaces: Same formulation as factory paint.

G. Cushion strip:
   1. For solvent welded plastic pipes in elevated temperatures, use a thermoplastic elastomer, cushion wrap designed for use from -50 degrees Fahrenheit to 275 degrees Fahrenheit. Contractor to add a cushion strip at each pipe support strap that meets this criteria.
      a. Manufacturers: One of the following or equal:
         1) Anvil, AS 3795.
         2) Unistrut, P2600 Unicushion.

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 15075

EQUIPMENT IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Equipment nameplates.
   2. Special items.

1.02 SUBMITTAL

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Shop drawings:
   1. Product data.
   2. Installation instructions.

C. Samples.

PART 2 PRODUCTS

2.01 EQUIPMENT NAMEPLATES

A. Material and fabrication:
   1. Stainless steel sheet engraved or stamped with text, holes drilled, or punch for fasteners.

B. Fasteners:
   1. Number 4 or larger oval head stainless steel screws or drive pins.

C. Text:
   1. Manufacturer’s name, equipment model number and serial number, identification tag number; and when appropriate, drive speed, motor horsepower with rated capacity, pump rated total dynamic head, and impeller size.

2.02 SPECIAL ITEMS

A. In addition, special coating of following items will be required:

Item	Color
Valve handwheels and levers	Red
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 01600 - Product Requirements.

3.02 PREPARATION

A. Prepare and coat surfaces of special items as specified in Section 09960 - High-Performance Coatings.

B. Prepare surface in accordance with product manufacturer's instructions.

END OF SECTION

SECTION 15076

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. Witness markers.
   5. Valve identification.

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 01330 - Submittal Procedures.

B. Submit following:
   1. Product data.
   2. Samples.
   3. Manufacturer's installation instructions.
   4. Submit following as specified in Section 01770 - Closeout Procedures:
      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 inches	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

2. Coating: As specified in Section 09960 - High-Performance Coatings.
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:
   a. Manufacturers: One of following or equal:
      1) Brady BradySnap-On B-915.
      2) Seton Setmark.

2.02 BURIED PIPELINE IDENTIFICATION

A. Underground warning tape:
   1. Manufacturer: One of the following or equal:
      a. Seton Name Plate Co.
      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
      b. Thickness minimum: 10 gauge.
      c. Insulation:
         1) Match insulation color to the color of the pipe being installed.
         2) UF type, direct bury.
         3) 30 mil HMWPE.

3. Splicing Kit:
    a. Manufacturers: One of the following or equal:
        1) Ryall Electric Co., 3M Kit#82-A1.
4. Station Box:
    a. Lid and collar materials: Cast iron.
    b. Able to withstand heavy traffic loading.
    c. Manufacturers: One of the following or equal:
        1) Farwest Corrosion Control Co, Glenn 4 Test Station.

C. Witness markers:
1. Manufacturers: One of the following or equal:
    a. Carsonite Composites, Utility Marker.
    b. Hampton Technical Associates, Inc.
2. Materials:
    a. Glass fiber and resin reinforced thermosetting composite material.
    b. UV resistant.
3. Constructed as a single piece.
4. Pointed at the bottom end.
5. Information to be included on the marker:
    a. “Caution” (type of service) “Pipeline”.
    b. Phone number for Blue Stakes of Utah.
    c. Phone number for Owner in case of emergency.
    d. Station number.
    e. Offset:
        1) Only provide offset if marker is not directly over the pipe.
    f. Name of appurtenance or fitting (e.g. 45, BO, ARV, etc.)

2.03 VALVE AND GATE IDENTIFICATION

A. Provide valve and gate schedule for each valve and gate in the Work with the following information:
1. Identification number.
2. Location.
3. Type.
4. Function.
5. Normal operating position.

B. Identification tag requirements.
1. Diameter: 2-inches.
2. Material:
    a. Buried applications: Stainless steel.
    b. Buried applications with concrete marker: Brass.
    c. Above ground and in-chase applications: 19-gauge aluminum or PVC.
3. Stamp tags in 1/4-inch high letter:
4. Provide non-corrosive metal wire suitable for attaching the tag to the operator base.
5. Secure tags to valve or gate:
    a. Attach tags in such a way as to allow free and full operation of the valve or gate.
6. Buried applications with concrete marker: Secure tags to concrete marker.

C. Submittal requirements:
   1. Submit 2 samples of the type of tag proposed and the manufacturer's standard color chart and letter styles to the Engineer for review.

D. Manufacturer: The following or equal:
   1. Seton Name Plate Co.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01600 - Product Requirements.

3.02 PREPARATION

A. Prepare and coat surfaces as specified in Section 09960 - High-Performance Coatings.

B. Prepare surface in accordance with product manufacturer's instructions.

3.03 ABOVE GROUND AND IN-CHASE PIPING IDENTIFICATION

A. Identify exposed piping, 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 piping with colors as selected by Owner.

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.

C. Witness markers:
   1. Install over pipe in unpaved open-space areas at intervals not greater than 200 feet.
   2. Place markers at appurtenances located in unpaved areas.
   3. Embed markers at least 18 inches into the soil.

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
Cooling Water	Blue	COOLING WATER
Domestic Cold Water	Light Blue	DOMESTIC COLD WATER
Domestic Hot Water	Light Blue	DOMESTIC HOT WATER
Deionized Water	Blue	DEIONIZED WATER
Drain	Charcoal	DRAIN
Exhaust Gas	Yellow	EXHAUST GAS
Engine Jacket Water	Dark Blue	ENGINE JACKET WATER

Service Fluid	Pipe Color	Marker Legend
Fuel Oil	Orange	FUEL OIL
Grit	Black	GRIT
Instrumental Air	Purple	INSTRUMENTATION AIR
Engine Lube Oil	Red	ENGINE LUBE OIL
Pumped Drain	Charcoal	PUMPED DRAIN
Process Water	Dark Blue	PROCESS WATER
Raw Wastewater	Buff	NONE USED
Return Water	Silver/Grey	RETURN WATER
Sample	Green	FLUID BEING SAMPLED
Sanitary Drain	Charcoal	SANITARY DRAIN
Service Air	Green	SERVICE AIR
Sodium Hypochlorite	Yellow	CHLORINE SOLUTION
Sodium Bisulfite	Yellow	SODIUM BISULFITE SOLUTION
Tank Drain	Charcoal	TANK DRAIN
Vent Pipe	Yellow	VENT PIPE
Washdown Water (W3)	Medium Blue	WASHDOWN WATER

Letters	Color of Pipe	Color of Bands	Color of Letters
Finished or Potable (cold)	Light blue	None	Black
Potable (hot)	Light blue	Red	Black
Non-potable or Raw	Light blue	Dark Gray	Black
Sample	Dark Blue	Black	White
Filter-to-Waste	Light Brown	None	Black
Wash Water Drain	Light Gray	None	Black
Solids	Dark Brown	None	White
Drain	Dark Gray	None	White
Sump Pump Pipe Line	Dark Gray	Red	White
Stainless Steel Pipe	White	Red	White

END OF SECTION

SECTION 15110

COMMON WORK RESULTS FOR VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic requirements for valves.

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. SP7 - Brush-Off Blast Cleaning.
   2. SP10 - 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 inches nominal size and larger: Flanged ends.
   2. Valves less than 3 inches 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 01330 - Submittal Procedures.

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 01782 - Operation and Maintenance Data.
    1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inches 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 01756 - Commissioning.

E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

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: 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-inch, except that:
         1) Lining thickness in grooves for gaskets: 0.005-inch.
         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 09960 - High-Performance Coatings.

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 09960 - High-Performance Coatings.

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 09997 - Pipeline Coatings and Linings.
      a. Ascertain that polyethylene wrapping does not affect operation of valve.

2.04 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 Co.

2.05 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 inches 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 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
   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.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning 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 15111

BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Ball valves.

B. As specified in Section 15110 - 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):
   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 01330 - Submittal Procedures.

B. Product data: As specified in Section 15110 - Common Work Results for Valves:
   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 01756 - Commissioning.

1.05 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 METAL BODY BALL VALVES, 6-INCH SIZE AND LARGER

A. Manufacturers: One of the following or equal:
   1. Crane ChemPharma Energy, Resilient seated valve.
   2. DeZURIK/APCO, Metal seated valve.
   3. Henry Pratt Company, Resilient seated valve.

B. General:
   1. Type: Non-lubricated, resilient seated or metal seated and capable of sealing in either flow direction.
   2. In accordance with AWWA C507.
   3. Stem packing: Manually adjustable while valve is under pressure.
   4. ASME B16.1, Class 125 flanged ends.

C. Materials:
   1. Body: ASTM A48 cast iron with 400 series Monel seats (metal seated valves only) and integrally cast bronze bushed trunnions.
   2. Ball: Type 304 or 316 stainless steel.
   3. Seats: PTFE or 300 series stainless steel.
   4. Stem seals: PTFE or 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.

2.02 METAL BODY BALL VALVES, LESS THAN 6-INCH SIZE

A. Manufacturers: One of the following, or equal:
   1. Conbraco Industries, Inc., Apollo Valves.
   2. Flow-Tek, Inc.
   3. Metso Automation/Jamesbury.
   4. NIBCO, 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 inches.
         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 15052 - Common Work Results for General Piping.
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.

2.03 PLASTIC BODY BALL VALVES

A. Manufacturers: One of the following or equal:
1. Asahi America.
2. Chemtrol Division, NIBCO, Inc.
3. Georg Fischer Piping Systems.
4. Hayward Flow Control.
5. Plast-O-Matic Valves, Inc.

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™) or EPDM.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install each type of valve in accordance with manufacturers' printed instructions.

3.02 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09960 - High-Performance Coatings.

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 01756 - Commissioning 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 15956 - Piping Systems Testing.

END OF SECTION

SECTION 15112

BUTTERFLY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Butterfly valves:
   1. As specified in Section 15110 - 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. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
   12. A890 - Standard Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application.

13. 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.
14. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
15. B691 - Standard Specification for Iron-Nickel-Chromium-Molybdenum Alloys (UNS N08366 and UNS N08367) Rod, Bar, and Wire.
16. 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.

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.
2) Provide butterfly valves in accordance with AWWA Class 250B in piping systems with test pressure greater than 150 pounds per square inch and less than 250 pounds per square inch.

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 01330 - Submittal Procedures

B. Product data: 15110 - Common Work Results for Valves
   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.

C. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.05 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

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 Co.

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.

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-inches and less: 1-piece, through disc design.
   b. Valves greater than 20-inch size: 2-piece, stub shaft 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 inches and less: Nylatron.
   b. Valves greater than 20-inch size: Teflon with stainless steel or fiberglass backing.

E. Seats:
1. Seat materials:
   a. In low-pressure air applications: EPDM.
   b. In all other applications: NBR or natural rubber.
2. For valves 20 inches in nominal size and smaller, bond or vulcanize seat into the valve body.
3. For valves 24 inches in nominal size and larger, retain seats mechanically or by adhesive:
   a. Mechanical retainage: Retain seat by a clamping ring with segmented clamping ring locks with adjusting locking screws.
      1) Clamping ring, ring locks, and adjusting locking screws: Type 316 stainless steel.
      2) Provide means to prevent ring locks and screws used to retain seats from loosening due to vibration or cavitation.
   b. Adhesive retainage: Inset the seat within a groove in the valve body and retain in place with epoxy injected behind the seat so that the seat expands into the body.

c. Do not provide valves with seats retained by snap rings or spring-loaded retainer rings.

4. Resilient seat: Withstand 75 pound per inch pull when tested in accordance with ASTM D429, Method B.

F. Valve packing:
1. Valves 4 inches to 48 inches nominal size: Self-adjusting V-type packing or chevron-type packing. NBR or EPDM to match seat material.
2. Valves 54 inches nominal size and larger: Adjustable V-type packing with bronze packing gland or self-adjusting V-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 09960 - High-Performance Coatings 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 09960 - High-Performance Coatings:
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 09960 - High-Performance Coatings 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 09960 - High-Performance Coatings.
        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

A. As specified in Section 01756 - Commissioning 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 15110 - Common Work Results for Valves.

BUTTERFLY VALVE APPLICATION SCHEDULE	
Valve Type and Style	**Acceptable Applications**
General Purpose AWWA Butterfly Valves - Flanged Body Design.	Aboveground or submerged in the following service applications only: - Acceptable in all service applications except oxygen and ozone service and high-pressure service. - May be used in buried applications when required by the specified piping system.
General Purpose AWWA Butterfly Valves - Mechanical Joint Body Design.	Buried in the following service applications only: - Acceptable in all service applications except oxygen and ozone service and high-pressure service.
General Purpose AWWA Butterfly Valves - Lugged Body Design.	Aboveground in the following service applications only: - Aeration Air Systems.
General Purpose AWWA Butterfly Valves - Wafer (not lugged) Body Design.	Not allowed.

END OF SECTION

SECTION 15114

CHECK VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Check valves.

B. As specified in Section 15110 - 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 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 01330 - Submittal Procedures.

B. Product data: As specified in Section 15110 - Common Work Results for Valves.

C. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.05 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 SWING CHECK VALVES

A. Valves 4 inches through 24 inches:
   1. Manufacturers: One of the following or equal:
      a. Val-Matic Series 7800.
      b. Kennedy, Figure 106LW or M&H, Model 159.
      c. Mueller Co., Model A-2600.
      d. APCO Model 250.
      e. 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.

PART 3 EXECUTION

3.01 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
   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.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning 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 15956 - Piping Systems Testing.

END OF SECTION

SECTION 15115

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 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 inch Standard.
   2. B16.47 - Large Diameter Steel Flanges: NPS 26 through NPS 60 inch Standard.
   3. B36 - Stainless Steel Pipe.

B. 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.

C. ASTM International (ASTM):
   1. B98 - Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15110 - Common Work Results for Valves.

C. Commissioning submittals: For valves larger than 16 inches:
   1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

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 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 Co. Figure No. 2140 Globe or No. 2141 Angle.
         2) In Welded steel piping:
            a) Crane, No. 351.
            b) Lunkenheimer Co., 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.

PART 3 EXECUTION

3.01 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
   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.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services: For valves larger than 16 inches.
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
   1. Valves:
      a. Test witnessing: Not Witnessed.
      b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.

END OF SECTION

SECTION 15116

PLUG VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Non-lubricated plug valves.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C517 - Resilient-Seated Cast Iron Eccentric Plug Valves.
   2. C606 - Grooved and Shouldered Joints.

B. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures and 15110 - Common Work Results for Valves.

B. Product data.

C. Shop drawings.

D. Calculations.

E. Vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data.

F. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning:
      a. Interior coating.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 15110 - Common Work Results for Valves.

2.02 NON-LUBRICATED PLUG VALVES

A. Manufacturers: One of the following or equal:
   1. DeZurik, "PEC".
   2. Clow Valve.
   3. Milliken Valve, Model 600/601.

B. Design:
   1. Type: Non-lubricated eccentric type, in accordance with AWWA C517.
   2. Plug face: Resilient material that operates satisfactorily at a temperature of 180 degrees Fahrenheit continuous and 215 degrees Fahrenheit intermittent, except for valves in compressed air or digester gas service.
      a. Valves in compressed air service: Resilient material suitable for continuous duty at 250 degrees Fahrenheit.
      b. Valves in digester gas service: Resilient material suitable for petroleum or digester gas at continuous duty at 180 degrees Fahrenheit.
   3. Compression washer: Provide flat compression washer made of Teflon, or of a material having equal physical characteristics on valve stem between plug and bonnet.
   4. Stem seals: Provide stem seals serviceable without unbolting the valve bonnet assembly.
   5. Grit excluders: Provide PTFE grit excluders at upper plug journals to prevent entry of foreign solids in bearing area.
   6. Clearly mark valves to indicate their open and closed positions.
   7. Provide valves with ends as required by piping details indicated on the Drawings.

C. Materials:
   1. Body and plug: ASTM A126, Class B, cast-iron**,** with plug face of Buna N material suitable for the intended service as specified under paragraph "Design" above.
   2. Body seats in valves 3-inch size and larger: Provide with overlay of not less than 90-percent nickel and minimum thickness of 1/8-inch on surfaces contacting the plug face.
   3. Stem bearing and bottom bearing: Type 316 stainless steel.
   4. Internal parts, except the body and plug: Type 316 stainless steel.
   5. Exposed nuts, bolts, and washers: Zinc plated. Exception: Exposed nuts, bolts, and washers for buried service: Stainless steel.

2.03 VALVE OPERATORS

A. Furnish valves with an operating wrench or worm gear operator:
   1. Equip valves 4-inch nominal size and smaller with a lever operator.
   2. Equip valves 6-inch nominal size and larger with a worm gear operator.

2.04 COATING

A. Coat and test interior metal surfaces as specified in Section 15110 - Common Work Results for Valves.

B. Field applied coating of valve exterior:
   1. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
      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.

2.05 SHIPMENT, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. As specified in Section 01600 - Product Requirements.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves as specified in Section 15110 - Common Work Results for Valves and the manufacturer's instructions.
   1. Unless differently indicated on the Drawings install valves so that in the closed position the pressure in the pipeline applies a seating head on the valves.
   2. Install valves so that in the open position the plug is located in the top half of the valve body.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning 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 15110 - Common Work Results for Valves.

END OF SECTION

SECTION 15117

SPECIALTY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Specialty valves.

B. As specified in Section 15110 - 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 01330 - Submittal Procedures.

B. Product data: As specified in Section 15110 - Common Work Results for Valves.

C. Commissioning submittals:
   1. Backflow preventer certification.
   2. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.05 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 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. Include shutoff valves at each end of backflow preventer with properly located test cocks.

D. 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.

2.02 MUD VALVES

A. Manufacturers: One of the following or equal:
   1. Clow Corp., Series F-3075T.
   2. Waterman Industries, Inc., Model MV-11.

B. Design:
   1. Provide mud valves with non-rising stem.
   2. Provide standard AWWA 2-inch valve nut on stainless steel stem extension to height required.

C. Materials:
   1. Body, cover, and yoke: Cast-iron.
   2. Disc plug: Cast-iron.
   3. Seat rings: Resilient Neoprene or Buna-N seating face.
   4. Stem and stem nut: Bronze.
   5. Cap screws to bolt valve to cast-iron pipe flange: Type 316 stainless steel.

2.03 SOLENOID VALVES

A. 2-way solenoid valves:
   1. Manufacturers: One of the following or equal:
      a. Automatic Switch Co., 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 Co., 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 Co., Bulletin 8344.
      b. Skinner Electric Valve Division, Series V9.

D. Design:
   1. Valves: Suitable for service under the following conditions:
      a. Fluid: Water.
      b. Temperature of fluid: 40 degrees Fahrenheit.
      c. Piping test pressure: 70 pounds per square inch gauge.
   2. Unless otherwise indicated on the Drawings, provide valves that meet the following requirements:
      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.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 15110 - Common Work Results for Valves in accordance with manufacturer's published instructions.

B. Install with a minimum clearance of 12 inches and with maximum clearance of 30 inches between the relief port and the floor or finished grade or top of containment wall.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning 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) Backflow preventer.
      b. Installation: 1 trip, 1 day minimum.
      c. Functional Testing: 1 trip, 1 day minimum each.

d. Training:
    1) Maintenance: 2 hours per session, 1 session.
    2) Operations: 2 hours per session, 1 session.

C. Functional testing:
    1. Backflow preventer:
        a. Test witnessing: Witnessed.
        b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.
        c. Backflow preventer certification.

END OF SECTION

SECTION 15118

PRESSURE REDUCING AND PRESSURE RELIEF VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pressure reducing and pressure relief valves for water service.

B. As specified in Section 15110 - 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 01330 - Submittal Procedures.

B. Product data: As specified in Section 15110 - Common Work Results for Valves.

C. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 WATER PRESSURE REDUCING VALVES

A. Water pressure reducing valves, 2 1/2 inches and smaller:
   1. Manufacturers: One of the following or equal:
      a. Watts Regulator, Series LF223.
      b. Wilkins, 500 Series.
   2. Direct operated, single seat type pressure reducing valve.
   3. Materials:
      a. Body and spring cover: Bronze.
      b. Valve seat: Series 300 stainless steel.
      c. Diaphragm: Reinforced Buna Nitrile.

d. Disk: EPDM.

B. Water pressure reducing valves, 3 inches and larger:
   1. Manufacturers: One of the following, or equal:
      a. Watts ACV Series 115.
      b. Cla-Val Model 90-01.
   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. Flanges: 150-pound rating, 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 WATER PRESSURE RELIEF VALVES

A. Water pressure relief valves:
   1. Manufacturers: One of the following, or equal:
      a. Watts ACV Series 116.
      b. Cla-Val Model 50-01.
   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.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 15110 - Common Work Results for Valves.

3.02 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09960 - High-Performance Coatings:
   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 01756 - Commissioning 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 15110 - Common Work Results for Valves.

END OF SECTION

SECTION 15119

AUTOMATIC AIR AND VACUUM VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Air release valves, air/vacuum valves, and combination air valves.

B. As specified in Section 15110 - 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 01330 - Submittal Procedures.

B. Product data: As specified in Section 15110 - Common Work Results for Valves.

C. Commissioning submittals:
   1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bond.

PART 2 PRODUCTS

2.01 AIR RELEASE VALVES, WATER SERVICE

A. Manufacturers: One of the following or equal:
   1. APCO Series 200.
   2. Crispin PL Series.

B. Design:
   1. Pressure rating: 150 pounds per square inch gauge.
   2. Inlet: Screwed, 2-inch.
   3. Orifice size: 1/4-inch diameter.

C. Materials:
   1. Valve body: Cast iron.
   2. Float and internal trim: Type 316 stainless steel.
   3. Seat or valve plunger: Buna-N.

2.02 COMBINATION AIR VALVES, WATER SERVICE

A. Manufacturers: One of the following or equal:
   1. APCO, Series 140C.
   2. Crispin, UL Series.

B. Design:
   1. Single body, double orifice.
   2. Inlet baffled for float protection.
   3. Mushroom cap on outlet.
   4. Pressure rating: 125 pounds per square inch.
   5. Inlet: Screwed, 2-inch size and smaller Flanged 3-inch size and larger.

C. Materials:
   1. Body: Ductile or Cast iron.
   2. Float: Type 316 stainless steel.
   3. Seat: Buna-N.
   4. Lever frame: Cast iron or Delrin.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 15110 - Common Work Results for Valves and manufacturer’s instructions.

B. Install air release valves and air and vacuum valves with suitable discharge lines to nearest equipment drain.

3.02 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09960 - High-Performance Coating.

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 09960 - High-Performance Coating.
    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 01756 - Commissioning 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 15110 - Common Work Results for Valves.

END OF SECTION

SECTION 15121

PIPE COUPLINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:

1. Pipe couplings for carbon steel 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. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
6. A449 - Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/9 ksi Minimum Tensile Strength, General Use.
7. A536 - Standard Specification for Ductile Iron Castings.
8. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
9. A576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
10. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
11. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
12. F594 - Standard Specification for Stainless Steel Nuts.

13. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

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 01330 - Submittal Procedures.

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 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements:
   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 01756 - Commissioning 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.

F. Exterior coatings for underground and submerged applications:
   1. Manufacturers: One of the following or equal:
      a. Tapecoat Co., Inc., T.C. Mastic.
      b. Kop-Coat Co., Inc., Bitumastic Number 50.
   2. Thickness: Minimum 0.040 inch.

2.02 PIPE COUPLINGS FOR CARBON STEEL PIPING

A. Dismantling joints:
   1. Manufacturers: One of the following or equal:
      a. Romac Ind., Inc., Style DJ400.
      b. Smith-Blair, Inc., Series 975.
   2. Materials:
      a. Flanged spool:
         1) C207 Schedule 40 pipe in accordance with ASTM A53 for sizes 3 inches to 12 inches.
         2) Steel for pipe in accordance with ASTM A36 or A53 for sizes 14 inches to 72 inches.
      b. End ring and body:
         1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A536.
         2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A36.
      c. Follower ring: Ductile iron in accordance with ASTM A536 or steel in accordance with ASTM A36 or A576.
      d. 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.
      e. Tie rods: High tensile steel in accordance with ASTM A193 grade B7.
   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: Fusion bonded epoxy certified in accordance with NSF 61.

B. Flanged coupling adapters:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 128-W.
      b. Romac Ind., Inc., Style FCA501 (10 inch and smaller) or Style FC400 (12 inch and larger).
      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 38.
   b. Smith-Blair, Inc., Series 411.
   c. Romac Ind., Inc., Style 511 or Style 400.
2. Materials:
   a. Center sleeve and follower flanges: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
   b. 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. 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 Diameter	Sleeve Length
2-1/2 inch and smaller	Manufacturer's standard
3 inch through 6 inch	7 inch
8 inch through 14 inch	7 inch
Greater than 14 inches	10 inch

D. Restrained flange coupling adapters:
1. Manufacturers: One of the following or equal:
   a. Romac Ind., 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 an apply forces evenly.
      3) Restraining bolts: Ductile iron in accordance with ASTM A536. 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 certified in accordance with NSF 61.

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 15052 - Common Work Results for General Piping.

END OF SECTION

SECTION 15125

STRAINERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Strainers.

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 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

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 maximum pressure of 250 pounds per square inch gauge.
   3. Screens: Perforations: 1/32 inch.
   4. Manufacturers: 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 01756 - Commissioning and this Section.

B. Manufacturer services for mechanically cleaned strainers, only:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.
   2. Manufacturer's Representative onsite requirements:
      a. Installation: 1 trip, 1 day minimum.
      b. Functional Testing: 1 trips, 1 day minimum each.
   3. Training:
      a. Maintenance: 2 hours per session, 2 sessions.
      b. Operation: 1 hours per session, 2 sessions.
   4. Process operational period:
      a. As required by Owner or Contractor.

C. Functional testing:
   1. Mechanically cleaned strainers only:
      a. Test witnessing: Witnessed.
      b. Conduct Level 1 General Equipment Performance Test.

END OF SECTION

SECTION 15241

HIGH DENSITY POLYETHYLENE (HDPE) PIPE: AWWA C906

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: High Density Polyethylene Pipe (HDPE), and fittings.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C906 - Standard for Polyethylene (PE) Pressure Pipe and Fittings, 4 in. Through 63 in., for Water Distribution.

B. 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.
   11. F2164 - Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure.

C. American Water Works Association (AWWA):
   1. C906 - Polyethylene (PE) Pressure Pipe and Fittings, 4-inch through 63-inch, for Water Distribution and Transmission, and all included references.
   2. M 55 - PE Pipe - Design and Installation Manual.

D. Plastic Pipe Institute (PPI):
   1. PE 4710.
   2. PE Handbook of Polyethylene Pipe.

E. NSF International:
   1. NSF/ANSI 61 - Drinking Water System Components.
   2. NSF/ANSI 14 - Plastic Piping System Components and Related Materials.

1.03 ABBREVIATIONS

A. HDPE: High-density polyethylene pipe.

B. ID: Inside diameter of piping or tubing.

C. IPS: Iron pipe size.

D. OD: Outside diameter.

E. SDR: Standard dimension ratio.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. 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.

C. Product data: As specified in Section 15052 - Common Work Results for General Piping:
   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.

D. Contractor shall submit proposed piping layout drawings prior to ordering materials. Proposed layout drawings shall clearly identify locations of fittings and couplings.

E. 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. Fusion machine technician qualifications: 3 years' experience in the installation of similar PE piping systems from the same manufacturer.

B. 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 GENERAL

A. In accordance with AWWA C906.

2.02 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.

C. Piping and pipe system components shall comply with NSF 61 or NSF 14 if used for drinking water service.

2.03 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 15052 - Common Work Results for General Piping; or, if not given, minimum SDR equals 9.
      b. Pipe Diameter: IPS dimensions as indicated on the Drawings.
   3. 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.

B. Materials:
   1. Manufacturers: One of the following or equal:
      a. Performance Pipe.
      b. Isco Ind.
   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 shall not be rated for less than the test pressure indicated in the Pipe Schedule.
   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. Flange gaskets:
    a. Gaskets for HDPE to HDPE flange connections are not required unless required by the flange manufacturer to satisfy the test pressure given in the pipe schedule.
9. 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 15052 - Common Work Results for General Piping.

2.04 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 to subsurface structures or piping, the temperature of each individual run of HDPE shall be allowed to approach the service temperature at which the pipe is intended to operate. Backfill materials may be placed around the pipe and up to 6-inches above the pipe to facilitate cooling:
         a) Any damage that occurs to subsurface structures or piping as a result of thermal expansion and contraction of the installed piping shall be repaired by the Contractor using a method acceptable to the Engineer at no additional cost to the Owner.
      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.

e. Excavation, backfill material and backfilling and compacting:
1) As specified in Specification 02318 - Trenching.

3.02 FIELD QUALITY CONTROL

A. Butt fusion testing on pipe size 14 inches 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. 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. Conduct as per ASTM F2164 in accordance with AWWA M 55 Chapter 9.
2. Test pressures as specified in the Pipe Schedule.
3. Temperature of test water shall be no more than 73 degrees Fahrenheit.

END OF SECTION

SECTION 15249

POLYVINYL CHLORIDE (PVC) PIPE: SCHEDULE TYPE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Schedule type PVC pipe and fittings.

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 the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.
   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 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

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 material in accordance with ASTM D1784.
    b. Schedule 80 unless otherwise indicated on the Drawings.
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 gasket.
3. Solvent cement:
    a. In accordance with ASTM D2564.
    b. Manufacturers: The following or equal:
        1) IPS Corp.

    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 15052 - Common Work Results for General Piping and Section 15956 - Piping Systems Testing.

END OF SECTION

SECTION 15278

STEEL PIPE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Steel piping, joints, fittings, and fabricated steel piping fittings and specials.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.3 - Malleable-Iron Threaded Fittings: Classes 150 and 300.
   3. B16.5 - Pipe Flanges and Flanged Fittings.
   4. B16.9 - Factory-Made Wrought Buttwelding Fittings.
   5. B16.12 - Cast Iron Threaded Drainage Fittings.

C. American Water Works Association (AWWA):
   1. C200 - Steel Water Pipe 6 Inches and Larger.
   2. C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe: 4 inches and Larger-Shop Applied.
   3. C206 - Field Welding of Steel Water Pipe.
   4. C207 - Standard for Steel Pipe Flanges for Waterworks Service-Sizes 4 inches Through 144 inches.
   5. C208 - Standard for Dimensions for Fabricated Steel Water Pipe Fittings.
   6. C606 - Standard for Grooved and Shouldered Joints.
   7. M11 - Steel Pipe: A Guide for Design and Installation.

D. ASTM International (ASTM):
   1. A47 - Standard Specification for Ferritic Malleable Iron Casting.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A105 - Standard Specification for Carbon Steel Forgings for Piping Applications.
   4. A106 - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
   5. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   6. A183 - Standard Specification for Carbon Steel Track Bolts and Nuts.
   7. A536 - Standard Specification for Ductile Iron Castings.
   8. D297 - Standard Test Methods for Rubber Products-Chemical Analysis.
   9. D395 - Standard Test Methods for Rubber Property-Compression Set.
   10. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.

11. D471 - Standard Test Methods for Rubber Property-Effect of Liquids.
12. D573 - Standard Test Methods for Rubber -Deterioration in an Air Oven.
13. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
14. D2240 - Standard Test Method for Rubber Property-Durometer Hardness.
15. E165 - Standard Practice for Liquid Penetrant Testing for General Industry.

1.03 SYSTEM DESCRIPTION

A. Design requirements:
   1. Design criteria for pipe and pipe fittings: In accordance with AWWA M11 with the following modifications:
      a. Wall thickness: Thicker of the thickness specified in Section 15052 - Common Work Results for General Piping Pipe Schedule, and the following thickness:
         1) For pipes smaller than 26 inches in diameter: Minimum 1/4 inch.
         2) For pipes 26 inches and larger but less than 38 inches in diameter: Minimum 5/16 inch.
         3) For pipes 38 inches and larger in diameter and including 72 inches in diameter: Minimum 3/8 inch.
      b. Inside diameter of unlined pipe: Nominal.
      c. Inside diameter of lined pipe: As measured from face to face of liner, but not less than nominal.
      d. Deflection of underground pipe inside diameter: Maximum 2 percent under trench load of H-20 live load in accordance with AASHTO specifications.
      e. Working stress of steel: Maximum 50 percent of yield stress.
      f. Contractor shall develop and submit calculations to determine the steel pipe and fitting wall thickness and design requirements according to the requirements of this specification.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

C. Shop drawings:
   1. Details of fittings and specials showing thickness and dimensions of plates.
   2. Details of welds and materials.
   3. Listing of proposed services and locations for use of grooved joint type piping.
   4. Tabulated layout schedules for cement-mortar lined and coated steel pipe.
   5. Grooved joint piping fittings, gaskets, and couplings.
   6. Grooving of pipe and fittings.

D. Calculations:
   1. Submit calculations prepared and stamped by a professional engineer licensed in the State of Utah. The calculations shall be based on the requirements defined in this Section.
   2. Design calculations: Wall thicknesses for external loading, special loading, internal pressure, and other necessary design cases.

E. Certificates of Compliance: Cement-mortar lined and coated steel pipe.

F. Mill certificates.

G. Test reports: Rubber gaskets.

1.05 QUALITY ASSURANCE

A. Applicable standards:
   1. Steel pipe larger than 12 inches diameter shall conform to the following standards, as complemented and modified in this Section:
      a. Steel pipe: AWWA C200.
      b. Fittings and specials: AWWA C208.
      c. Reinforcement of fittings and specials: AWWA M11.

PART 2 PRODUCTS

2.01 MATERIALS

A. Steel pipe:
   1. Type, pipe 6 inches and smaller: ASTM A53, black or galvanized, seamless or straight seam electric resistance welded. Minimum Schedule 40.
   2. Type, from 6 to 12 inches: ASTM A53, black or galvanized pipe, seamless or straight seam electric resistance welded. Minimum Schedule 20.
   3. Type, larger than 12 inches: AWWA C200, without butt strap, riveted, or swaged joints; wall thickness as indicated on the Drawings.
   4. Type, 24 inches and larger, with grooved type couplings and wall thickness less than 1/2-inch: Provided with stub ends, sized as follows, for grooves.
      a. Thickness: As recommended by coupling manufacturer, but not less than 1/2-inch.
      b. Length: Width of coupling plus 1 inch, but not less than 6 inches.

B. Steel pipe fittings:
   1. Screwed fittings:
      a. Malleable iron: ASME B16.3, 150 pounds; galvanized in accordance with ASTM A153 where used with galvanized pipe.
      b. Cast iron drainage: ASME B16.12, galvanized in accordance with ASTM A153 where used with galvanized pipe.
   2. Flanged fittings:
      a. Type for 12-inch and smaller pipe: ASME B16.1, cast iron or ductile iron, 125 pounds; or ASME B16.5, steel, 150 pounds, galvanized in accordance with ASTM A153 where used with galvanized pipe.
      b. Type for larger than 12-inch pipe: ASME B16.5, steel, 150 pounds; galvanized in accordance with ASTM A153 where used with galvanized pipe; or AWWA C207 and AWWA C208, fabricated from flanges and steel pipe, respectively.
      c. Companion flanges for 4 inches and smaller pipe: ASME B16.1, cast iron or ductile iron, 125 pounds; ASME B16.5, steel, 150 pounds, slip-on or welding neck; or ammonia type for use on chlorine liquid or gas piping.
      d. Companion flanges for larger than 4 inch to and including 12-inch pipe: ASME B16.5, slip-on or welding neck type.

e. Companion flanges for larger than 12-inch pipe: ASME B16.5, steel, 150 pounds; galvanized in accordance with ASTM A153 where used with galvanized pipe; or AWWA C207, steel plate or raised hub type.
f. Weld flanges to pipe or fittings before applying lining.
g. Machine flanges or provide tapered filler for changes in grade or to slope lines for drainage.
h. Flange bolts: As specified in Section 15052 - Common Work Results for General Piping.
i. Gaskets: As specified in Section 15052 - Common Work Results for General Piping.

3. Welding fittings:
   a. Welding fittings for piping 8 inches and less in nominal diameter: Butt-welding fittings in accordance with ASME B16.9, standard wall, or standard weight.
   b. Welding fittings for piping larger than 8 inches in nominal diameter: Butt-welding fittings in accordance with ASME B16.9, or, at the option of the Contractor, made up out of sections of pipe welded together, except where smooth bends are indicated for air lines.
   c. Fittings made up of sections of pipe welded together shall be made of pipe of at least the same wall thickness as the pipe with which used, and bends shall be miter bends, fabricated in accordance with AWWA C208 and as supplemented by AWWA M11. Welding of these made-up fittings shall be in accordance with AWWA C206.
      1) Design and fabricate outlets and 4 branch fittings in accordance with AWWA M11.
      2) Bends may be welded to adjacent pipe sections.
         a) Bends shall be manufactured of the following number of pieces:
            (1) Bends from 0 to 30 degrees angle, 2 pieces.
            (2) Bends from 30 to 45 degrees angle, 3 pieces.
            (3) Bends from 45 to 67-1/2 degrees angle, 4 pieces.
            (4) Bends from 67-1/2 to 90 degrees angle, 5 pieces.

4. Grooved joint fittings:
   a. Fittings for grooved joint steel piping: Rigid-grooved type, and as follows:
      1) Grooves: Cut; rolled grooves are not acceptable.
      2) Couplings: Cast in 2 or more segments of ductile iron in accordance with ASTM A536, Grade 65-45-12 or malleable iron in accordance with ASTM A47, Grade 32510.
      3) Bolts and nuts: As specified in Section 15052 - Common Work Results for General Piping.
      4) Gaskets: Composition water sealing designed so that the internal piping pressure serves to increase the seal's watertightness.
         a) Gaskets for water service and oil-free air systems at temperatures less than 230 degrees Fahrenheit shall be made of ethylene propylene diene monomers (EPDM) in accordance with ASTM D2000 Line Call Out 2CA615A25B24.
         b) Gaskets for use with cement-mortar lined steel piping shall be captured between the ends of the pipe to protect exposed metal from corrosion and shall be made of nitrile in accordance with ASTM D2000, Line Call Out 2CA615A25B24.
      5) Perform grooving of the pipe wall only on standard or heavier schedule weight pipe.

a) For pipe with wall thickness less than standard weight, weld a shouldered end on the pipe in accordance with AWWA C606.
b) Fabricated pipe, pipe in accordance with AWWA C200, shall have shouldered ends welded onto the pipe.
c) Shoulder: Type B or D in accordance with AWWA C606.

6) Couplings and grooving:
a) Manufacturers: One of the following or equal:
(1) Gustin-Bacon Piping Products.
(2) Victaulic Co.

b. Fittings for grooved joint piping: Ductile iron in accordance with ASTM A536, Grade 65-45-12, or malleable iron in accordance with ASTM A47, Grade 32510, and as follows:
1) Where cast fittings are not made, standard fittings including large diameter elbows shall be made of forged steel in accordance with ASTM A105, Grade B with 0.375-inch wall thickness, or shall be standard segmentally welded fittings fabricated of Schedule 40 carbon steel pipe.
a) Grooves:
(1) Manufacturers: One of the following or equal:
(a) Gustin-Bacon Piping Products.
(b) Victaulic Co.
2) Fittings for grooved joint piping shall be furnished by the manufacturer of the grooved joint material.
3) Fittings for grooved joint piping shall be for rigid-grooved type joints.
4) Connection to flanged units shall be by means of flange to grooved joint adapters.
a) Where the flanged to grooved joint adapters interfere with the operation of adjacent valves, pumps, or other items, the connection shall be by means of a spool with one end flanged and the other grooved, long enough to prevent interference with adjacent valves, pumps, or other items.

C. Steel pipe lining and coating.
1. General:
a. Except where otherwise specified in the Specifications or indicated on the Drawings, lining and coating for steel pipe shall be as specified in 15052 - Common Work Results for General Piping.
b. Refer to specification 09997 - Pipeline Coatings and Linings for lining and coating requirements.

D. Fabricated steel piping fittings and specials:
1. General: Specified herein are the design and fabrication of fabricated steel piping fittings and specials, which include elbows, branches, nozzles, manifolds, headers, heads, collars, stiffeners, reinforcements, and other steel fabrications relating to steel piping, but shall not include steel pipe.
2. Design:
a. Contractor shall design and detail fittings and specials.
1) Design: In accordance with the recommended procedures in AWWA Manual M11, as complemented and modified in this Section.
2) Nozzles: Reinforced in accordance with recommended practice in AWWA M11, Steel Pipe Manual.

3) Design reinforcing for fittings and specials for the specified test pressure.
4) Fittings shall conform in dimension to AWWA C208, complemented with the provisions specified in this Section.
5) The working stress for steel used for fabrication of pipe shall not exceed 50 percent of the yield stress.

b. The thickness of pipe, large elbows, and headers, except header nozzles, shall be the thicker of:
1) The thickness designed in accordance with the design methods specified in this Section.
2) The thickness indicated on the Drawings or specified in Section 15052 - Common Work Results for General Piping Pipe Schedule, or as required by the Contractor's calculations.
3) The following thicknesses:
a) For pipes smaller than 26 inches in diameter: Minimum 1/4 inch.
b) For pipes 26 inches and larger but less than 38 inches in diameter: Minimum 5/16 inch.
c) For pipes 38 inches and larger in diameter and including 72 inches in diameter: Minimum 3/8 inch.

c. Elbows shall be of the number of pieces as specified in this Section, and thickness of material shall conform to thickness of pipe or manifold shells specified.
d. Ends of fittings to be welded to pipe shall be beveled for welding.

3. Fabrication:
a. Shop fabricate steel piping fittings and specials in units as long as practicable for safe hauling and installation. Minimize number of field welds.
b. Fabricate fittings and specials to uniform lengths with proper end clearance for the specified types of joint or attachment.
c. Fabricate fittings and specials to allow field assembly without cutting or special work.
d. Where specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping or indicated on the Drawings, the inside of fabricated steel manifolds and other fittings and specials shall receive a cement-mortar lining in accordance with AWWA C205.
1) Reinforce lining for piping 24 inches in diameter and larger with wire fabric.
e. Do not weld flanges to nozzles until the nozzles and reinforcements are completely welded to the header.
1) Accurately space and align flanges so that when connections have been made there will be no stress on the header, piping, or equipment. Properly locate and align equipment.

4. Dished heads:
a. Dished heads on 84-inch diameter and smaller manifolds: 1 piece (seamless) spherically dished (torispherical) heads.
1) Larger heads may be seamed.
b. Dish radius: Same dimension as the outside diameter of the head measured at skirt.
c. Skirt face length: Not less than 3 inches.
d. Design heads in accordance with recommended practice in AWWA M11, Steel Pipe Manual.

5. Testing: No shop testing will be required for manifolds or piping connected thereto.

E. Steel pipe, cement-mortar lined and tape wrapped with mortar over coat:
   1. General:
      a. Applicable standards: Cement-mortar lined and tape wrapped with mortar over steel pipe shall conform to the standards specified in General of this Section.
      b. Identification marks: Provide identification marks in accordance with AWWA C200. These marks shall be stenciled or otherwise shown at the top of the piping items exterior, including the following information:
         1) Name or trademark of the manufacturer.
         2) Date of manufacture of the item.
         3) Internal diameter in inches.
         4) Number of the item, sequential from initial to end station.
      c. Diameter designation: The pipe diameter specified in the Specifications and indicated on the Drawings shall be the clear inside diameter after application of the cement-mortar lining with a tolerance of plus 0 inch and minus 1/4 inch.
   2. Design:
      a. Pipe and fittings shall be designed by Contractor.
      b. Design: In accordance with the recommended procedures in AWWA Manual M11, as complemented and modified in this Section.
      c. Thicknesses of pipe, fittings and specials shall be the thicker of:
         1) The thickness designed in accordance with the design methods specified in this Section
         2) The thickness indicated on the Drawings or specified in Section 15052 - Common Work Results for General Piping Pipe Schedule.
         3) The following thicknesses:
            a) For pipes smaller than 26 inches in diameter: Minimum 1/4 inch.
            b) For pipes 26 inches and larger but less than 38 inches in diameter: Minimum 5/16 inch.
            c) For pipes 38 inches and larger in diameter and including 72 inches in diameter: Minimum 3/8 inch.
      d. The working stress for steel used for fabrication of pipe shall not exceed 50 percent of the yield stress.
      e. Break longitudinal and girth seams for straight seam pipe shall be no greater in number than would be required for the fabrication of pipe with 96-inch by 120-inch steel plates.
         1) Break longitudinal seams at the girth seams.
      f. Calculate earth loads using the following formula:

$$W = 192 \times H \times B$$

         wherein the various terms shall have the following meaning:

         W: Earth load, pounds per linear foot of pipe.
         H: Height of fill over the pipe, feet.
         B: Outside diameter of the pipe, feet.
         x: Mathematical symbol for multiplication.

      g. Add AASHTO's H-20 loading to earth loads.

h. Design pipe, fittings and specials for a deflection, under external loads, not to exceed 2 percent of the diameter.
    1) Stiffness computations shall not consider the effect of the cement-mortar lining and coating.
    2) Calculate deflection using the Spangler formula and the following values:
        a) Bedding constant K = 0.100.
        b) Modulus of soil reaction E' = 700 pounds per square inch.
        c) Deflection lag constant D_1 = 1.00.
i. Where piping is designated to be flanged or welded in order to restrain thrust, the design of the cylinder and flange or welded joint shall take into account the effect of stresses caused by thrust loads.
j. Steel cylinder shall be subject to no more than the lesser of 15,000 pounds per square inch or 50 percent of the steel yield stress.

3. Materials:
    a. Cement: ASTM C150, Type II, low alkali.
    b. Gaskets shall be as specified in Section 15052 - Common Work Results for General Piping and meet the following requirements:
        1) Minimum tensile strength, tested in accordance with ASTM D 412, between 2,000 and 2,700 pounds per square inch.
        2) Minimum elongation, tested in accordance with ASTM D 412, between 350 and 400 percent.
        3) Shore A durometer hardness, tested in accordance with ASTM D 2240, between 50 and 65.
        4) Specific gravity, tested in accordance with ASTM D 297, between 0.90 and 1.50.
        5) Maximum compression set, tested in accordance with Method B of ASTM D 395, 20 percent.
        6) Maximum tension strength loss, tested in accordance with ASTM D 573 at 96 hours, 70 degrees Centigrade, in air, 20 percent.
        7) Maximum elongation loss, tested in accordance with ASTM D 573 at 96 hours, 70 degrees Centigrade, in air, 20 percent.
        8) Maximum absorption, tested in accordance with ASTM D 471 at 48 hours, 70 degrees Centigrade, in air, 5 percent.
4. Joints and connections:
    a. Joints:
        1) Except as otherwise specified or indicated on the Drawings, provide lap welded or bell and spigot type joints with rubber gaskets for pipelines 54 inches and smaller.
        2) Butt-strap joints shall be used only where required for closures or where indicated on the Drawings.
        3) The joints furnished shall have the same or higher-pressure rating as the abutting pipe.
    b. Connections:
        1) Connections to existing systems shall be made using a flange isolation joint.
        2) If an existing pipeline or facility does not include a flange at or near the connection point:
            a) An isolation flange shall be placed in the first length of pipe.
            b) A butt-strap joint shall be used to connect the first length of pipe to the existing pipeline.
    c. Bell and spigot joint rings: Rolled Carnegie shape M-3516.

d. Lap welded joints:
    1) Double fillet weld lap welded joints shall be welded on the inside and outside of the joint.
    2) Lap joints prepared for electric field welding shall be in accordance with AWWA C 206.
    3) Joint forming:
        a) Joint geometry and joint field weld will be such that no part of any field weld will be closer than 1 inch to the nearest point of tangency to the bell radius.
        b) Bell ends shall be formed by and expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape.
    4) Faying surfaces of the bell and spigot shall be essentially parallel, but in no case shall the bell slope vary more than 2 degrees from the longitudinal axis of the pipe.
e. Butt-strap joints: Butt-strap joints where used or required, shall be:
    1) A minimum of 10 inches wide.
    2) The same thickness as the pipe wall.
    3) Provide for a minimum of 2-inch lap at each pipe joint.
    4) Double fillet weld each side of joint on the inside and outside of the joint.
f. Flanges: AWWA C207, Class D, steel ring, and as follows:
    1) Match pipe flanges to the valve flanges:
        a) At flanged joints connecting to valves, provide a steel pipe section without rod reinforcing and not less than 24 inches in length.
        b) Apply cement-mortar lining and coating to the steel pipe section.
    2) Flange bolts: As specified in Section 15052 - Common Work Results for General Piping.
    3) Gaskets: As specified in Section 15052 - Common Work Results for General Piping.

5. Fabrication:
    a. Shop coat of primer: Flanges and portions of pipe not covered with cement-mortar shall be given a shop coating of primer.
    b. Bend radii of fittings: Not less than 2.5 times the nominal diameter in accordance with AWWA C208.

PART 3 EXECUTION

3.01 INSTALLATION

A. Joints:
    1. Steel pipe joints shall be screwed, welded, flanged, grooved, or made with flexible joints. The type of joint for piping is indicated on the Drawings.
    2. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, and other types of joints or means necessary to allow ready assembly and disassembly of the piping.
    3. Unless otherwise indicated on the Drawings, pipe joints shall be as follows:
        a. Pipe smaller than 2 inches in nominal diameter shall have screwed joints or flexible couplings.

b. Pipe 2 inches to 4 inches in nominal diameter shall have screwed joints, flanged joints, welded joints, or joints made with flexible couplings.
c. Pipe larger than 4 inches in nominal diameter shall have flanged joints, welded joints, or joints made with flexible couplings.

B. Screwed joints:
1. Perform threading with clean, sharp dies.
a. Wavy, rough, or otherwise defective pipe threads are not acceptable.
2. Make screwed joints tight and clean with an application of Teflon tape or approved paste compound applied to the male threads only, except as follows:
a. Make up liquid and dry chlorine lines, and liquefied petroleum gas lines, with litharge and glycerin.
3. Provide railroad type unions with bronze-to-iron seat, galvanized where used with galvanized pipe.
a. Flanged joints may be used instead of unions.

C. Flanged joints:
1. In flanged joints, flanges shall come together at the proper orientation with no air gaps between the flanges after the gaskets are in place.
2. Attach slip-on flanges to pipe by 2 fillet welds, in accordance with AWWA C207.
3. Secure welding neck flanges with full penetration butt welds without backing rings.
a. After welding in place, the faces of flanges shall be perpendicular to the axis of the pipe, or, in the case of fittings, at the proper angle to each other, and bolt holes shall be in proper alignment.

D. Welded joints:
1. Welded joints shall be electric welded in accordance with AWWA C206.
2. Welders shall be qualified pursuant to the provisions of AWWA C206.
a. Welders' testing shall be at the Contractor's expense, including cost of test nipples, welding rods, and equipment.
3. Do not weld galvanized pipe.

E. Grooved joints:
1. Piping with grooved joints shall be installed where indicated on the Drawings and may be installed in place of flanged piping and screwed piping, except that grooved joint piping shall not be used in the following installations:
a. In underground and underwater installations.
b. In piping subject to test pressures of 150 pounds per square inch gauge, or more.
c. In steam and gas piping.
d. In sludge and scum piping designed to be steam cleaned.
2. Assemble in accordance with manufacturer's published instructions.
3. Support grooved-end pipe in accordance with manufacturer's recommendations. In addition, provide at least 1 support between consecutive couplings.

F. Lining and coating:
1. Coat aboveground and submerged steel pipe as specified in Section 09960 - High-Performance Coatings.

2. Field applied cement-mortar lining shall be of the same density, smoothness, and thickness as shop applied lining, and in accordance to applicable portions of AWWA C602.
3. Plastic tape wrap application procedures shall be in accordance with manufacturer's published instructions.
    a. Apply primer with brush, without runs and drips.
    b. Lap wrapping not less than 1/2-inch. A single wrap lapped 50 percent or more will not be acceptable.
    c. Application on welded joints:
        1) Remove sharp edges of weld spatter and slag with a file or ball peen hammer before wrapping welded joints.
        2) Apply a single thickness of tape base wrap over the primer, around the weld.
        3) Start first wrapping 4 inches back on the pipe wrap, spiral wrap tape over the joint holding the proper tension and overlap, and finish 4 inches back on the pipe wrap on the other side of the joint.
        4) Apply final wrapping in same manner.
    d. Wrap fittings, valves, and other odd shaped components in the pipeline with first and finish wrapping over the prime coat.
    e. Wrap joints, fittings, valves, and other irregular shapes of piping with extruded coatings with tape as specified in this subparagraph.
4. Protect lining of fabricated steel piping fittings and specials during hauling, installation, and operation.
5. Finish joints of fabricated steel piping fittings and specials as specified for pipe lining after field welding is done.
6. After final field welding of fabricated steel piping fittings and specials, complete the lining and exterior painting at and near the welded connections.
    a. Repair or replace lining damaged as a result of welding heat, handling, or other causes.

3.02 FIELD QUALITY CONTROL

A. Testing: Fabricated steel manifolds shall be field tested with the pipe to which they connect.

B. Weld testing: Liquid penetrant testing: As soon as possible after welding of pipeline joints, all fillet welds shall be tested by the liquid penetrant inspection procedure in accordance with ASTM E165 under Method “B” and “Leak Testing”. All defects shall be chipped out, rebelled and retested. Upon retest, the repaired area shall show no leaks or other defects.

C. Holiday detection testing of plastic tape wrap coatings:
    1. Perform a complete high voltage electrical inspection (holiday detection testing) of all steel piping systems and fittings coated with plastic tape wrap prior to burying.
        a. Perform high voltage electrical inspection in strict accordance with NACE RP0274-74.
        b. Test voltage used for the electrical inspection of the piping and fittings shall be in accordance with the recommendations given by the tape coating manufacturer in their published literature.

c. Repair all holidays and defects found in the coating system through the high voltage electrical inspection in strict accordance with the tape coating manufacturer's recommendations.
d. Retest repaired areas in the coating prior to burial of the piping to ensure that all holidays and defects in the coating have been properly repaired.

2. Before conducting holiday detection testing on any piping systems, submit to the Engineer for review and approval technical literature and data describing the testing instrumentation, equipment, electrodes, and other accessories that will be used.
   a. The literature and data shall include complete information covering the operation and use of the testing equipment, including operational voltage ranges.
3. All holiday detection testing and coating repair work shall be witnessed, inspected and approved by the Engineer.

D. Holiday detection testing of extruded coatings:
1. Perform a complete high voltage electrical inspection (holiday detection testing) of all steel piping systems and fittings coated with extruded high-density polyethylene prior to burial of the pipe.
2. Perform the high voltage electrical testing as specified under the preceding paragraph “Holiday Detection Testing of Plastic Tape Wrap Coatings.”

END OF SECTION

SECTION 15956

PIPING SYSTEMS TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Test requirements for piping systems.

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 15052 - Common Work Results for General Piping; 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 01410 - Regulatory Requirements, and UL requirements.
   4. When testing with water, the specified test pressure is considered to be the pressure at the lowest point of the piping section under test.
      a. Lower test pressure as necessary (based on elevation) if testing is performed at higher point of the pipe section.

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 01500 - Temporary Facilities and Controls.

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: Dispose of testing water as directed by the Owner and 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 01330 - Submittal Procedures.

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 gas, air, liquefied petroleum gas, liquid chlorine, and chlorine gas 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 15052 - Common Work Results for General Piping:
   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) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
            a) For concrete piping with rubber gasket joints: 80 gallons per day per inch of diameter per mile of piping under test:
               (1) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
            b) For vitrified clay piping: 500 gallons per day per inch of diameter per mile of piping under test.
            c) 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 be 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 15052 - Common Work Results for General Piping.
   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 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 15958

MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Testing of mechanical equipment and systems.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. S1.4 Specification for Sound Level Meters.

B. Hydraulic Institute (HI).

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

1.03 SUBMITTALS

A. Project closeout documents:
   1. Provide vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 GENERAL

A. Commissioning of equipment as specified in:
   1. This Section.
   2. Section 01756 - Commissioning.
   3. Equipment sections:
      a. If testing requirements are not specified, provide Level 1 Tests.

B. Test and prepare piping as specified in Section 15956 - Piping Systems Testing.

C. Operation of related existing equipment:
   1. Owner will operate related existing equipment or facilities necessary to accomplish the testing.
   2. Schedule and coordinate testing as required by Section 01756 - Commissioning.

D. Provide necessary test instrumentation that has been calibrated within 1 year from date of test to recognized test standards traceable to the NIST or approved source.

1. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for tests.
2. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.

E. Test measurement and result accuracy:
1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments.
a. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
2. Do not adjust results of tests for instrumentation accuracy.
a. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

3.02 VARIABLE SPEED EQUIPMENT TESTS

A. Establish performance over the entire speed range and at the average operating condition.

B. Establish performance curves for the following speeds:
1. The speed corresponding to the rated maximum capacity.
2. The speed corresponding to the minimum capacity.
3. The speed corresponding to the average operating conditions.

3.03 PUMP TESTS, ALL LEVELS OF TESTING

A. Test in accordance with the following:
1. Applicable HI Standards.
2. This Section.
3. Equipment sections.

B. Test tolerances: In accordance with appropriate HI Standards, except the following modified tolerances apply:
1. From 0 to plus 5 percent of head at the specified flows rated design point flow.
2. From 0 to plus 5 percent of flow at the rated design point head.
3. No negative tolerance for the efficiency at the specified flows rated design point.
4. No positive tolerance for vibration limits. Vibration limits and test methods in HI Standards do not apply, use limits and methods specified in this or other Sections of the Specifications.

3.04 DRIVERS TESTS

A. Test motors as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.

B. Test other drivers as specified in the equipment section.

3.05 NOISE REQUIREMENTS AND CONTROL

A. Perform noise tests in conjunction with vibration test analysis.

B. Make measurements in relation to reference pressure of 0.0002 microbar.

C. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.

D. Set sound level meter to slow response.

E. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.

F. Noise test normally not applicable to a submersible.

3.06 PRESSURE TESTING

A. Hydrostatically pressure test pressure containing parts at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher.

3.07 INSPECTION AND BALANCING

A. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits.

B. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.

C. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.

D. Critical speed of rotating equipment:
   1. Satisfy the following:
      a. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, all non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment's maximum operating speed.
      b. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall at least 25 percent below the equipment's lowest operating speed.
      c. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.

E. Vibration tests:
   1. Definitions:
      a. Root mean square: for pumps operating at speeds greater than 600 rpm, the vibration measurement shall be measured as the overall velocity in inches per second root mean square (RMS).
      b. Peak-to-peak displacement: The root means squared average of the peak-to-peak displacement multiplied by the square root of 2.
      c. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.

d. Peak acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.
e. High frequency enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectrum of acceleration versus frequency.
    1) Manufacturers: One of the following or equal:
        a) Rockwell Automation, Entek Group, "Spike Energy" analysis.
        b) CSI, "PeakVue."
f. Rotor bar pass frequency (RBF), for detecting loose rotor bars.
g. Low speed equipment: Equipment or components of equipment rotating at less than 600 revolutions per minute.
h. High speed equipment: Equipment and equipment components operating at or above 600 revolutions per minute.
i. Preferred operating range: Manufacturer's defined preferred operating range (POR) for the equipment.
j. Allowable operating range: Manufacturer's defined allowable operating range (AOR) for the equipment.

2. Vibration instrumentation requirements:
    a. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12-bit A/D converter, fast fourier transform circuitry, phase measurement capability, time wave form data storage, high-frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles per minute, adjustable fast fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra, data output port, circuitry for integration of acceleration data to velocity or double integration to displacement.
        1) Manufacturers: One of the following or equal:
            a) Computational Systems Inc., (CSI) Division of Emerson Process Management, Model 2120A, Data Collector/analyzer with applicable analysis software.
            b) Pruftechnik, VIBXPERT II.
    b. Analyzer settings:
        1) Units: English, inches/second, mils, and gravitational forces.
        2) Fast fourier transform lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 revolutions per minute; 3,200 lines minimum for High Frequency Enveloping; 1,600 lines minimum for low speed equipment.
        3) Sample averages: 4 minimum.
        4) Maximum frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
        5) Amplitude range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
        6) Fast fourier transform windowing: Hanning Window.
        7) High pass filter: Minus 3 dB at 120 cycles per minute for high speed equipment. Minus 3 dB at 21 cycles per minute for low speed equipment.
    c. Accelerometers:
        1) For low speed equipment: Low frequency, shear mode accelerometer, 500 millivolts per gravitational force sensitivity,

10 gravitational force range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount.

a) Manufacturers: One of the following or equal:
(1) Wilcoxon Research, Model 797L.
(2) PCB, Model 393C.

2) For high speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder.

a) Manufacturers: One of the following or equal:
(1) Wilcoxon Research, Model 793.
(2) Entek-IRD Model 943.

3. Accelerometer mounting:
   a. Use magnetic mounting or stud mounting.
   b. Mount on bearing housing in location with best available direct path to bearing and shaft vibration.
   c. Remove paint and mount transducer on flat metal surface or epoxy mount for High Frequency Enveloping measurements.
4. Vibration acceptance criteria:
   a. Testing of rotating mechanical equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.
   b. Vibration displacement limits: Unless otherwise specified, equipment operating at speeds 600 revolutions per minute or less is not to exhibit unfiltered readings in excess of following:

Operating Conditions and Application Data	Overall Peak-to-Peak Displacement	
	Field, mils	Factory, mils
Operation within the POR	3.0	4.0
Operation within the AOR	4.0	5.0
Additive value when measurement location is greater than 5 feet above foundation.	2.0	2.0
Additive value for solids-handling pumps	2.0	N/A
Additive value for slurry pumps	2.0	N/A

   c. Vibration velocity limits: Unless otherwise specified, equipment operating at speeds greater than 600 revolutions per minute is not to exceed the following peak velocity limits:

HI Pump Type	Horsepower	Field Test	Factory Test
		Overall RMS	Overall RMS
Horizontal Solids Handling Centrifugal Pumps	Below 33 hp	0.25	0.28

HI Pump Type	Horsepower	Field Test	Factory Test
		Overall RMS	Overall RMS
Horizontal and Vertical In-Line Centrifugal Pumps (other than Non-Clog type) Vertical Solids Handling Centrifugal Pumps	Between 33 and 100 hp	0.28	0.31
	100 hp and above	0.31	0.34
	Below 33 hp	0.30	0.33
Vertical Turbine, Mixed Flow, and Propeller Pumps (solids-handling type pumps)	Between 33 and 100 hp	0.32	0.35
	100 hp and above	0.34	0.35
Non-Solids Handling Centrifugal Pumps HI Types BB1, BB2, BB3, BB4, BB5, OH1, OH2, OH3, OH4, OH5, and OH7	Below 268 hp	0.15	0.19
	268 hp and above	0.19	0.22
Vertical Turbine, Mixed Flow, and Propeller Pumps HI Types VS1, VS2, VS3, VS4, VS5, VS6, VS7, and VS8	Below 268 hp	0.13	
	268 hp and above	0.17	
Slurry Pumps		0.25	0.30
Motors		See Applicable Motor Specification	See Applicable Motor Specification
Gear Reducers, Radial		Not to exceed AGMA 6000-B96 limits	Not to exceed AGMA 6000-B96 limits
Other Reducers, Axial		0.1	N/A

d. Equipment operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.

e. Additional criteria:

1) No narrow band spectral vibration amplitude components, whether sub-rotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without manufacturer's detailed verification of origin and ultimate effect of such excitation.

2) The presence of discernable vibration amplitude peaks in Test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.

3) For motors, the following shall be cause for rejection:
   a) Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that is more than 40 percent of the peak at rotational frequency.
   b) Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.
   c) Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around 2 times the rotor bar pass frequency.
   d) Phasing problems evidenced by 1/3 line frequency side band spectral peaks around the 2 times electrical line frequency peak.
4) The presence of peaks in a High Frequency Enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high frequency envelope analysis repeated.

5. Vibration testing results presentation:
   a. Provide equipment drawing with location and orientation of measurement points indicated.
   b. For each vibration measurement take and include appropriate data on equipment operating conditions at the time vibration data is taken; for pumps, compressors, and blowers record suction pressure, discharge pressure, and flow.
   c. When Vibration Spectra Data required:
      1) Plot peak vibration velocity versus frequency in cycles per minute.
      2) Label plots showing actual shaft or part rotation frequency, bearing inner and outer race ball pass frequencies, gear mesh frequencies and relevant equipment excitation frequencies on the plot; label probable cause of vibration peaks whether in excess of specification limits or not.
      3) Label plots with equipment identification and operating conditions such as tag number, capacity, pressure, driver horsepower, and point of vibration measurement.
      4) Plot motor spectra on a log amplitude scale versus frequency.
   d. For low speed equipment, plot peak vibration displacement versus frequency as well as velocity versus frequency.
   e. Provide name of manufacturer and model number of the vibration instrumentation used, including analyzer and accelerometer used together with mounting type.

3.08 TESTING LEVELS

A. Level 1 Tests:
   1. Level 1 General Equipment Performance Test:
      a. For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.
      b. Operate at rated design load conditions.

c. Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

2. Level 1 Pump Performance Test:
   a. Measure flow and head while operating at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
   b. 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 16222 - Low Voltage Motors up to 500 Horsepower or the applicable equipment section. Use actual driver for field tests.
   c. Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.
3. Level 1 Vibration Test:
   a. Test requirement:
      1) Measure filtered vibration spectra versus frequency in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component.
      2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
   b. Equipment operating condition: Test at specified maximum speed.
4. Level 1 Noise Test:
   a. Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.

B. Level 2 Tests:
1. Level 2 General Performance Test:
   a. For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
   b. Operate at rated design load conditions.
   c. Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
2. Level 2 Pump Performance Test:
   a. Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
   b. 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 16222 - Low Voltage Motors up to 500 Horsepower. Use actual driver for field tests.
   c. 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.

d. Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.

3. Level 2 Vibration Test:
   a. Test requirement:
      1) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
      2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
   b. Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.
   c. Natural frequency test of field installed equipment:
      1) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears, and supports.
      2) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.
      3) Perform with equipment and attached piping full of intended service or process fluid.
4. Level 2 Noise Test:
   a. Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at 3 feet horizontally from the surface of the equipment at mid-point height of the noise source.

C. Level 3 Tests:
1. Level 3 General Equipment Performance Tests:
   a. For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
   b. Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
   c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.
   d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
   e. Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.
2. Level 3 Pump Performance Test:
   a. Test 4 hours minimum for flow and head at or near the rated condition; for factory testing, testing may be at a reduced speeds with flow and head

corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.

b. 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 16222 - Low Voltage Motors up to 500 Horsepower. Use actual driver for field tests.

c. 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.

d. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.

3. Level 3 Vibration Test:

a. Requirements: Same as Level 2 vibration test except data taken at each operating condition tested and with additional requirements below.

b. Perform High Frequency Enveloping Analysis for gears and bearings.

1) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a smooth surface and direct path to the bearing to detect bearing defects.

2) Report results in units of acceleration versus frequency in cycles per minute.

c. Perform Time Wave Form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).

d. Plot vibration spectra on 3 different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.

4. Level 3 Noise Test: Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at 4 locations approximately 90 degrees apart in plain view; report results for each of 8 octave band mid-points beginning at 63 hertz.

D. Level 4 Tests:

1. Level 4 General Equipment Performance Test:

a. For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.

b. Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.

c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.

d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings, using appropriate test

instrumentation to confirm equipment meets specified performance requirements at the design rated condition.

e. Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.

2. Level 4 Pump Performance Test:
   a. Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test with furnished motor at full speed.
   b. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
   c. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.
   d. Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
   e. Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
      1) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
      2) Perform efficiency testing with test fluids at maximum rated speed.
      3) Perform priming time testing with test fluids at maximum rated speed.
3. Level 4 Vibration Test: Same as Level 3 vibration test.
4. Level 4 Noise Test: Same as Level 3 Noise Test except with data taken at each operating condition tested.

END OF SECTION

SECTION 16050

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

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

B. Interfaces to equipment, instruments, and other components:
   1. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers.
   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.
   4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:
      a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
   5. Loop drawings:
      a. Provide all electrical information required in the preparation of loop drawings including, but not limited to:
         1) Conduit numbers and associated signal(s) contained within each conduit.
         2) Wire numbers.
         3) Equipment terminal numbers.
         4) Junction boxes and signal(s) contained within each junction box.
         5) Equipment power sources, and associated circuit numbers.
         6) As-built drawings detailing wiring.

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

D. Contract Documents:
   1. General:
      a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.
   2. Specifications:
      a. The General and Supplementary Conditions of the Contract Documents govern the Work.
      b. These requirements are in addition to all General Requirements.
   3. Contract Drawings:
      a. The Electrical Drawings show desired locations, arrangements, and components of the Electrical Work in a diagrammatic manner.
      b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work to ensure the best possible installation:
         1) The equipment locations and dimensions indicated on the Drawings are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
         2) The Contractor has the freedom to select any of the named manufacturers identified in the individual specification sections; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
      c. Installation details:
         1) The Contract Drawings include typical installation details the Contractor is to use to complete the Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
         2) Not all typical installation details are referenced within the Drawing set. Apply and use typical details where appropriate.
      d. Schematic diagrams:
         1) All controls are shown de-energized.
         2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
         3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
         4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
         5) Schematic diagrams are to be used in conjunction with the descriptive operating sequences in the Contract Documents. Combine all information and furnish a coordinated and fully functional control system.

1.02 REFERENCES

A. Code compliance:
   1. As specified in Section 01410 - Regulatory Requirements.
   2. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.
   3. The standards listed are hereby incorporated into this Section.
      a. American National Standards Institute (ANSI).
      b. American Society of Civil Engineers (ASCE):
         1) ASCE 7 - Minimum Design Loads for Buildings and Other Structures.
      c. ASTM International (ASTM).
      d. Illuminating Engineering Society (IES).
      e. Institute of Electrical and Electronics Engineers (IEEE).
      f. Insulated Cable Engineers Association (ICEA).
      g. International Code Council (ICC):
         1) International Code Council Evaluation Service (ICC-ES).
            a) AC 156 - Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).
      h. International Society of Automation (ISA).
      i. National Electrical Manufacturers Association (NEMA):
         1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
      j. National Fire Protection Association (NFPA):
         1) 70 - National Electrical Code (NEC).
      k. National Institute of Standards and Technology (NIST).
      l. Underwriters' Laboratories, Inc. (UL).

1.03 DEFINITIONS

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

B. Specific definitions:
   1. FAT: Factory acceptance test.
   2. ICSC: Instrumentation and controls subcontractor.
   3. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
   4. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
   5. PCIS: Process control and instrumentation system.
   6. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.

7. Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
8. Spare: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that physically contains a device with no load connections to be made.
9. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
10. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.04 SYSTEM DESCRIPTION

A. General requirements:
1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from:
   a. The Electrical Drawings are schematic in nature; use the Structural, Architectural, Mechanical, and Civil Drawings for all dimensions and scaling purposes.
2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work.
4. Coordinate all aspects of the Work with the electrical subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the electrical subcontractor, the other subcontractors or suppliers.
5. Demolition:
   a. Where demolition is specified or indicated on the Drawings, disconnect all associated electrical equipment and render the equipment safe.
   b. Remove and dispose of all conduit, wire, electrical equipment, controls, etc. associated with the items and/or areas to be demolished as indicated on the Drawings unless otherwise indicated.
   c. Salvage electrical equipment as specified in Section 01738 - Selective Alterations and Demolition.
   d. For each piece of equipment to be removed, remove all ancillary components (e.g. instruments, solenoid valves, disconnect switches, etc.).
   e. Conduit:
      1) Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:
         a) Remove exposed conduit to the point of encasement or burial.

b) Cut conduit flush and plug or cap encased or buried conduit.
2) Where conduits are to remain in place and removal is not indicated on the Drawings:
a) Cap conduit open ends.
b) Re-label empty conduits as spare.
f. Remove all wire back to the source for all conduits to be removed or abandoned in place.
g. Provide new nameplates for modified electrical distribution equipment, motor control centers etc. to identify equipment and circuits that are no longer used as spares.
h. Provide new typewritten schedules for all modified panelboards.
6. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
b. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.
7. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation:
a. As specified in the Contract Documents.
8. Defective work:
a. Repair or replace all defective work as directed by the Engineer.

B. Operating facility:
1. As specified in Section 01140 - Work Restrictions.
2. Portions of this facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction schedule to meet the requirements of the Owner. All changes in schedule and any needs to reschedule are included in the Work.
b. As weather and water demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
c. Coordinate the construction and power renovation, bear all costs, so that all existing facilities can continue operation throughout construction.
3. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
4. The standards of documentation, instrument tagging, cable and conductor ferruling, terminal identification and labeling that apply to the new installation apply equally to the existing installation which forms part of the modified system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330 - Submittal Procedures and this Section.

B. General:
   1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
   2. Furnish the submittals required by each section in the Electrical Specifications.
   3. Adhere to the wiring numbering scheme specified in Section 16075 - Identification for Electrical Systems throughout the Project:
      a. Uniquely number each wire.
      b. Wire numbers must appear on all Equipment Drawings.
   4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

C. Seismic requirements:
   1. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads based on the seismic design criteria in Section 01612 - Seismic Design Criteria.
   2. For equipment installed in structures designated as seismic design category C, D, E or F, prepare and submit the following:
      a. Statement of seismic qualification, and special seismic certification:
         1) "Statement of seismic qualification:" Provide manufacturer's statement that the equipment satisfies the seismic design requirements of the building code indicated in Section 01410 - Regulatory Requirements, including the requirements of ASCE 7, Chapter 13.
         2) "Special seismic certification:" Provide manufacturer's certification that the equipment, when subjected to shake table testing in accordance with ICC-ES AC 156, meets the "Post-Test Functional Compliance Verification" requirements of ICC-ES AC 156 for "Components with Ip = 1.5." Compliance shall include both operability and containment of hazardous materials as appropriate to the unit being tested.
      b. Substantiating test data: With seismic qualification and special seismic certification statements, submit results of testing in accordance with ICC-ES AC 156.
      c. Anchoring design calculations and details:
         1) Submit project-specific drawings and supporting calculations, prepared and sealed by a professional engineer licensed in the state where the Project is being constructed, and showing details for anchoring electrical equipment to its supports and for anchoring supports provided with the equipment to the structure. Prepare calculations in accordance with the requirements of Section 01612 - Seismic Design Criteria.
   3. Exemptions: A "statement of seismic qualification" and a "special seismic certification" are not required for the following equipment:
      a. Temporary or moveable equipment.
      b. Equipment anchored to the structure and having a total weight of 20 pounds or less.
      c. Distribution equipment anchored to the structure and having a total unit weight of 3 pounds per linear foot, or less.

D. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Data.

2. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before Functional Acceptance Testing.

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

F. Schedule of values:
   1. In addition to completing all items referred to in the schedule of values, Section 01292 - Schedule of Values, submit per unit material and labor costs used in developing the final bid for the electrical system, for the express purpose of pricing and cost justification for any proposed change orders. In addition to the items shown on the schedule of values, provide per unit material and labor costs for conduit and wire installation for specific types, sizes, and locations as indicated on the Drawings and Conduit Schedule. It is the responsibility of the electrical subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.

G. Roof penetrations:
   1. Submit details of all portions of the electrical installation that penetrate the roof. Include details showing support of the penetrating component, and the sealing means to be utilized.

H. Record Documents:
   1. Furnish as specified in Section 01770 - Closeout Procedures.

I. Test reports:
   1. As specified in Section 01330 - Submittal Procedures.
   2. Additional requirements for field acceptance test reports are specified in Sections 01756 - Commissioning and 16950 - Field Electrical Acceptance Tests.

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

1.06 QUALITY ASSURANCE

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

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements.

1.08 PROJECT OR SITE CONDITIONS

A. Site conditions:
   1. Provide an electrical, instrumentation and control system, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
   2. Seismic load resistance:
      a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612 - Seismic Design Criteria.
   3. Wind load resistance:
      a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site wind loads as specified in Section 01614 - Wind Design Criteria.
   4. Altitude, temperature and humidity:
      a. As specified in Section 01610 - Project Design Criteria.
      b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating factors applied.
      c. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer's guidelines:
         1) Provide all power conduits wiring for these devices (e.g. heaters, fans, etc.) whether indicated on the Drawings or not.
   5. Site security:
      a. Abide by all security and safety rules concerning the Work on the Site, as specified in Sections 01329 - Safety Plan and 01500 - Temporary Facilities and Controls.

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

5. Plant area Electrical Work requirements:
   a. 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
WASH WATER RECYCLE PUMP STATION #1	NEMA 1	GRC	C	Galvanized Steel
WASH WATER RECYCLE PUMP STATION #2	NEMA 4X	GRC	W/D	Stainless Steel
EXTERIOR LOCATIONS	NEMA 4X	PCS	W/D	Stainless Steel

6. Modify exposed conduit runs as specified in Section 16130 - Conduits.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. General:
   1. As specified in Sections 01312 - Project Meetings and 01756 - Commissioning.
   2. Testing requirements are specified in Section 01756 - Commissioning, 16950 - Field Electrical Acceptance Tests and other sections.
   3. Work restrictions and other scheduling requirements are specified in Section 01140 - Work Restrictions.
   4. Commissioning requirements as specified in Section 01756 - Commissioning.

1.11 WARRANTY (NOT USED)

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.

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

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

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

PART 3 EXECUTION

3.01 EXAMINATION

A. The electrical subcontractor is encouraged to visit the site to examine the premises completely before bidding.

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

C. Comply with pre-bid conference requirements.

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

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

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

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

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

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

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

F. 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.
   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 16075 - Identification for Electrical Systems.

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

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. For Owner and Engineer witnessed FAT:
   1. Contractor is responsible for the Owner's and Engineer's costs associated with FAT as specified in Section 01756 - Commissioning.

C. Owner training:
   1. As specified in Section 01756 - Commissioning and in this Section.
   2. Provide source testing and owner training on electrical equipment as defined in the table below:

Table1: Source Testing and Owner Training Requirements:

Section Number	Section Title	Source Testing	Owner Training Requirements	
		(Witnessed or Non-witnessed)	Maintenance (hrs per session)	Operation (hrs per session)
16264	Variable Frequency Drives 60 - 500 Horsepower	Witnessed	16	16

3.08 FIELD QUALITY CONTROL

A. Inspection:
   1. Allow for inspection of electrical system installation as specified in Section 01450 - Quality Control.

2. Provide any assistance necessary to support inspection activities.
3. Engineer inspections may include, but are not limited to, the following:
    a. Inspect equipment and materials for physical damage.
    b. Inspect installation for compliance with the Drawings and Specifications.
    c. Inspect installation for obstructions and adequate clearances around equipment.
    d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
    e. Inspect equipment nameplate data to verify compliance with design requirements.
    f. Inspect raceway installation for quality workmanship and adequate support.
    g. Inspect cable terminations.
4. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in Section 16950 - Field Electrical Acceptance Tests.

B. Field acceptance testing (Functional Testing):
1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
2. Perform the field acceptance tests as specified in Section 16950 - Field Electrical Acceptance Tests.
3. Record results of the required tests along with the date of test:
    a. Use conduit identification numbers to indicate portion of circuit tested.

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

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 01770 - Closeout Procedures.

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

C. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust or other matter before energization of the equipment or system start-up:
1. Use of compressors or air blowers for cleaning is not acceptable.

D. Clean and re-lamp all new and existing luminaries that were used in the areas affected by the construction.

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

3.11 PROTECTION

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

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

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16070

HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

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

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Conform to the requirements of the Building Code as specified in Section 01410 - Regulatory Requirements.
   2. Demonstrate the following using generally accepted engineering methods:
      a. That the anchors to the structure are adequate to resist the loads generated in accordance with the Building Code and equipment requirements.
      b. That the required load capacity of the anchors can be fully developed in the structural materials to which they are attached.
   3. Design loading and anchoring requirements:
      a. As indicated in the Building Code unless otherwise specified.
      b. Seismic loading requirements:
         1) Freestanding, suspended or wall-hung equipment shall be anchored in place by methods that will satisfy the requirements for the seismic design specified in Section 16050 - Common Work Results for Electrical.
      c. Wind loading requirements:
         1) All exterior equipment shall be anchored in place by methods that will satisfy the requirements for wind design specified in Section 16050 - Common Work Results for Electrical.
      d. Minimum safety factor against overturning: 1.5.

e. The foundation and structures to which hangers and supports are attached shall be capable of withstanding all anchor loads.

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

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

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

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

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

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM STARTUP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Preformed channel:
      a. Thomas & Betts.
      b. Power-Strut.
      c. Unistrut.
      d. Cooper B-Line.
      e. Robroy.
      f. Tyco.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Use materials appropriate for the area as specified in Section 16050 - Common Work Results for Electrical.

B. Preformed channel:
   1. Hot dip galvanized steel:
      a. Supports:
         1) In accordance with ASTM A123 or A153.
         2) Minimum zinc coating thickness of 2.5 mils.
      b. Hardware:
         1) Electro-galvanized.
         2) In accordance with ASTM A153.
   2. Stainless steel:
      a. Supports:
         1) In accordance with ASTM A240.
         2) ANSI Type 316 material.

b. Hardware:
    1) ANSI Type 316 material.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Anchor bolts:
    1. As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Paint and finish all supporting structures as specified in Section 09960 - High-Performance Coatings.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Preformed Channel:
    1. Mount all raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated racks unless otherwise indicated on the Drawings.
        a. Provide the necessary sway bracing to keep trapeze type structures from swaying under seismic events or wind loading.
    2. Brace and anchor freestanding equipment supports using methods that provide structural support based on the seismic loads and wind loads:
        a. Lateral deflection at top of supports not to exceed support height divided by 240 unless otherwise approved by the Engineer.
    3. Provide fabricated steel support pedestals for wall mounted panels that weigh more than 200 pounds:
        a. Fabricate pedestals out of welded angle, tube sections, or preformed channel.
        b. If the supported equipment is a panel or cabinet, match the supported equipment in physical appearance and dimensions.

c. Provide auxiliary floor supports for transformers hung from stud walls and weighing more than 200 pounds.

4. Mount all equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel.
    1) Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.
5. Corrosion protection:
    a. Isolate dissimilar metals, except where required for electrical continuity.
        1) Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.
6. Raceway:
    a. Furnish all racks and trapeze structures needed to support the raceway from the structure.
        1) Group raceway and position on racks to minimize crossovers.
        2) Provide the necessary bracing to keep trapeze type structures from swaying under loads from cable installation, seismic forces, or wind forces.
7. Anchoring methods:
    a. Solid concrete: Anchor bolts, anchor rods or post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
    b. Metal surfaces: Machine screws or bolts.
    c. Hollow masonry units: Post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
8. Recoat or seal all drilled holes, cut or scratched surfaces or with products recommended by the manufacturer.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16075

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

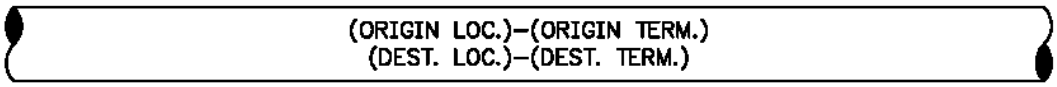
1.04 SYSTEM DESCRIPTION

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

B. Wire numbers:
   1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
      a. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
      b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
      c. Internal panel wires on a common terminal shall have the same wire number.
      d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:
         1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers in Section 16130 - Conduits.

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

OR



Where:

ORIGIN LOC .= Designation for originating panel or device
ORIGIN TERM. = Terminal designation at originating panel or device
DEST. LOC. = Designation for destination panel or device
DEST. TERM. = Terminal designation at destination panel or device or PLC I/O address at destination panel:

a. Identify equipment and field instruments as the origin.
b. PCMs are always identified as the destination.
c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g. T1, T2, T3, etc.).
f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen-Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):
    1) Discrete Point: W:X:Y/Z.
       Analog Point: W:X:Y.Z.
       Where:
       W= I for input, O for output
       X= PLC number (1, 2, 3…)
       Y= Slot number (01, 02, 03…)
       Z= Terminal number (00, 01, 02…) for a discrete point or a word number for an analog point (1, 2, 3…)
g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g. C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g. C0010A).

3. **Case 1**: 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

4. **Case 2**: 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

5. **Case 3** 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

6. **Case 4**: 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

7. 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 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
1. Nameplates:
a. Color.
b. Size:
1) Outside dimensions.
2) Lettering.
c. Material.
d. Mounting means.
2. Nameplate schedule:
a. Show exact wording for each nameplate.
b. Include nameplate and letter sizes.
3. Wire numbers:
a. Manufacturer’s catalog data for wire labels and label printer.

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

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

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

C. Conduit and raceway markers:
   1. Non-metallic, 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. Colors:
      a. Warning nameplates: White-center, red face.
      b. Other nameplates: Black-center, white face.
   2. Laminated plastic engraving stock:
      a. 3/32-inch thick material.
      b. 2-ply.
      c. With chamfered edges.
   3. Block style engraved characters of adequate size to be read easily from 6 feet:
      a. No characters smaller than 1/8-inch in height.

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

C. Conductor and cable markers:
   1. Machine printed black characters on white tubing.
   2. 10-point type or larger.

D. Conduit and raceway markers:
   1. 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 16050 - Common Work Results for Electrical.

B. Nameplates:
   1. Attach nameplates to equipment with rivets, bolts or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
   2. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 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:
a. Conduit markings shall match the conduit schedule.
2. Mark conduits at the following locations:
a. Each end of conduits that are greater than 10 feet in length.
b. The middle of conduits that are 10 feet or less in length.
c. Where the conduit penetrates a wall or structure.
d. Where the conduit emerges from the ground, slab, etc.
3. Mark conduits after the conduits have been fully painted.
4. Position conduit markers so that they are easily read from the floor.
5. Attach non-metallic conduit markers with nylon cable ties:
a. Provide ultraviolet resistant cable ties for conduit markers exposed to direct sunlight.
6. 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 permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
a. Fasten warning signs with round head stainless steel screws or bolts.
b. Locate and mount in a manner to be clearly legible to operations personnel.
2.
3. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

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

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16123

600-VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

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

C. CSA International (CSA).

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

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

F. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
   1. 568-C.2 - Balanced Twisted-Pair Telecommunication Cabling and Components Standard.
   2. 569-B - Commercial Building Standards for Telecommunications Pathways and Spaces.
   3. 1005 - Industrial Cabling Standard.

G. Underwriter's Laboratories Inc., (UL):
   1. 83 - Standard for Safety Thermoplastic-Insulated Wires and Cables.
   2. 1277 - Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
   3. 1424 - Standard for Cables for Power-Limited Fire-Alarm Circuits.
   4. 1569 - Standard for Metal-Clad Cables.
   5. 2196 - Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control, and Data Cables.
   6. 2225 - Standard for Cables and Cable-Fittings for Use in Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions and abbreviations:
   1. AWG: American wire gauge.
   2. BCCS: Bare copper-covered steel.
   3. CPE: Chlorinated polyethylene.
   4. FEP: Fluorinated ethylene propylene.
   5. FHDPE: Foam high-density polyethylene.
   6. FPE: Foam polyethylene.
   7. OD: Outside diameter.
   8. PVC: Polyvinyl chloride.
   9. THWN: Moisture and heat resistant thermoplastic.

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

1.04 SYSTEM DESCRIPTION

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

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

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

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

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

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

b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

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

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER`S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

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

2.04 MANUFACTURED UNITS

A. General:
   1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
   2. Permanently mark each wire and cable with the following at 24-inch intervals:
      a. AWG size.
      b. Voltage rating.
      c. Insulation type.
      d. UL symbol.
      e. Month and year of manufacture.
      f. Manufacturer's name.
   3. Identify and mark wire and cable as specified in Section 16075 - Identification for Electrical Systems:
      a. Use integral color insulation for #2 AWG and smaller wire.
      b. Wrap colored tape around cable larger than #2 AWG.

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

C. Instrumentation class cable:
   1. Type TC.
   2. Suitable for use in wet locations.
   3. Voltage rating: 600 volts.
   4. Temperature rating:
      a. 90-degree Celsius rating in dry locations.
      b. 75-degree Celsius rating in wet locations.
   5. Conductors:
      a. Insulation:
         1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
      b. #16 AWG stranded and tinned.

c. Color code: ICEA Method 1:
1) Pair: Black and white.
2) Triad: Black, white and red.
3) Multiple pairs or triads:
a) Color-coded and numbered.

6. Drain wire:
a. #18 AWG.
b. Stranded, tinned.
7. Jacket:
a. Flame retardant, moisture and sunlight resistant PVC.
b. Ripcord laid longitudinally under jacket to facilitate removal.
8. Shielding:
a. Individual pair/triad:
1) Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
b. Multiple pair or triad shielding:
1) Group shield: Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
2) Completely isolate group shields from each other.
3) Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
c. All shielding to be in contact with the drain wire.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

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

B. Wire markers:
1. As specified in Section 16075 - Identification for Electrical Systems.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

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

B. Test Type THWN in accordance with the requirements of UL 83.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Color-coding:
   1. Color-coding shall be consistent throughout the facility.
   2. The following color code shall be followed for all 240/120 volt and 208/120 volt systems:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
      d. Single phase system: Black for 1 hot leg, red for the other.
      e. Neutral: White.
      f. High phase or wild leg: Orange.
      g. Equipment ground: Green.
   3. The following color code shall be followed for all 480/277 volt systems:
      a. Phase A: Brown.
      b. Phase B: Orange.
      c. Phase C: Yellow.
      d. Neutral: Gray.
      e. Equipment ground: Green.
   4. The following color code shall be followed for all 120 VAC control wiring:
      a. Power: Red.
      b. Neutral: White.
   5. The following color code shall be followed for all general purpose DC control circuits:
      a. Grounded conductors: White with blue stripe.
      b. Ungrounded conductors: Blue.
   6. Wires in intrinsically safe circuits shall be light blue.
   7. 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. Cable pulling:
   1. Prevent mechanical damage to conductors during installation.
   2. For cables #1 AWG and smaller, install cables by hand.

3. For cables larger than #1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.
5. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.
6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer's recommendation for the specified cable size:
    a. Make splices in manholes or pull boxes only.
    b. Leave sufficient slack to make proper connections.

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

F. 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.

G. 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.

H. Splices:
1. Provide continuous circuits from origin to termination whenever possible:
    a. Obtain Engineer's approval prior to making any splices.
2. Lighting and receptacle circuit conductors may be spliced without prior approval from the Engineer.
3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
    a. Splice box NEMA rating requirements as specified in Section 16050 - Common Work Results for Electrical.
    b. Make splices in labeled junction boxes for power conductors.
    c. Make splices for control and instrument conductors in terminal boxes:
        1) Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.
4. Power and control conductors routed in common raceways may be spliced in common junction boxes.
5. Clearly label junction and terminal boxes containing splices with the word "SPLICE LOCATED WITHIN".
6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:
    a. In NEMA Type 4 or NEMA Type 4X areas, provide heat-shrink sleeves that are listed for submersible applications.

8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
    a. A heat shrink insulating system listed for submersible applications.
    b. Or an epoxy resin splicing kit.

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

J. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material.

K. 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:
    a. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
    b. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
    c. Terminate the signal cable shield on a dedicated grounding terminal block.

L. Wiring allowances:
1. Equipment locations may vary slightly from the drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
2. Locations for pull boxes, manholes, and duct banks may vary slightly from the drawings. Include an allowance for necessary conductors and related materials to provide conductors to all pull boxes, manholes and duct banks within 20 linear feet of locations indicated on the Drawings.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16130

CONDUITS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. American National Standards Institute (ANSI):
   1. C80.1 - Electrical Rigid Steel Conduit.
   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, 80, Type EB and A 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 16050 - Common Work Results for Electrical.

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

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

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

C. Shop drawings:
   1. Detail the intended routing of each conduit, conduit material and include supporting methods.
   2. Number conduits in accordance with the Contract Documents.
      a. Provide conduit labels as specified in Section 16075 - Identification for Electrical Systems.

D. Certifications:
   1. Furnish PVC-coated conduit manufacturer's certification for each installer.

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

1.05 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

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

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

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Do not expose non-metallic conduit to direct sunlight.

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

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 SEQUENCING

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

1.09 SCHEDULING (NOT USED)

1.10 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.11 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

B. PVC-coated rigid steel conduit:
   1. One of the following or equal:
      a. Robroy Ind.
      b. Ocal, Inc.
      c. Calbond.
      d. Allied.
      e. NEC, Inc. BlackGuard.

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

D. Rigid nonmetallic PVC conduit:
   1. One of the following or equal:
      a. Carlon.
      b. Cantex.
      c. Triangle Conduit and Cable.

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

F. Joint compound:
   1. The following or equal:
      a. Thomas and Betts.

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

H. PVC-coated rigid steel conduit expansion fittings:
   1. One of the following or equal:
      a. Ocal, Inc.
      b. Robroy Ind.
      c. NEC, Inc. BlackGuard.

I. Conduit hangers and supports:
   1. As specified in Section 16070 - Hangers and Supports.

2.02 SYSTEM DESCRIPTION

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

2.03 EXISTING PRODUCTS (NOT USED)

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

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

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

g. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
    1) The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
    2) The sleeve shall provide a vapor- and moisture resistant seal at every connection.

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

2.08 ACCESSORIES

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

B. Insulated throat metallic bushings:
1. Construction:
    a. Malleable iron or zinc-plated steel when used with steel conduit
    b. Positive metallic conduit end stop.
    c. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.

d. Use fully insulated bushings on nonmetallic conduit system made of high-impact 150 degrees Celsius rated non-combustible thermosetting phenolic.

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

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

F. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
   1. Construction:
      a. Insulated throat.
      b. PVC-coated when used in corrosive areas.
      c. Bonding locknut.
      d. Recessed neoprene o-ring to ensure watertight and dusttight connector.
      e. 1/2-inch through 1-1/4-inch steel zinc electroplated.
      f. 1-1/2-inch through 6-inch malleable iron zinc plated.

2. Usage:
    a. All conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.

G. 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.

H. 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.
    e. PVC-coated when used with Type PCS.

I. Conduit markers:
1. As specified in Section 16075 - Identification for Electrical Systems.

2.09 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. General:
1. Conduit routing:
a. The electrical drawings are diagrammatic in nature:
1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
b) Make changes in conduit routing due to the relocation of equipment.
3) The electrical drawings do not indicate all required junction boxes and pull boxes:
a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
(1) To meet cable manufacturer's pulling tension requirements.
(2) To limit total conduit bends between pull locations.
b) Install junction boxes and pull boxes at locations acceptable to the Engineer.
b. The Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
1) The Engineer is the sole source in determining whether the change is constituted as a deviation:
2) Perform any changes resulting in additional conduits, or extra work from such deviations.
3) Incorporate any deviations on the Record Documents.
2. Use only tools recommended by the conduit manufacturer for assembling the conduit system.
3. Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:
a. Clearance of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
b. Clearance of 12 inches from surfaces greater than 149 degrees Fahrenheit.
c. Keep conduits at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings, and 12 inches from fuel lines and gas lines.
d. Where it is necessary to route conduits close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
a. Do not run conduits within water-bearing walls unless otherwise indicated on the Drawings.
5. Do not install 1-inch or larger conduits in or through structural members unless approved by the Engineer.
6. Run conduits exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.

b. Make changes in direction with long radius bends or with conduit bodies.

7. Install conduits with total conduit bends between pull locations less than or equal to 270 degrees.
8. Route all exposed conduits to preserve headroom, access space and workspace, and to prevent tripping hazards and clearance problems:
   a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment-removal hatches.
   b. Route conduits to avoid drains or other gravity lines. Where conflicts occur, relocate the conduit as required.
9. 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.
10. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
11. Install conduits through wall and floor seals where indicated on the Drawings.
12. For existing and new 2-inch and larger conduit runs, snake conduits with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit:
    a. Remove and replace conduits through which mandrel will not pass.
13. 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.
14. Install complete conduit systems before conductors are installed.
15. 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.
16. Underground conduits:
    a. Direct bury underground conduits. Use PCS elbows to transition from direct buried conduit to exposed conduit.
    b. Make underground conduit size transitions at handholes and manholes.
    c. Seal around conduit penetrations of below grade walls with a mechanical seal.

C. Conduit usage:

1. Exposed conduits:
   a. Rigid conduit:
      1) Install the rigid conduit type for each location as specified in Section 16050 - Common Work Results for Electrical.
      2) Minimum size: 3/4-inch.
   b. Flexible conduit:
      1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment, or where required for equipment servicing:
         a) Use Type SLT with rigid metallic conduit.
      2) Minimum size: 3/4-inch:
         a) 1/2 when required for connection to instruments.

3) Maximum length:
a) Fixed equipment:

Conduit Trade Size	Flexible Conduit Length (inch)
3/4	18
1	18
1-1/4	18
1-1/2	18
2	36
2-1/2	36
3	36
3-1/2	38
4	40

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

2. Underground conduits:
a. Install Schedule PVC-40 for all underground conduit runs.
1) Minimum size: 1-inch.
b. Transition from exposed conduit to underground conduit with PCS conduit.
1) The PCS shall extend from 6-inches above grade to 6-inches below grade.
c. Minimum burial depth: 24-inches,
1) Increase the burial depth as required by the NEC.

D. 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. Provide large-radius factory-made bends for 1-1/4-inch trade size or larger.
e. 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.
f. 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.

E. Conduit sealing and drainage:
1. Conduit drainage and sealing other than required for hazardous and classified areas:
    a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above-grade conduit runs at the points at which the conduit enters buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
    b. Provide seal fittings with drains in vertical drops directly above grade for exterior and above-grade conduit runs that are extended below grade.
    c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
        1) Where portions of an interior raceway pass through walls, ceilings, or floors that separate adjacent areas having widely different temperatures.
    d. Provide conduit seals similar to O-Z/Gedney (Type CSM) on all conduits between corrosive and non-corrosive areas.
    e. Seal one end only of all underground conduits at highest point with O-Z/Gedney sealing (non-hazardous) filling, or equal.
2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: control panels, junction boxes, pullboxes, or low points of the conduit.

F. Conduit supports:
   1. General:
      a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
         1) As specified in Section 16070 - Hangers and Supports.
         2) Provide support materials consistent with the type of conduit being installed as specified in Section 16050 - Common Work Results for Electrical.
      b. Support conduit at the intervals required by the NEC.
      c. Perforated strap and plumbers tape are not acceptable for conduit supports.
   2. Conduit on concrete or masonry:
      a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
      b. Use preset inserts in concrete when possible.
      c. Use pipe spacers (clamp backs) in wet locations.
   3. 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.
   4. 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.

G. Expansion or expansion/deflection fittings:
   1. General:
      a. Align expansion coupling with the conduit run to prevent binding.
      b. Follow manufacturer’s instructions to set the piston opening.
      c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
      d. Furnish fittings of the same material as the conduit system.
   2. For metallic conduit, provide expansion or expansion/deflection couplings, as appropriate, where:
      a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.

H. 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.

I. 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. Provide conduit housekeeping curb around all embedded or below-grade conduits exiting or entering the slab, per the Typical Details.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16134

BOXES

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

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

D. Joint Industry Conference (JIC).

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

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions:
   1. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
   2. Raceway system boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.

1.04 SYSTEM DESCRIPTION

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

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

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

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

C. Shop drawings:
   1. Include identification and sizes of pullboxes.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

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

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Formed steel enclosures:
      a. Hoffman.
      b. Thomas and Betts.
      c. Stahlin.
      d. Rittal.
   2. 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. Formed steel enclosures:
   1. Steel:
      a. NEMA Type 12.
      b. Fabricated from 14-gauge steel, minimum.
      c. All seams continuously welded ground smooth.
      d. Door:
         1) Rolled lip around 3 sides.
         2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
      e. Neoprene door gasket to provide a watertight, dusttight, oiltight seal:
         1) Attached with an adhesive.
         2) Retained by a retaining strip.
      f. Fabricate all external removable hardware for clamping the door to the enclosure body from zinc-plated heavy gauge steel:
         1) With a hasp and staple for padlocking.
      g. Provide large enclosures with door and body stiffeners for extra rigidity.
      h. No holes or knockouts.

i. Finish:
1) ANSI-61 gray electrostatically applied polyester powder inside and out over cleaned and primed surfaces.
2) White electrostatically applied polyester powder mounting plate.
j. Heavy gauge steel external mounting brackets when surface mounted.

2. Stainless steel:
a. NEMA Type 4X:
1) Boxes in locations subject to flooding or temporary submersion:
a) NEMA Type 6.
b. Fabricated from 14-gauge Type 316 stainless steel.
c. All seams continuously welded.
d. Door:
1) Rolled lip around 3 sides.
2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
e. Neoprene door gasket to provide a watertight seal:
1) Attached with an adhesive.
2) Retained by a retaining strip.
f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
1) With a hasp and staple for padlocking.
g. Provide large enclosures with door and body stiffeners for extra rigidity.
h. No holes or knockouts.
i. Finish:
1) Brushed.
j. Stainless steel external mounting brackets when surface mounted.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

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

B. Provide breather and drain fittings where appropriate.

C. Internal panels:
1. Provide internal panels where required for mounting of terminal strips or other equipment.
2. With plated steel shoulder studs.
3. Steel with white polyester powder finish.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. General:
   1. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 16050 - Common Work Results for Electrical.
   2. 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.
      c.
   3. Size boxes in accordance with NEC requirements and to provide sufficient room for the future components and cables indicated on the Drawings.
   4. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.

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

D. For boxes not indicated:
   1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 16050 - Common Work Results for Electrical.
   2. Fire rated construction: Use materials and methods to comply with the listing requirements for the classified construction.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16150

LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

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

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

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

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

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

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

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

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. All materials shall be UL listed.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Control connections:
   1. Use insulated ring type wire terminators for connections to all screw terminals:
      a. With chamfered/funneled terminal barrel entry.
      b. Deep internal serrations.
      c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
      d. Electroplated-tin copper conductor.
      e. Manufacturers: The following or equal:
         1) Thomas and Betts, Stakon.
   2. For process equipment connections work from manufacturer's drawings.

B. Joints, splices, taps, and connections:
   1. 600-volt conductors:
      a. Use solderless connectors.
      b. Use only plated copper alloy connectors or lugs:
         1) Aluminum connectors or lugs are not acceptable for copper conductors.
      c. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.
      d. For wire Number 10 AWG and smaller use compression splice caps, with insulating caps:
         1) Manufacturers: The following or equal:
            a) Buchanan, 2006S or 2011S, with 2007 or 2014 insulating caps.
      e. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
         1) Manufacturers: One of the following or equal:
            a) Burndy.
            b) Thomas and Betts.
      f. Heat shrink tubing:
         1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
         2) Minimum shrink ratio: 4 to 1.
         3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
         4) Internally applied adhesive sealant.
         5) Cross-linked polyolefin:
            a) Manufacturers: One of the following or equal:
               (1) 3M, ITCSN.
               (2) Thomas & Betts, Shrink-Kon.
   2. Instrumentation class cable splices:
      a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
      b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
      c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
      d. Two-part mold body with tongue and groove seams and built in spacer webbing.
      e. Manufacturers: The following or equal:
         1) 3M, Scotchcast 72-N.

C. Insulating tape:
   1. General purpose insulating tape:
      a. Minimum 7 mil vinyl tape.
      b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
      c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
      d. Flame retardant, hot- and cold- weather resistant, UV resistant.
      e. For use as a primary insulation for wire cable splices up to 600 VAC.
      f. Meeting and complying with:
         1) ASTM D3005 Type I.
         2) UL 510.
         3) CSA C22.2.

g. Manufacturers: The following or equal:
1) 3M, Scotch Number Super 33+.

2. General-purpose color-coding tape:
a. Minimum 7 mil vinyl tape.
b. Suitable for application on PVC and polyethylene jacketed cables.
c. For use indoors and outdoors in weather protected enclosures.
d. Available with the following colors:
1) Red.
2) Yellow.
3) Blue.
4) Brown.
5) Gray.
6) White.
7) Green.
8) Orange.
9) Violet.
e. For use as phase identification, marking, insulating, and harnessing.
f. Meeting and complying with:
1) UL 510.
2) CSA C22.2.
g. Manufacturers: The following or equal:
1) 3M, Scotch Number 35.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Load connections:
1. Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 16123 - 600-Volt or Less Wires and Cables.

C. Zero to 600-volt systems:
1. Make all connections with the proper tool and die as specified by the device manufacturer.

2. Use only tooling and dies manufactured by the device manufacturer.
3. Insulate all connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
4. Number all power and control wires before termination.

D. Motor connections (600 volts and below):
1. Terminate all leads and wires with compression type ring lugs.
2. Terminations on all motor leads, including leads that are connected together to accommodate the motor voltage, and the machine wires entering the motor terminal box from the power source, shall have ring type compression lugs.
3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
   a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
   b. Shrink cap with low heat as recommended by manufacturer.
4. Wire markers shall be readable after boot installation.
5. Manufacturers: The following or equal:
   a. Raychem, MCK.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16222

LOW VOLTAGE MOTORS UP TO 500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

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 - Machinery Protection 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. 303 - Recommended Practice for Auxiliary Devices for Rotating Electrical Machines in Class I, Division 2 and Zone 2 Locations.
   4. 841 - IEEE 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).
   5. 1349 - Guide for Application of Electric Motors in Class I, Division 2 and Class I, Zone 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 16050 - Common Work Results for Electrical.

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 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

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 versus 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. Power factor correction capacitors:
         1) Size in KVAR, for all motors not connected to variable frequency drives.
      b. Motor winding heaters:
         1) Voltage.
         2) Watts.
      c. Winding temperature detectors:
         1) Type.
         2) Rating.
      d. Moisture detectors.
   6. Mechanical data:
      a. Bearing design and bearing life calculations.
      b. Resonant frequencies for all VFD-driven motors 50 hp 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 16050 - Common Work Results for Electrical exceed manufacturer's ratings, provide derating calculations for each motor.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

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

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S 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. Explosion-proof:
         1) Tapped drain holes with corrosion resistant plugs for frames 286 and smaller and automatic breather and drain devices for frames 324 and larger.
      d. 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 and 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. 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. All motors except explosion proof motors:
    a. Shaft grounding ring:
        1) Provide a shaft grounding ring for each VFD-driven motor.
        2) Aluminum frame and internal components.
        3) Conductive microfiber brushes.
        4) Maintenance free design.
        5) Aegis Bearing Protection ring as manufactured by Electro Static Technology or equal.

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. 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 16050 - Common Work Results for Electrical.

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 01756 - Commissioning.

B. Factory testing:
   1. Motors less than 250 hp:
      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 16050 - Common Work Results for Electrical.

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 16950 - Field Electrical Acceptance Tests.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

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 16264

VARIABLE FREQUENCY DRIVES 60 - 500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. National Electrical Manufacturers Association (NEMA).

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

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

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Each VFD system shall consist of all components required to meet the performance, protection, safety, testing and certification criteria of this Section.
   2. The VFD system:
      a. Is a fully integrated package.
      b. Includes all material necessary to interconnect VFD system elements, even if shipped separately.
   3. Any modifications to a standard product necessary to meet this Section shall be made only by the VFD manufacturer.
   4. Each VFD shall be completely factory pre-wired, assembled and then tested as a complete package by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.
   5. The VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics:
      a. The VFD manufacturer shall furnish equipment necessary to mitigate potential damage to motor insulation.

b. Coordinate bearing protection methods with the supplier of the driven equipment.
c. Motors as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.

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 at the input terminals of the VFD system.
2) Current harmonics: The maximum allowable total harmonic current distortion limit, TDD, for each VFD shall not exceed 5 percent as measured at the input terminals of the VFD system.
3. Efficiency:
a. VFD system minimum efficiency shall be 93 percent at rated kilowatt output of the VFD. VFD system efficiency shall be calculated as follows:

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

b. Power:
1) Load power is the total 3-phase power measured at the output terminals of the drive system, including the output filter.
2) Supply power is the total power measured at the input terminals of the VFD including phase shifting transformer, harmonic distortion attenuation equipment and auxiliary equipment (e.g., controls, fans) for complete system operation.
4. Total power factor:
a. Minimum of 0.96 lagging across the entire speed range.
b. Under no operating conditions shall the VFD have a leading power factor.
5. Frequency accuracy:
a. Minimum of within 0.01 percent.
6. Speed regulation:
a. Minimum of within 0.5 percent across the entire speed range.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical:
   1. Custom prepared by the VFD manufacturer and specific for the equipment furnished.

B. Product data:
   1. Manufacturer of the VFD.
   2. Manufacturer of all components of the VFD.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
   4. Weight.
   5. Nameplate schedule.
   6. Bill of material.
   7. Ratings:
      a. Voltage.
      b. Phase.
      c. Input current.
      d. Output current.
      e. Interrupting rating.
      f. Momentary current rating.
   8. Catalog 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 16050 - Common Work Results for Electrical:
      a. Manufacturer’s statement of seismic qualification with substantiating test data.
      b. Manufacturer’s special seismic certification with substantiating test data.

C. Shop drawings:
   1. Complete plan and elevation drawings showing:
      a. All dimensions.
      b. Panel, sub-panel and component layout indexed to the bill of material.
      c. Conduit connections.
      d. Required clearance around equipment.

2. Block diagram showing the basic control and protection systems identifying the protection, control, trip and alarm functions, the reference signals and commands and the auxiliary devices.
3. Complete schematic, wiring and interconnection diagrams showing connections to both internal and external devices:
    a. Wiring diagrams shall include terminal number and wire numbers.
4. Complete 1-line and 3-line diagrams including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system:
    a. Device electrical ratings shall be clearly indicated on the Drawings.

D. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
2. For equipment installed in structures designated as seismic design category A or B:
    a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
3. For equipment installed in structures designated as seismic design category C, D, E, or F:
    a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050 - Common Work Results for Electrical.
    b. Submit anchoring drawings with supporting calculations.
    c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

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.
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 16050 - Common Work Results for Electrical.

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

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

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

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

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

A. Conduct 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 01756 - Commissioning.

1.10 SCHEDULING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

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

1.13 OWNERS INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

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

C. Spare parts:
   1. The following spare parts shall be furnished:
      a. 1 set of all power and control fuses for each VFD.
      b. 1 complete main control keypad for each type and rated size of VFD.
      c. 1 spare fan for each VFD unit.
      d. 2 sets of ventilation filters for each VFD unit (if applicable in VFD cabinet louvers).
      e. 1 set of thyristors or power electronics for each type and rated size of VFD.
      f. Any special dedicated tools for emergency service and troubleshooting.
      g. 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.
   2. Allen-Bradley.
   3. Schneider-Electric.
   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. Integral phase shifting autotransformer:
         1) Converts 3-phase utility power to 3 sets of 3 power circuits with each set phase shifted and powering its own 3-phase bridge rectifier.
      b. Direct current link with capacitors.
      c. Minimum 18-pulse diode rectifier section consisting of 3 three-phase bridge rectifiers.
         1) Specifically designed as a system to share currents between the bridges to within 1 percent.
      d. Insulated gate bipolar transistor (IGBT), inverter section.
      e. Microprocessor based controls.
      f. Output filter.
   2. VFDs that have an active input section for either harmonic or voltage control are not acceptable.

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

C. Operational features:
   1. Protective features:
      a. Include the following protective features:
         1) Motor overload protection.
         2) Instantaneous overcurrent.
         3) Instantaneous overvoltage.
         4) Undervoltage.
         5) Power unit overtemperature.
         6) Phase loss.
         7) VFD output short circuit.
         8) VFD output ground fault.
         9) Blown fuse.
   2. Control mode:
      a. The VFD shall operate in a either a constant volts/hertz or sensorless vector mode. Selectable using the programming keypad.
   3. Frequency control:
      a. Minimum of 3 selectable skip frequencies with adjustable bandwidths.
      b. Programmable minimum frequency.
      c. Programmable maximum frequency.
   4. Acceleration/Deceleration:
      a. Separately adjustable acceleration and deceleration rates.
      b. Each rate shall be adjustable from 0.01 to 1,800 seconds.
   5. Spinning load:
      a. Capable of determining the speed and direction of a spinning load, “catch” the load and accelerate or decelerate it without damage to the load.

6. Programmable loss of signal:
    a. Upon loss of reference speed signal the VFD shall be programmable to either stop, maintain current speed, or default to preselected speed.
7. Power interrupt ride through:
    a. Capable of continuous operation in the event of a power loss of 5 cycles or less.
8. Hardwired inputs and outputs:
    a. Manufacturer's standard number the following:
        1) Analog inputs:
            a) Configurable as either 0 to 10 volts or 4 to 20 milliamperes.
        2) Analog outputs:
            a) Programmable 4 to 20 milliamperes isolated.
        3) Discrete inputs:
            a) Programmable.
        4) Discrete outputs:
            a) Programmable.
            b) Form C relay contacts.
        5) Potentiometer 3-wire input.
    b. Provide additional inputs and outputs as required to meet the control functions indicated on the Drawings.
9. 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.
    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. Autotransformer.
    2. Integral part of the VFD assembly and factory mounted and wired within the VFD enclosure.
    3. Rated for rectifier duty.
    4. Copper or aluminum windings with 180-degree Celsius insulation.

D. Output filter:
   1. 3 percent load reactor.

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

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

2.07 ACCESSORIES

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

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

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

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

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

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

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

C. General:
   1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories needed to complete installation of the VFD (free-standing 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 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 16123 - 600-Volt or Less Wires and Cables.
    b. Label all wires at each end with wire numbers shown on the approved Control Drawings.
    c. All connections to and from the VFD (free-standing 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 01756 - Commissioning.

B. Factory testing:
1. Owner and Engineer will witness the factory acceptance test as specified in Section 16050 - Common Work Results for Electrical.
2. General:
    a. All VFDs furnished under this Section shall be tested and inspected as specified below.
    b. The testing procedures specified are the minimum acceptable requirements. The manufacturer may perform additional tests at its discretion.
3. Failure of any component during testing requires replacement of the faulted component and a complete retest.
4. Testing sequence:
    a. Submit a detailed test procedure for the VFD factory test:
        1) A minimum of 8 weeks in advance of the proposed testing date.
        2) No tests shall be performed until the test procedure is reviewed and accepted by the Engineer.
5. Component tests:
    a. Preliminary inspection:
        1) Verify that all components are correct.
        2) Verify that all connections are properly torqued.
    b. Printed circuit boards:
        1) Test each printed circuit board per the manufacturer’s standard testing procedure.
    c. Wiring:
        1) Control and power wiring continuity verified point-to-point.
        2) Hi-pot power and control wiring at manufacturer’s recommended levels.
        3) Verify ground bond resistance.

d. Load testing:
    1) No load testing in accordance with the manufacturer's standard factory test procedure.
    2) Full load testing:
        a) Test each VFD and all control logic with a representative motor or dynamometer load to simulate field operation conditions at 25 percent, 50 percent, and 100 percent full load current.
        b) Tests shall be conducted in a manner in which the inverter (IGBT) section supplies all the output power (kw) of the VFD system. Control strategies using a contactor or other means of bypassing the VFD when operating at the line frequency shall not be permitted.
        c) Tests shall be conducted using a minimum output frequency of 60 hertz, and a minimum switching frequency of 2.5 kHz.

C. Owner training:
    1. As specified in Sections 01756 - Commissioning and 16050 - Common Work Results for Electrical.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Provide the services of a VFD manufacturer representative for start-up assistance and training:
    1. Inspection and field adjustment:
        a. Supervise the following and submit written certification that the equipment and controls have been properly installed, aligned, adjusted, and readied for operation.
    2. Start-up field testing:
        a. Provide technical direction for testing, checkout, and startup of the VFD equipment in the field.
        b. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.
        c. Compliance with the following specified parameters shall be verified by the VFD manufacturer:
            1) Motor terminal voltage:
                a) Make field measurements at the motor connection box.
                b) Make measurements of the full speed range of the VFD.
                c) Make measurements with a recording type oscilloscope.
            2) Harmonics:
                a) Make field measurements at the input terminals of the VFD with and without the VFD in operation.
                b) Make measurements with a recording type harmonic analyzer displaying individual and total harmonic currents and voltages:
                    (1) Record currents and voltages for a minimum of 10 minutes.
                    (2) Analyzers using snapshots are not acceptable.

3.09 ADJUSTING

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

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

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16411

DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Fusible and non-fusible disconnect switches.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. National Electric Manufacturer's Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment.
   2. KS 1-2001 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

C. Underwriters Laboratories Inc. (UL):
   1. 20 - General-Use Snap Switches.
   2. 98 - Enclosed and Dead-Front Switches.
   3. 508 - Standard for Industrial Control Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions:
   1. Safety switches and disconnect switches are to be considered synonymous.

1.04 SYSTEM DESCRIPTION

A. Provide heavy-duty type disconnect switches as indicated on the Drawings and specified in the Contract Documents.

B. Provide disconnect switches with the number of poles, voltage, current, short circuit, and horsepower ratings as required by the load and the power system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Manufacturer.
   2. Manufacturer's specifications and description.
   3. Ratings:
      a. Voltage.
      b. Current.

c. Horsepower.
d. Short circuit rating.
4. Fused or non-fused.
5. NEMA enclosure type.
6. Dimensions:
a. Height.
b. Width.
c. Depth.
7. Weight.

C. Shop drawings:
1. Manufacturer's installation instructions:
a. Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance, Regulatory Requirements below.
b. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
2. Identify motor or equipment served by each switch; indicate nameplate inscription.

D. Installation instructions:
1. Provide anchorage instructions and requirement based on the seismic requirements at the Project Site as specified in Section 16050 - Common Work Results for Electrical and calculations:
a. Stamped by a professional engineer registered in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Regulatory requirements:
1. NEMA KS1- Enclosed and Miscellaneous Distribution Switches (600 V Maximum).
2. UL 98 - Enclosed and Dead-Front Switches.

C. Disconnect switches shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Schneider Electric.
   2. Eaton.
   3. General Electric.
   4. Siemens.
   5. Appleton.
   6. Crouse-Hinds.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Switch mechanism:
   1. Quick-make, quick-break heavy-duty operating mechanisms:
      a. Provisions for padlocking the switch in the Off position.
      b. A minimum of 90-degree handle travel position between Off and On positions:
         1) Provide handle position indicators to identify the handle position.
      c. Full cover interlock to prevent opening of the switch door in the On position and to prevent closing the switch mechanism with the door open:
         1) With an externally operated override.

B. Switch interior:
   1. Switch blades visible when the switch is Off and the cover is open.
   2. Lugs:
      a. Front accessible.
      b. Removable.
      c. UL listed for 60/75-degree Celsius copper conductors.
   3. Current carrying parts completely plated to resist corrosion.
   4. Removable arc suppressors to facilitate easy access to line side lugs.
   5. Furnish equipment ground kits for every switch.

C. Fused switches:
   1. Furnish with fuses as indicated on the Drawings:
      a. Provide fuses as specified in Section 16494 - Low Voltage Fuses.

2. UL approved for field conversion from standard Class H fuse spacing to Class J fuse spacing:
    a. Ratings 100 amperes through 600 amperes at 240 volts.
    b. Ratings 30 amperes through 600 amperes at 600 volts.
    c. Provide spring reinforced and plated fuse clips.

D. Ratings:
1. UL horsepower rated for AC or DC with the rating not less than the load served.
2. Current:
    a. 30 to 1,200 amperes.
3. Voltage:
    a. 250 volts AC, DC.
    b. 600 volts (30 A to 200 A, 600 volts DC).
4. Poles:
    a. 2, 3, 4, and 6 poles.
5. UL listed short circuit ratings:
    a. 10,000 RMS symmetrical amperes when used with or protected by Class H or K fuses (30-600 amperes).
    b. 200,000 RMS symmetrical amperes when used with or protected by Class R or J fuses (30-600 amperes employing appropriate fuse rejection).
    c. 200,000 RMS symmetrical amperes when used with or protected by Class L fuses (800-1,200 amperes).
6. Provide switches with the NEMA ratings specified in Section 16050 - Common Work Results for Electrical for the installed location.

E. Size, fusing and number poles as indicated on the Drawings or as required:
1. Provide solid neutral where indicated on the Drawings.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Disconnect switches to have provisions for a field installable “B” type electrical interlock for position indication as indicated on the Drawings.

B. Disconnect switches to have provisions for a field installed insulated groundable neutral kit as indicated on the Drawings.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

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

C. General:
   1. Use Myers hubs or bolt-on hubs for all conduit penetrations on NEMA Type 12, Type 4, and Type 4X enclosures.
   2. Provide all mounting brackets, stands, supports and hardware as required:
      a. Match finish and materials for all brackets, stands, and hardware with the switch installed.
      b. Provide adequate supporting pillar(s) for disconnect switches in accordance with the approved seismic calculations, and locate aboveground or above decks, where there is no structural wall or surface for box.
   3. When possible, mount switches rigidly to exposed building structure or equipment structural members:
      a. For NEMA Type 4 and Type 4X locations, maintain a minimum of 7/8 inch air space between the enclosure and supporting surface.
      b. When mounting on preformed channel, position channel vertically so that water may freely run behind the enclosure.
   4. Provide a nameplate for each disconnect switch:
      a. Provide per requirements specified in Section 16075 - Identification for Electrical Systems.
      b. Identify voltage, circuit, fuse size, and equipment served on the nameplate.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16412

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

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

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

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. In accordance with UL 489.

1.04 SYSTEM DESCRIPTION

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

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

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

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

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

1.07 DELIVERY, STORAGE AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Eaton.
   2. General Electric Co.
   3. Schneider Electric.
   4. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. Conforming to UL 489.
   2. Operating mechanism:
      a. Quick-make, quick-break, non-welding silver alloy contacts.
      b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
      c. Mechanically trip free from the handle.
      d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
      e. Lockable in the "OFF" position.

3. Arc extinction:
    a. In arc chutes.
4. Voltage and current ratings:
    a. Minimum ratings as indicated on the Drawings.
    b. Minimum frame size 100A.
5. Interrupting ratings:
    a. Minimum ratings as indicated on the Drawings.
    b. 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. Thermal magnetic:
    a. Instantaneous short circuit protection.
    b. Inverse time delay overload.
    c. Ambient or enclosure compensated by means of a bimetallic element.

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 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING

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

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

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16422

MOTOR STARTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Motor starters and contactors.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. International Electrotechnical Commission (IEC):
   1. 60 947-4 - Low-Voltage Switchgear and Control Gear.
   2. 801-1 - Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment - Part 1: General Information.

C. National Electrical Manufacturer's Association (NEMA):
   1. ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 V.

D. Underwriters Laboratories (UL):
   1. 508 - Standard for Industrial Control Equipment.
   2. 508A - Standard for Industrial Control Panels.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions and abbreviations:
   1. FVNR: Full voltage non-reversing.
   2.
   3. RVSS: Reduced voltage solid state.
   4. Overload relay class: A classification of an overload relay time current characteristic by means of a number which designates the maximum time in seconds at which it will operate when carrying a current equal to 600 percent of its current rating.

1.04 SYSTEM DESCRIPTION

A. General requirements:
   1. Starters for motor control centers, individual enclosed starters, or control panels.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical:
   1. Submit motor starter data with equipment submittal.

B. Product data:
   1. Manufacturer.
   2. Catalog cut sheets.
   3. Technical information.
   4. Complete nameplate schedule.
   5. Complete bill of material.
   6. List of recommended spare parts.
   7. Confirmation that the overload relay class for each starter meets the requirements of the equipment and motor supplier.
   8. Electrical ratings:
      a. Phase.
      b. Wire.
      c. Voltage.
      d. Ampacity.
      e. Horsepower.
   9. Furnish circuit breaker submittals as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.

C. Shop drawings:
   1. Elementary and schematic diagrams:
      a. Provide 1 diagram for every starter and contactor.
      b. Indicate wire numbers for all control wires on the diagrams:
         1) Wire numbering as specified in Section 16075 - Identification for Electrical Systems.
      c. Indicate interfaces with other equipment on the drawings.

D. Operation and maintenance manuals:
   1. Submit complete operating and maintenance instructions presenting full details for care and maintenance of equipment furnished or installed under this Section. Including but not limited to:
      a. Electrical ratings:
         1) Phase.
         2) Wire.
         3) Voltage.
         4) Ampacity.
      b. Complete bill of material.
      c. Manufacturer’s operating and maintenance instructions starter and/or contactor component parts, including:
         1) Protective devices (fuses, breakers, overload relays, heater elements, etc.).
         2) Pilot devices.
      d. Complete renewal parts list.
      e. As-built drawings:
         1) Furnish as-built drawings for each starter and contactor indicating final:
            a) Wire numbers.

b) Interfaces with other equipment.
2) 11-inch by 17-inch format.

E. Certifications:
1. Provide manufacturer's certification that the reduced voltage solid state starter will reliably control the acceleration and deceleration of the driven load at the installed conditions:
a. Failure of the manufacturer to provide said certification will be interpreted to mean that the manufacturer has agreed that the reduced voltage solid state starter is matched to the driven load at the installed conditions and will function without fault.
b. If the reduced voltage solid-state starter fails to perform as desired, replace or modify the reduced voltage solid-state starter in order to achieve the desired operational conditions, as directed by the Engineer.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Regulatory requirements:
1. All starters and components shall be UL listed and labeled:
a. UL 508 - Industrial Control Equipment.
b. UL 508A - Industrial Control Panels.
2. NEMA ICS 2 - Industrial Control and System Controllers; Contactors and Overload Relays Rated: 600 Volts.
3. Combination starters shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. Reduced voltage solid state starters:
1. Submit certification that the RVSS will reliably accelerate and decelerate the driven load at the installed conditions as part of the equipment submittal.
2. RVSS start-up and testing by manufacturer after connection to equipment.
3. RVSS training by manufacturer after start-up and testing, and before plant commissioning.

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

B. RVSS:
1. Provide the services of the manufacturer's technical representative for start-up, adjustment, and troubleshooting, a minimum of 2 hours per starter at the Owner's facility.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Spare parts:
1. Provide the following spare parts, suitably packaged and labeled with the corresponding equipment number:
a. 1 spare fuse of each size and type per starter.
b. 1 of each type of circuit board used in the RVSS starters, including but not limited to:
1) Control board.
2) Power board.
3) Bridge rectifier.
4) Inverter module.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
1. Reduced voltage solid state starters:
a. Eaton.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
1. NEMA size, design, and rated:
a. NEMA Size 1 minimum.
2. Coordinate motor circuit protector, thermal magnetic circuit breaker, or fusible disconnect, and overload trip ratings with nameplate horsepower and current ratings of the installed motor:
a. If motors provided are different in horsepower rating than those specified or indicated on the Drawings, provide starters coordinated to the actual motors furnished.
3. Mount extended overload reset buttons to be accessible for operation without opening starter enclosure door.

B. RVSS:
1. Manufactured and tested in accordance with the applicable requirements of IEEE, UL, and NEMA, including the following:
a. Dielectric withstand per UL 508.
b. Noise and RF immunity per NEMA ICS-2-230.

2. Furnish with a motor circuit protector or thermal magnetic circuit breaker as indicated on the Drawings.
3. Provide protection against internal faults and high SCR temperature during operation of the motor including starting, running (except when bypassed), and stopping modes.
4. Capable of continuously delivering full rated current of the motor plus the motor service factor in ambient temperatures from 0 degrees Celsius to 40 degrees Celsius at the installed altitude.
5. Provide a magnetically operated bypass contactor in parallel with the solid state starter:
    a. The bypass contactor to energize when the motor has reached full speed:
        1) The electronic overload protection circuits must be fully functional with the bypass contactor closed.
6. RVSS control module requirements:
    a. Microcomputer based, and contains the required circuitry to drive the power semiconductors in the power section of the starter.
    b. Integrally mounted on the power section and requires no additional panel space or wiring.
    c. Mounted for easy wiring, testing, service, and replacement.
    d. Provide 3-phase current sensing.
    e. Quick disconnect plug-in connectors for current transformer inputs, line and load voltage inputs, and SCR gate firing output circuits.
    f. Operates on power supplied from a control power transformer.
    g. Phase insensitive or with phase rotation protection.
    h. Control modes:
        1) Soft start with adjustable linear ramp time and a “kick start” or “boost” feature to provide a short time (typically 0.1 seconds) application of approximately full voltage.
        2) Soft start with adjustable linear ramp time, with a current limit:
            a) The current limit shall be adjustable over the range of 2 to 4 times normal full load current.
        3) Across the line starting.
        4) Reverse voltage ramp (line voltage to zero voltage):
            a) Adjustable from 2 to 30 seconds to provide smooth stop.
            b) Automatic shutdown at end of voltage ramp.
    i. Protective functions:
        1) Single phase protection.
        2) Under voltage protection.
        3) Short circuit electronic trip overcurrent protection. Time not to exceed 3 cycles.
        4) Inverse time running overcurrent protection.
        5) Auxiliary trip circuitry.
        6) Gate firing circuit lockout protection on trip.
        7) Jam and stall detection.
        8) Fault relay lockout protection.
        9) 100 percent to 130 percent full load running current trip adjustment.
        10) 100 percent to 450 percent of starting current limit adjustment.
        11) Dwell time at current limit with ramp continuation after acceleration.
        12) Individual light emitting diodes (LEDs) for trip and phase loss.
        13) Minimum and maximum initial starting voltage adjustments.
        14) Initial torque adjustment.

7. RVSS power section requirements:
    a. 3 sets of back-to-back phase-controlled power semiconductors:
        1) Minimum repetitive peak inverse voltage of 1,500 volts at 480 VAC.
        2) Resistor/capacitor snubber networks to prevent false firing of the SCRs.
        3) Equipped with individual heat sink assemblies.
        4) Provide high-speed fuses for protection of the SCR stacks against short circuit conditions.
    b. Provide metal oxide varistors for surge protection on the line side power terminal connections:
        1) Rated for a minimum of 120 joules.
    c. Capable of supplying the following current levels:
        1) 600 percent of full load current for a minimum of 10 seconds.
        2) 450 percent of full load for a minimum of 30 seconds.
    d. Furnish ground lugs, one for incoming and one for outgoing ground connections.
    e. Furnish pressure type terminals for top or bottom entry power terminations.
8. Remote indicators:
    a. Provide Form C dry contacts for remote indication of:
        1) Internal fault error.
        2) Undervoltage.
        3) Overvoltage.
        4) Phase reversal.
        5) Phase loss.
        6) Overload.
        7) Frequency out of range.
        8) Excessive starts per hour.
        9) Drive electronics over temperature.
        10) Stall.
        11) Jam.
        12) System failure.
        13) Starter failure.
        14) Run status.
        15) Full speed.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Molded case circuit breakers:
    1. Circuit breaker type and ratings as indicated on the Drawings.
    2. Provide as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.

2.07 ACCESSORIES

A. Lugs and terminals:
    1. For all external connections of No. 6 AWG and larger.
    2. UL listed for either copper or aluminum conductors.

B. Surge protective devices:
   1. Furnish surge protection devices across the coil of each starter, contactor, and relay.

C. Pilot devices:
   1. Provide pilot lights, switches, elapsed time meters, and other devices as specified or as indicated on the Drawings.
   2. General:
      a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
      b. Size:
         1) 30.5 millimeters.
      c. Heavy duty.
      d. NEMA Type 4/13.
      e. Pushbuttons:
         1) Contacts rated:
            a) NEMA Type A600.
         2) Furnish 1 spare normally open contact and normally closed contact with each switch.
      f. 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.
      g. Pilot lights:
         1) Type:
            a) LED for interior installations.
         2) Push to test.
         3) Lamp color as indicated on the Drawings.

D. Nameplates and wire markers:
   1. As specified in Section 16075 - Identification for Electrical Systems.

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

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. RVSS starters:
   1. The manufacturer of the respective RVSS starter shall supply certified test results to confirm that the controller has been tested to substantiate designs according to applicable ANSI and NEMA standards.

2. The tests shall verify not only the performance of the unit and integrated assembly, but also the suitability of the enclosure venting, rigidity, and bus bracing. In addition, the unit shall be factory tested in accordance with ANSI standards.
3. The RVSS starter manufacturer shall test for noise immunity on both input and output power connections and provide test results to the Engineer. Noise testing shall be performed in accordance with NEMA ICS 2-230.40.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Factory testing:
   1. Owner and Engineer will witness the factory acceptance test as specified in Section 16050 - Common Work Results for Electrical.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING

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

B. Set all overloads and motor circuit protectors based on the nameplate values of the installed motor.

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16950

FIELD ELECTRICAL ACCEPTANCE TESTS

PART 1 GENERAL

1.01 SUMMARY

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

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

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. American National Standards Institute (ANSI).

C. 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- 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 01756 - Commissioning and 16050 - Common Work Results for Electrical.

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

1.04 SYSTEM DESCRIPTION

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

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

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

D. Responsibilities:
   1. Contractor responsibilities:
      a. Ensure that all resources are made available for testing, and that all testing requirements are met.
   2. Electrical subcontractor responsibilities:
      a. Perform routine tests during installation.
      b. Demonstrate operation of electrical equipment.
      c. Commission the electrical installation.
      d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:
         1) Providing electrical power as required.
         2) Operating of electrical equipment in conjunction with testing of other equipment.
         3) Activating and shutting down electrical circuits.
         4) Making and recording electrical measurements.

5) Replacing blown fuses.
6) Installing temporary jumpers.

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

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Manufacturers' testing procedures:
   1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer prior to beginning testing.

C. 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.

D. Test data records:
   1. Include the following:
      a. Identification of the testing organization.
      b. Equipment identification.
      c. Nameplate data.
      d. Humidity, temperature and or other conditions that may affect the results of the tests and or calibrations.
      e. Dates of inspections, tests, maintenance and or calibrations.
      f. Indication of the inspections, tests, maintenance, and or calibrations to be performed and recorded.
      g. Expected results when calibrations are to be performed.
      h. Indication of as-found and as-left results as applicable.
      i. Indication of all test results outside specified tolerances.

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 16050 - Common Work Results for Electrical.

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

1.07 DELIVERY, STORAGE, AND PROTECTION (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

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

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

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

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

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

3.03 INSTALLATION

A. Test decal:
   1. The testing laboratory shall affix a test decal on the exterior of equipment or equipment enclosure of protective devices after performing electrical tests.
   2. The test decal shall be color coded to communicate the condition of maintenance of the protective. The color scheme for condition of maintenance of overcurrent protective devices shall be:
      a. White: electrically and mechanically acceptable.
      b. Yellow; minor deficiency not affecting fault detection and operation, but minor electrical or mechanical condition exists.
   3. The decal shall include the following information at a minimum:
      a. Testing organization.
      b. Project identifier.
      c. Test date.
      d. Technician identifier.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

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

3) Inspect anchorage and alignment.
4) Verify the unit is clean.
5) Operate the circuit breaker to ensure smooth operation.
6) Inspect bolted electrical connections for high resistance by one of the following methods:
    a) Use of low-resistance ohmmeter.
    b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
7) Perform adjustments for final protective device settings in accordance with the coordination study.

b. Electrical tests:
1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
2) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
    a) Apply voltage in accordance with manufacturer's published data.
    b) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) Perform a contact/pole-resistance test.
4) Determine long-time pickup and delay by primary current injection.
5) Determine short-time pickup and delay by primary current injection.
6) Determine ground-fault pickup and delay by primary current injection.
7) Determine instantaneous pickup value by primary current injection.
8) Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
9) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function and trip unit battery condition:
    a) Reset all trip logs and indicators.
10) Verify operation of charging mechanism.

c. Test values:
1) Compare bolted connection resistance values to values of similar connections:
    a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    a) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) Insulation-resistance values shall be in accordance with manufacturer's published data:
    a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    b) Investigate values of insulation-resistance less than the allowable minimum.

4) Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
    a) If manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
5) Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band including adjustment factors:
    a) If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
6) Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
7) Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
8) Instantaneous pickup values shall be as specified and within manufacturer's published tolerances:
    a) Refer to NETA ATS tables in the absence of manufacturer's published data.
9) Pickup values and trip characteristics shall be within manufacturer's published tolerances.
10) Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.
11) The charging mechanism shall operate in accordance with manufacturer's published data.

4. Motor starters, low voltage:
    a. Visual and mechanical inspection:
        1) Compare equipment nameplate information with the Contract Documents.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, and grounding.
        4) Verify the unit is clean.
        5) Inspect contactors:
            a) Verify mechanical operation.
            b) Verify contact gap, wipe, alignment, and pressure is in accordance with manufacturer's published data.
        6) Motor-running protection:
            a) Verify overload element rating/motor protection settings are correct for its application.
            b) If motor running protection is provided by fuses, verify correct fuse rating.
        7) Inspect bolted electrical connections for high resistance using one of the following methods:
            a) Use of low-resistance ohmmeter.
            b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
                (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
        8) Lubrication requirements:
            a) Verify appropriate lubrication on moving current-carrying parts.
            b) Verify appropriate lubrication on moving and sliding surfaces.

b. Electrical tests:
    1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    2) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase to ground with the starter closed, and across each open pole for 1 minute:
        a) Test voltage shall be in accordance with manufacturer's published data.
        b) Refer to NETA ATS tables in the absence of manufacturer's published data.
    3) Test motor protection devices in accordance with manufacturer's published data.
    4) Test circuit breakers as specified in this Section.
    5) Perform operational tests by initiating control devices.
c. Test values:
    1) Compare bolted connection resistance values to values of similar connections:
        a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    2) Bolt-torque levels shall be in accordance with manufacturer's published data:
        a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    3) Insulation-resistance values shall be in accordance with manufacturer's published data:
        a) Refer to NETA ATS tables in the absence of manufacturer's published data.
        b) Investigate values of insulation-resistance less than the allowable minimum.
    4) Motor protection parameters shall be in accordance with manufacturer's published data.
    5) Circuit breaker test results shall as specified in this Section.
    6) Control devices shall perform in accordance with system design requirements.

5. Variable frequency drive systems:
    a. Visual and mechanical inspection:
        1) Compare equipment nameplate data with the Contract Documents.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, and grounding.
        4) Verify the unit is clean.
        5) Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
        6) Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
        7) Motor running protection:
            a) Verify drive overcurrent setpoints are correct for their application.
            b) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
            c) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.

8) Inspect bolted electrical connections for high resistance using one of the following methods:
    a) Use of low-resistance ohmmeter.
    b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
9) Verify correct fuse sizing in accordance with manufacturer's published data.
10) Perform visual and mechanical inspection of input circuit breaker as specified in this Section.

b. Electrical tests:
1) Perform resistance measurements through bolted connections with low resistance ohmmeter.
2) Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
3) Test for the following parameters in accordance with relay calibration procedures specified in NETA ATS or as recommended by the manufacturer:
    a) Input phase loss protection.
    b) Input overvoltage protection.
    c) Output phase rotation.
    d) Overtemperature protection.
    e) Direct current overvoltage protection.
    f) Overfrequency protection.
    g) Drive overload protection.
    h) Fault alarm outputs.
4) Perform continuity tests on bonding conductors as specified in accordance with NETA ATS.
5) Perform start-up of drive in accordance with manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.
6) Perform operational tests by initiating control devices:
    a) Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
    b) Verify operation of drive from remote start/stop and speed control signals.
7) Perform electrical tests of input circuit breaker as specified in this Section.
8) Measure fuse resistance.

c. Test values:
1) Compare bolted connection resistance values to values of similar connections:
    a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    a) Refer to NETA ATS tables in the absence of manufacturer's published data.

3) Overload test trip times at 300 percent of overload element rating shall be in accordance with manufacturer's published time-current curve.
4) Test values for input circuit breaker shall be as specified in this Section.
5) Relay calibration results shall be as specified in this Section.
6) Continuity of bonding conductors shall be in accordance with NETA ATS.
7) Control devices shall perform in accordance with system requirements.
8) Operational tests shall conform to system design requirements.
9) Investigate fuse resistance values that deviate from each other by more than 15 percent.

6. Switches, air, low voltage:
   a. Visual and mechanical inspection:
      1) Compare equipment nameplate data with the Contract Document.
      2) Inspect physical and mechanical condition.
      3) Inspect anchorage, alignment, grounding, and required clearances.
      4) Verify the unit is clean.
      5) Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
      6) Verify that fuse sizes and types as indicated on the Drawings, short circuit studies, and coordination study.
      7) Verify that each fuse has adequate mechanical support and contact integrity.
      8) Inspect bolted electrical connections for high resistance using one of the following methods:
         a) Use of a low resistance ohmmeter.
         b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
            (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
      9) Verify operation and sequencing of interlocking systems.
      10) Verify correct phase barrier installation.
      11) Verify correct operation of all indicating and control devices.
      12) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
   b. Electrical tests:
      1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      2) Measure contact resistance across each switchblade and fuseholder.
      3) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data:
         a) In the absence of manufacturer's published data, use NETA ATS requirements.
      4) Measure fuse resistance.
      5) Verify cubicle space heater operation.
      6) Perform ground fault test as specified in this Section, if applicable.
      7) Perform tests on other protective devices as specified in this Section, if applicable.

c. Test values:
    1) Compare bolted connection resistance values to values of similar connections:
        a) Investigate values which deviate from those of similar bolted connection by more than 50 percent of the lowest value.
    2) Bolt-torque levels shall be in accordance with manufacturer's published data:
        a) Refer to NETA ATS tables in the absence of manufacturer's published data.

d. Test values - electrical:
    1) Compare bolted connection resistance values to values of similar connections:
        a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    2) Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
        a) If manufacturer's published data is not available, investigate values which deviate from those of similar bus connections and sections by more than 50 percent of the lowest value.
    3) Insulation-resistance values shall be in accordance with manufacturer's published data:
        a) Refer to NETA ATS tables in the absence of manufacturer's published data.
        b) Investigate insulation values less than the allowable minimum.
    4) Investigate fuse-resistance values that deviate from each other by more than 15 percent.
    5) Heaters shall be operational.
    6) Ground fault tests shall be as specified in this Section.
    7) Results of protective device tests shall be as specified in this Section.

3.08 FIELD QUALITY CONTROL (NOT USED)

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

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

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16990

CONDUIT SCHEDULE

PART 1 GENERAL

1.01 SUMMARY

A. Specific definitions:

1. Conduits:

a.	ARM:	Armored cable.
b.	GRC:	Galvanized rigid conduit.
c.	PCS:	PVC jacketed rigid steel conduit.
d.	IMC:	Intermediate metallic conduit.
e.	EMT:	Electrical metallic steel tubing.
f.	PVC:	Polyvinyl chloride rigid plastic conduit.
g.	SLT:	Sealtight - liquidtight flexible conduit.
h.	RAC:	Rigid aluminum conduit.
i.	FLX:	Flexible metallic conduit.
j.	NFC:	Non-metallic flexible conduit.

2. Cables:

a.	DN Thick:	DeviceNet “thick” cable.
b.	DN Thin:	DeviceNet “thin” cable.
c.	PBPA:	Profibus PA cable.
d.	PBDP:	Profibus DP cable.
e.	PBDPP:	Profibus DP cable with 24VDC power.
f.	FFBUS:	Foundation Fieldbus cable.
g.	RS-485	RS-485 cable.
h.	CAT5e:	Category 5 enhanced Ethernet cable.
i.	CAT6:	Category 6 Ethernet cable.
j.	CNET:	ControlNet cable.
k.	DH+:	Data Highway Plus cable.
l.	RIO:	Remote I/O cable.
m.	DF1:	Serial cable.
n.	MODB:	Modbus cable.
o.	MODB+:	Modbus Plus cable.
p.	*/FO:	Fiber optic cable (* indicates number of fibers).
q.	2/C#16S:	2 conductor, 16 gauge, twisted shielded pair. (*/2/C#16S * indicates number of pairs).
r.	3/C#16S:	3 conductor, 16 gauge, twisted shielded triplet. (*/3/C#16S * indicates number of triplets).
s.	*/C#Y:	Multiconductor cable (* indicates number of conductors, Y indicates conductor size and insulation).
t.	MFR:	Manufacturer or vendor furnished cable.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 CONDUIT SCHEDULE

A. Conduit Schedule is presented on the following pages.

SECTION 16990A

CONDUIT SCHEDULE

PART 1 GENERAL

1.01 SUMMARY

A. Conduit requirements:
   1. As defined in Section 16050 - Common Work Results for Electrical and Section 16130 - Conduits.

B. Cable requirements and definitions:
   1. As defined in Section 16050 - Common Work Results for Electrical and Section 16123 - 600-Volt or Less Wires and Cables.
   2. 2/CS#16: 2 conductor, 16 gauge, twisted shielded pair.
   3. */C#Y: Multiconductor cable (* indicates number of conductors, Y indicates conductor size and insulation).
   4. MFR: Manufacturer or vendor furnished cable.
   5. VFD: Shielded VFD cable with integral ground.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 CONDUIT SCHEDULE

A. Conduit Schedule is presented on the following pages.

CONDUIT SCHEDULE AREA 1

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CONDUIT			CONDUCTORS			GROUND				
NUMBER	**DWG**	**SIZE**	**#**	**SIZE**	**TYPE**	**#**	**SIZE**	**TYPE**	**DESCRIPTION**	**CONNECTING SEGMENTS**
C010		0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSH-4353	P012
									TO: CONDUIT TEE	
									2 #14 >> PSH-4353 CONTROL	
C015		0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSH-4354	P017
									TO: CONDUIT TEE	
									2 #14 >> PSH-4354 CONTROL	
C030		0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: LE-4433	
									TO: LIT-4433	
									1 MFR >> LE-4433 CONTROL	
C041		0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSH-4442	P043
									TO: CONDUIT TEE	
									2 #14 >> PSH-4442 CONTROL	
C046		0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSH-4443	P048
									TO: CONDUIT TEE	
									2 #14 >> PSH-4443 CONTROL	
C050		0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: LE-4350	
									TO: LIT-4350	
									1 MFR >> LE-4350 CONTROL	
C070		0.75"	12	#14	XHHW-2	1	#14	XHHW-2	FR: VFD-4425	C080
									TO: CONDUIT TEE	
									12 #14 >> VFD-4425 CONTROL	
C075		0.75"	12	#14	XHHW-2	1	#14	XHHW-2	FR: VFD-4426	C080
									TO: CONDUIT TEE	
									12 #14 >> VFD-4426 CONTROL	
C080		1.5"	24	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE	
									TO: RECLAIM-RTU	
									12 #14 >> VFD-4425 CONTROL	C070
									12 #14 >> VFD-4426 CONTROL	C075
C220		0.75"	10	#14	XHHW-2	1	#14	XHHW-2	FR: EDR-4441	C223
									TO: CONDUIT TEE	
									10 #14 >> EDR-4441 CONTROL	
C221		0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-4440	
									TO: DISC-4440	
									2 #12 >> AIT-4440 POWER	
C222		0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: DISC-4440	C223
									TO: CONDUIT TEE	
									2 #12 >> AIT-4440 POWER	
C223		0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE	C225
			10	#14	XHHW-2				TO: CONDUIT TEE	
									2 #12 >> AIT-4440 POWER	C222
									10 #14 >> EDR-4441 CONTROL	C220
C224		0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: AIT-4440	C225
									TO: CONDUIT TEE	
									2 #14 >> AIT-4440 CONTROL	
C225		1"	2	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE	
			12	#14	XHHW-2				TO: RECLAIM-RTU	
									2 #12 >> AIT-4440 POWER	C223
									10 #14 >> EDR-4441 CONTROL	C223
									2 #14 >> AIT-4440 CONTROL	C224
L025		0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LIT-4433	
									TO: SWITCH	
									2 #12 >> LIT-4433 POWER	
L026		0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LIT-4350	
									TO: SWITCH	
									2 #12 >> LIT-4350 POWER	
L030		0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: SWITCH	
									TO: CONDUIT TEE	
									2 #12 >> LIT-4433 POWER	
L031		0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: SWITCH	
									TO: CONDUIT TEE	
									2 #12 >> LIT-4350 POWER	
L035		0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE	
									TO: EXSTJ-BOX	
									2 #12 >> LIT-4433 POWER	L30
									2 #12 >> LIT-4350 POWER	L31

CONDUIT SCHEDULE AREA 1

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CONDUIT			CONDUCTORS			GROUND				
NUMBER	**DWG**	**SIZE**	**#**	**SIZE**	**TYPE**	**#**	**SIZE**	**TYPE**	**DESCRIPTION**	**CONNECTING SEGMENTS**
L300		0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LIT-4357 TO: DISC-4357 2 #12 >> LIT-4357 POWER	
L301		0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: DISC-4357 TO: J-BOX 2 #12 >> LIT-4357 POWER	L306
L304		0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LIT-4356 TO: DISC-4356 2 #12 >> LIT-4356 POWER	
L305		0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: DISC-4356 TO: J-BOX 2 #12 >> LIT-4356 POWER	L306
L306		0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: J-BOX 2 #12 >> LIT-4357 POWER 2 #12 >> LIT-4356 POWER	L310 L301 L305
L308		0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LIT-4355 TO: DISC-4355 2 #12 >> LIT-4355 POWER	
L309		0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: DISC-4355 TO: J-BOX 2 #12 >> LIT-4355 POWER	L310
L310		0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: UPS SCREEN 2 #12 >> LIT-4357 POWER 2 #12 >> LIT-4356 POWER 2 #12 >> LIT-4355 POWER	 L306 L306 L309
P001		1"	3	#6	XHHW-2	1	#8	XHHW-2	FR: DISC-SLP-4351 (MCC) TO: CONDUIT TEE 3 #6 >> SLP-4351 POWER (MCC)	
P002		1"	3	#6	XHHW-2	1	#8	XHHW-2	FR: DISC-SLP-4352 (MCC) TO: CONDUIT TEE 3 #6 >> SLP-4352 POWER (MCC)	
P003		1.5"	6	#6	XHHW-2	1	#8	XHHW-2	FR: EXSTJ-BOX TO: CONDUIT TEE 3 #6 >> SLP-4351 POWER (MCC) 3 #6 >> SLP-4352 POWER (MCC)	 P1 P2
P004		1"	3	#6	XHHW-2	1	#8	XHHW-2	FR: DISC-SLP-4351 (PMP) TO: CONDUIT TEE 3 #6 >> SLP-4351 (PMP) POWER	
P005		1"	3	#6	XHHW-2	1	#8	XHHW-2	FR: DISC-SLP-4352 (PMP) TO: CONDUIT TEE 3 #6 >> SLP-4352 (PMP) POWER	
P006		1.5"	6	#6	XHHW-2	1	#8	XHHW-2	FR: EXSTJ-BOX TO: CONDUIT TEE 3 #6 >> SLP-4351 (PMP) POWER 3 #6 >> SLP-4352 (PMP) POWER	 P4 P5
P010		1"	3 2 2	#6 #12 #14	XHHW-2 XHHW-2 XHHW-2	1	#8	XHHW-2	FR: SLP-4352 TO: CONDUIT TEE 3 #6 >> SLP-4352 POWER 2 #12 >> MWH-4352 POWER 2 #14 >> TSH-4352 CONTROL	P012
P012		1"	3 2 4	#6 #12 #14	XHHW-2 XHHW-2 XHHW-2	1	#8	XHHW-2	FR: CONDUIT TEE TO: EXSTJ-BOX 3 #6 >> SLP-4352 POWER 2 #12 >> MWH-4352 POWER 2 #14 >> TSH-4352 CONTROL 2 #14 >> PSH-4353 CONTROL	 P010 P010 P010 C010
P015		1"	3 2 2	#6 #12 #14	XHHW-2 XHHW-2 XHHW-2	1	#8	XHHW-2	FR: SLP-4351 TO: CONDUIT TEE 3 #6 >> SLP-4351 POWER 2 #12 >> MWH-4351 POWER 2 #14 >> TSH-4351 CONTROL	P017

CONDUIT SCHEDULE AREA 1

JVWTP IMPROVEMENT PROJECT

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ENGINEER	xxx
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CONDUIT			CONDUCTORS			GROUND				
NUMBER	**DWG**	**SIZE**	**#**	**SIZE**	**TYPE**	**#**	**SIZE**	**TYPE**	**DESCRIPTION**	**CONNECTING SEGMENTS**
P017		1"	3	#6	XHHW-2	1	#8	XHHW-2	FR: CONDUIT TEE	
			2	#12	XHHW-2				TO: EXSTJ-BOX	
			4	#14	XHHW-2				3 #6 >> SLP-4351 POWER	P015
									2 #12 >> MWH-4351 POWER	P015
									2 #14 >> TSH-4351 CONTROL	P015
									2 #14 >> PSH-4354 CONTROL	C015
P031		1"	3	#6	XHHW-2	1	#8	XHHW-2	FR: DISC-WWP-4432	P033
									TO: CONDUIT TEE	
									3 #6 >> WWP-4432 POWER (MCC)	
P032		1"	3	#6	XHHW-2	1	#8	XHHW-2	FR: DISC-WWP-4431	P033
									TO: CONDUIT TEE	
									3 #6 >> WWP-4431 POWER (MCC)	
P033		1.5"	6	#6	XHHW-2	1	#8	XHHW-2	FR: CONDUIT TEE	
									TO: EXSTJ-BOX	
									3 #6 >> WWP-4432 POWER (MCC)	P031
									3 #6 >> WWP-4431 POWER (MCC)	P032
P034		1"	3	#6	XHHW-2	1	#8	XHHW-2	FR: DISC-WWP-4432	P036
									TO: CONDUIT TEE	
									3 #6 >> WWP-4432 POWER (PMP)	
P035		1"	3	#6	XHHW-2	1	#8	XHHW-2	FR: DISC-WWP-4431	P036
									TO: CONDUIT TEE	
									3 #6 >> WWP-4431 POWER (PMP)	
P036		1.5"	6	#6	XHHW-2	1	#8	XHHW-2	FR: CONDUIT TEE	
									TO: EXSTJ-BOX	
									3 #6 >> WWP-4432 POWER (PMP)	P034
									3 #6 >> WWP-4431 POWER (PMP)	P035
P041		1"	3	#6	XHHW-2	1	#8	XHHW-2	FR: CONDUIT TEE	P043
			2	#12	XHHW-2				TO: EXSTJ-BOX	
			2	#14	XHHW-2				3 #6 >> WWP-4431 POWER	
									2 #12 >> MWH-4431 POWER	
									2 #14 >> TSH-4431 CONTROL	
P043		1"	3	#6	XHHW-2	1	#8	XHHW-2	FR: CONDUIT TEE	
			2	#12	XHHW-2				TO: EXSTJ-BOX	
			4	#14	XHHW-2				3 #6 >> WWP-4431 POWER	P041
									2 #12 >> MWH-4431 POWER	P041
									2 #14 >> TSH-4431 CONTROL	P041
									2 #14 >> PSH-4442 CONTROL	C041
P046		1"	3	#6	XHHW-2	1	#8	XHHW-2	FR: WWP-4432	P048
			2	#12	XHHW-2				TO: CONDUIT TEE	
			2	#14	XHHW-2				3 #6 >> WWP-4432 POWER	
									2 #12 >> MWH-4432 POWER	
									2 #14 >> TSH-4432 CONTROL	
P048		1"	3	#6	XHHW-2	1	#8	XHHW-2	FR: CONDUIT TEE	
			2	#12	XHHW-2				TO: EXSTJ-BOX	
			4	#14	XHHW-2				3 #6 >> WWP-4432 POWER	P046
									2 #12 >> MWH-4432 POWER	P046
									2 #14 >> TSH-4432 CONTROL	P046
									2 #14 >> PSH-4443 CONTROL	C046
P070		1.5"	3	#2/0	XHHW-2	1	#4	XHHW-2	FR: WWP-4425	
									TO: VFD-4425	
									3 #2/0 >> WWP-4425 POWER	
P071		2.5"	1	3/C-#2/0:VFD	VFD			INTEGRAL	FR: VFD-4425	
									TO: MCC-WW	
									1 3/C-#2/0:VFD >> WWP-4425 POWER	
P072		2.5"	1	3/C-#2/0:VFD	VFD			INTEGRAL	FR: VFD-4426	
									TO: MCC-WW	
									1 3/C-#2/0:VFD >> VFD-4426 POWER	
P075		1.5"	3	#2/0	XHHW-2	1	#4	XHHW-2	FR: WWP-4426	
									TO: VFD-4426	
									3 #2/0 >> WWP-4426 POWER	
P100		1.5"	6	#6	XHHW-2	1	#8	XHHW-2	FR: EXSTJ-BOX	
			4	#12	XHHW-2				TO: MCC-WW	
									3 #6 >> SLP-4352 POWER	
									3 #6 >> SLP-4351 POWER	
									2 #12 >> MWH-4352 POWER	
									2 #12 >> MWH-4351 POWER	

CONDUIT SCHEDULE AREA 1

JVWTP IMPROVEMENT PROJECT

JVWTP

ENGINEER	**xxx**
REVISION	**0**
DATE	1/29/20

CONDUIT			CONDUCTORS			GROUND				
NUMBER	**DWG**	**SIZE**	**#**	**SIZE**	**TYPE**	**#**	**SIZE**	**TYPE**	**DESCRIPTION**	**CONNECTING SEGMENTS**
P200		1.5"	6 4	#6 #12	XHHW-2 XHHW-2	1	#8	XHHW-2	FR: EXSTJ-BOX TO: MCC-WW 3 #6 >> WWP-4432 POWER 3 #6 >> WWP-4431 POWER 2 #12 >> MWH-4432 POWER 2 #12 >> MWH-4431 POWER	
P220		0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-4441 TO: DISC-4441 3 #10 >> EDR-4441 POWER	
P221		0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-4441 TO: MCC-WW 3 #10 >> EDR-4441 POWER	
S030		0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-4433 TO: CONDUIT TEE 1 2/CS-#16 >> LIT-4433 SIGNAL	
S031		0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-4350 TO: CONDUIT TEE 1 2/CS-#16 >> LIT-4350 SIGNAL	
S035		0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: RECLAIM-RTU 1 2/CS-#16 >> LIT-4433 SIGNAL 1 2/CS-#16 >> LIT-4350 SIGNAL	S30 S31
S070		0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: VFD-4425 TO: CONDUIT TEE 2 2/CS-#16 >> VFD-4425 SIGNAL	S080
S075		0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: VFD-4426 TO: CONDUIT TEE 2 2/CS-#16 >> VFD-4426 SIGNAL	S080
S080		1"	4	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: RECLAIM-RTU 2 2/CS-#16 >> VFD-4425 SIGNAL 2 2/CS-#16 >> VFD-4426 SIGNAL	S070 S075
S221		0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: AIT-4440 TO: RECLAIM-RTU 1 2/CS-#16 >> AIT-4440 SIGNAL	
S300		0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-4357 TO: J-BOX 1 2/CS-#16 >> LIT-4357 SIGNAL	S306
S304		0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-4356 TO: J-BOX 1 2/CS-#16 >> LIT-4356 SIGNAL	S306
S306		0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: J-BOX TO: J-BOX 1 2/CS-#16 >> LIT-4357 SIGNAL 1 2/CS-#16 >> LIT-4356 SIGNAL	S310 S300 S304
S308		0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-4355 TO: J-BOX 1 2/CS-#16 >> LIT-4355 SIGNAL	S310
S310		1"	3	2/CS-#16		1	#14	XHHW-2	FR: J-BOX TO: RTU SCREEN 1 2/CS-#16 >> LIT-4357 SIGNAL 1 2/CS-#16 >> LIT-4356 SIGNAL 1 2/CS-#16 >> LIT-4355 SIGNAL	S306 S306 S308

END OF CONDUIT SCHEDULE

END OF SECTION

SECTION 17050

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.
   3. As specified in this Section, PLC programming and SCADA/HMI software configuration will be provided by the Owner.

B. Interfaces to equipment, instruments, and other components:
   1. Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers, which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
   2. Provide all material and labor needed to install the actual equipment furnished, include all costs to add any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., which may be necessary to make a complete, functional installation based on the actual equipment furnished:
      a. Make all changes necessary to meet the manufacturer's wiring requirements.
   3. Submit all such changes and additions to the Engineer for acceptance as specified in the General Conditions.
   4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation and control systems are completely accounted for. Include any items indicated on the Drawings or in Specifications from another discipline in the scope of Work:
      a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
   5. Loop drawings:
      a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and for all pre-purchased equipment.
      b. The form, minimum level of detail, and format for the loop drawings must match that of the sample loop drawings included in the Contract Documents.
      c. The Owner and Engineer are not responsible for providing detailed loop diagrams for Contractor furnished equipment.

C. All instrumentation, and control equipment and systems for the entire project to comply with the requirements specified in the Instrumentation and Control Specifications, whether referenced in the individual Equipment Specifications or not:
   1. The requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in other Specifications, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
   2. Inform all vendors supplying instrumentation, control systems, panels, and/or equipment of the requirements of the Instrumentation and Control Specifications.

D. Contract Documents:
   1. General:
      a. The drawings and specifications are complementary and are to be used together in order to fully describe the Work.
   2. Specifications:
      a. General Conditions 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 Instrumentation and Control Drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the Instrumentation Work. Follow the drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the best possible installation, use the entire drawing set for construction purposes.
      b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only, exercise professional judgment in executing the Work to ensure the best possible installation:
         1) The equipment locations and dimensions indicated on the Drawings and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all instrumentation and control equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
         2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual Specifications; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
      c. Installation details:
         1) The Contract Drawings include installation details showing means and methods for installing instrumentation and control equipment. For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary for completing the Work, and submit these details for review by the Engineer.
      d. Schematic diagrams:
         1) All controls are shown de-energized.

2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
5) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences indicated on the Drawings or in the Specifications. Combine all information and furnish a coordinated and fully functional control system.

E. Alternates/Alternatives:
1. Substitute item provisions as specified in General Conditions.

F. Changes and change orders:
1. As specified in Section 01600 - Product Requirements.

1.02 REFERENCES

A. Code compliance:
1. As specified in Section 01410 - Regulatory Requirements:
a. The publications are referred to in the text by basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of Bid governs.
2. The following codes and standards are hereby incorporated into this Section:
a. American National Standards Institute (ANSI).
b. American Petroleum Institute (API):
1) RP 550 - Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5-Oxygen Analyzers.
2) RP 551 - Process Measurement Instrumentation.
c. International Organization for Standardization (ISO):
1) 9001 - Quality Management Systems - Requirements.
d. International Society of Automation (ISA):
1) 5.1 - Instrumentation Symbols and Identification.
2) 5.4 - Instrument Loop Diagrams.
3) 20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
e. National Electrical Manufacturers Association (NEMA):
1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
f. National Fire Protection Association (NFPA).
g. National Institute of Standards and Technology (NIST).
h. Underwriters Laboratories, Inc. (UL):
1) 508 - Standard of Safety for Industrial Control Equipment.
2) 508A - Standard of Safety for Industrial Control Panels.

B. Compliance with Laws and Regulations:
1. As specified in General Conditions.

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. Modifications: Changing, extending, interfacing to, removing, or altering an existing circuit.

C. NEMA:
   1. Type 1 enclosure in accordance with NEMA 250.
   2. Type 2 enclosure in accordance with NEMA 250.
   3. Type 3 enclosure in accordance with NEMA 250.
   4. Type 3R enclosure in accordance with NEMA 250.
   5. Type 3S enclosure in accordance with NEMA 250.
   6. Type 3X enclosure in accordance with NEMA 250.

7. Type 3RX enclosure in accordance with NEMA 250.
8. Type 3SX enclosure in accordance with NEMA 250.
9. Type 4 enclosure in accordance with NEMA 250.
10. Type 4X enclosure in accordance with NEMA 250.
11. Type 5 enclosure in accordance with NEMA 250.
12. Type 6 enclosure in accordance with NEMA 250.
13. Type 6P enclosure in accordance with NEMA 250.
14. Type 12 enclosure in accordance with NEMA 250.
15. Type 12K enclosure in accordance with NEMA 250.
16. Type 13 enclosure in accordance with NEMA 250.

D. Acronym definitions:
1. ACB: Automatic current balance.
2. ATS: Automatic Transfer Switch.
3. CCS: The PCS central computer system (CCS) consisting of computers and software. The personal computer-based hardware and software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher-level control system software and functions.
4. DPDT: Double-pole, double-throw.
5. ES: Enterprise system: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
6. FAT: Factory acceptance test also known as Source Test.
7. HART: Highway addressable remote transducer.
8. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped, and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
9. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically, information is displayed in a graphical format.
10. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
11. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
12. I/O: Input/Output.
13. IP: Internet protocol or ingress protection.
14. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
15. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
16. LOI: Local Operator Interface is an operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The LOI is typically a flat panel type of display mounted on the front of an enclosure with either a touch screen or tactile button interface.

17. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the HOA. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
18. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO, etc.
19. P&ID: Process and instrumentation diagram.
20. PC: Personal computer.
21. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings. This includes all the PCS and instruments and networking components as well as the various servers, workstations, thin clients, etc.
22. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
23. PCS: Process Control System: A general name for the computerized system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOs, LOIs, HMIs, both LCPs, VCPs and all data management systems accessible to staff.
24. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.
25. PLC: Programmable logic controller.
26. PS: Power supply.
27. RIO: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.
28. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
29. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment located outside of the facility, such as wells, lift stations, metering stations, etc.
30. SPDT: Single-pole, double-throw.
31. SPST: Single-pole, single-throw.
32. UPS: Uninterruptible power supply.
33. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, LOI, HMI, etc.
34. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330 - Submittal Procedures and this Section.

B. General:
   1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
   2. Furnish the submittals required by each section in the Instrumentation Specifications.
   3. Adhere to the wiring numbering scheme specified in Section 16075 - Identification for Electrical Systems throughout the Project:
      a. Uniquely number each wire.
      b. Wire numbers must appear on all Equipment Drawings.
   4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

C. Submittal preparation:
   1. During the period of preparation of submittals, the Contractor shall authorize direct, informal liaison between the ICSC and the Engineer for exchange of technical information. As a result of this liaison, certain minor refinements and revisions may be authorized informally by the Engineer, which do not alter the scope of Work or cause increase or decrease in the Contract price or times. During this informal exchange, no oral statement by the Engineer shall be construed to give formal approval of any component or method, nor shall any statement be construed to grant exception to, or variation from, these Contract Documents.
   2. In these Contract Documents, some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
      a. Employ the nomenclature and numbers designated in this Section and indicated on the Drawings exclusively throughout shop drawings, data sheets, and similar submittals.
      b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, suppliers, or subcontractor's standard methods with those identified in this Section and indicated on the Drawings.

D. Specific submittal requirements:
   1. Shop drawings:
      a. Required for materials and equipment listed in this and other sections.
      b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
      c. Shop drawings requirements:
         1) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
         2) Locations of conduit entrances and access plates.
         3) Component layout and identification.
         4) Schematic and wiring diagrams with wire numbers and terminal identification.
         5) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
         6) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
         7) Weight.
         8) Finish.

9) Nameplates:
a) As specified in Section 16075 - Identification for Electrical Systems or as indicated on the Drawings.
10) Temperature limitations, as applicable.

d. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
e. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
1) Uniquely number each wire per the Specifications.
f. Wire numbers must appear on all equipment drawings.
g. Organize the shop drawing submittals for inclusion in the Operation and Maintenance Manuals:
1) Furnish the initial shop drawing submittal bound in one or more standard size, 3-ring, D-ring, loose-leaf, vinyl plastic, hard-cover binders suitable for bookshelf storage.
2) Binder ring size: 2 inches.
h. Include the letterhead and/or title block of the firm responsible for the preparation of all shop drawings. Include the following information in the title block, as a minimum:
1) The firm's registered business name.
2) Firm's physical address, email address, and phone number.
3) Owner’s name.
4) Project name and location.
5) Drawing name.
6) Revision level.
7) Personnel responsible for the content of the drawing.
8) Date.
i. The work includes modifications to existing circuits:
1) Clearly show all modifications to existing circuits.
2) In addition, show all existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.

2. Product data:
a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
b. Include:
1) Catalog cuts.
2) Bulletins.
3) Brochures.
4) Quality photocopies of applicable pages from these documents.
5) Identify on the data sheets the Project name, applicable specification section, and paragraph.
6) Identify model number and options for the actual equipment being furnished.
7) Neatly cross out options that do not apply or equipment not intended to be supplied.
c. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
d. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
1) Uniquely number each wire per the Specifications.
e. Wire numbers must appear on all equipment drawings.

3. Detailed sequence of operation for all equipment or systems.
4. Operation and maintenance manuals:
    a. As specified in Section 01782 - Operation and Maintenance Data.
    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. 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.
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, including digital bus communication.

7) Scale range with units and multiplier.
8) Requirements for electric supply.
9) Requirements for air supply.
10) Power consumption.
11) Response timing.
12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
13) Special requirements or features, such as specifications for ambient operating conditions.
14) Features and options that are furnished.

b. Provide a technical brochure or bulletin (“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 01292 - Schedule of Values, submit per unit instrument and labor costs used in developing the final bid for the PCS system, for the express purpose of pricing and cost justification for any proposed change orders. It is the responsibility of the ICSC subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.
10. Installation recommendations:
    a. Submit the manufacturer's printed recommendations for installation of instrumentation equipment.
11. Training submittals:
    a. Develop and submit for review a general training plan for approval by Owner within 14 calendar days from Notice to Proceed. Include complete descriptions of all planned training classes, a preliminary training schedule, a list of all proposed instructors along with resumes, examples of proposed training manuals, and a description of any special training tools to be used (simulators, self-paced modules, personal computer-based training, etc.).
    b. The Engineer will review the general training plan. Special emphasis will be placed on review of the qualifications of the proposed instructors and the timing of the individual courses to maximize their effectiveness. If, in the opinion of the Engineer, the proposed instructors are not sufficiently qualified to conduct the specified training courses, or lack experience, where required, on the specific configuration of the system, provide more qualified instructors.
    c. The general training plan and schedule shall be updated by the Contractor at the beginning of each Phase and approved by the Owner a minimum of 30 days prior to commencement of training.
    d. Training course plan submittals:
        1) For each training course or other training activity, submit a detailed, complete outline and agenda for each lesson as specified in Section 01756 - Commissioning.
        2) Describe any student pre-requisites for the course or training activity.
        3) Provide an updated schedule for all sessions of the course, including dates, times, durations, and locations.
        4) Submit training materials.
    e. Incorporate all submittal review comments into the course.
    f. Do not conduct training courses before review and acceptance of the Course Plan submittal for the course.
12. Project Record documents:
    a. Furnish as specified in Section 01770 - Closeout Procedures.
    b. Record Drawing requirements:
        1) Provide Project Record Drawing of all Instrumentation Drawings.
        2) Update Record Drawings weekly.
        3) Record Drawings must be fully updated as a condition of the monthly progress payments.
        4) Clearly and neatly show all changes including the following:
            a) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.

13. Loop Drawings:
    a. Submit loop drawings for every analog, discrete, and fieldbus signal and control circuit:
        1) Provide a loop drawing submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop on this Project.
        2) This requirement applies to all signal and control circuits associated with equipment on this Project including vendor supplied equipment packages and control panels.
        3) Provide loop drawings in the format indicated in the contract drawings. Provide all tagging in accordance with the Owner's standard.
    b. Show every instrument and I/O point on at least one loop diagram.
    c. Provide a complete index in the front of each bound volume:
        1) Index the loop drawings by systems or process areas.
    d. Provide drawings showing definitive diagrams for every instrumentation loop system:
        1) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
        2) Furnish a separate drawing sheet for each system or loop diagram.
    e. In addition to the ISA-5.4 requirements, show the following details:
        1) Functional name of each loop.
        2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
        3) Show all terminal numbers, regardless of the entity providing the equipment.
        4) MCC panel, circuit, and breaker numbers for all power feeds to the loops and instrumentation.
        5) Designation of and, if appropriate, terminal assignments associated with, every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
        6) Show vendor control panel, instrument panel, conduit, junction box, equipment and PCS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
        7) If a circuit is continued on another drawing, show the name and number of the continuation drawing on the loop drawing. Provide complete references to all continuation drawings whether vendor control panels, other loop drawings, existing drawings provided by the Owner, or other drawings.
    f. In addition to the above requirements, provide loop diagrams in accordance with the example loop diagram as indicated on the Drawings.
14. Instrument Installation Drawings:
    a. Submit, instrument installation, mounting, and anchoring details for all components and assemblies, including access requirements and conduit connection or entry details.
    b. Furnish for each instrument a dedicated 8 1/2-inch by 11-inch installation detail that pertains to the specific instrument by tag number.
    c. For each detail, provide certification and the hard copies, by the instrument manufacturer, that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable.

d. For each detail, provide, as a minimum, the following contents:
    1) Necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
    2) Ambient temperature and humidity where the instrument is to be installed.
    3) Corrosive qualities of the environment where the instrument is to be installed.
    4) Hazardous rating of the environment where the instrument is to be installed.
    5) Process line pipe or tank size, service and material.
    6) Process tap elevation and location.
    7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
    8) Routing of tubing and identification of supports.
    9) Mounting brackets, stands, anchoring devices, and sunshades.
    10) Conduit entry size, number, location, and delineation between power and signal.
    11) NEMA ratings of enclosures and all components.
    12) Clearances required for instrument servicing.
    13) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

15. Control Panel Drawings:
    a. Layout Drawings:
        1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
        2) As a minimum, include the following information:
            a) To scale front, side, and plan views.
            b) Dimensions.
            c) Interior and exterior arrangements.
            d) Mounting information, including conduit entrance location.
            e) Finish data.
            f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
            g) Nameplate legend including text, letter size, materials, and colors.
    b. Wiring and piping diagrams:
        1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.
        2) Include the following information:
            a) Name of panel.
            b) Wiring and piping sizes and types.
            c) Terminal strip numbers.
            d) Wire tags and labels.
            e) Functional name and manufacturer's designation for items to which wiring and piping are connected.
            f) Electrical control schematics in accordance with ANSI standards.

c. Installation drawings:
    1) Provide site-specific installation drawings for all control equipment panels, including dimensions.
    2) Provide scaled drawings and show the position of the equipment at its intended installation location.
    3) Show the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas.
    4) Show all required access and clearances associated with the equipment with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.

16. Schematic Diagrams:
    a. Submit schematic diagrams for all electrical equipment in ladder diagram format.
    b. Include device and field connection terminal numbers on all schematic diagrams.
    c. Incorporate equipment manufacturer’s shop drawing information into the schematic diagrams in order to document the entire control system.
17. Control 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.
18. 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.
19. Test reports:
    a. As specified in Section 01330 - Submittal Procedures.

1.05 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.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements.

B. Special instructions:
   1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

C. Tagging:
   1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.
   2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment constituting the PCS.
   3. Tag instruments immediately upon receipt in the field.
   4. Prominently display identification on the outside of the package.
   5. Utilize the Tag and Loop Number identifications shown on the P&IDs.

D. Delivery and inspection:
   1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

1.07 PROJECT OR SITE CONDITIONS

A. Site conditions:
   1. Provide a PCS, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
   2. Seismic classification:
      a. Provide all equipment and construction techniques suitable for the seismic requirements for the site, as specified in Section 01612 - Seismic Design Criteria.
   3. Wind:
      a. Provide all equipment and construction techniques suitable for the site wind loading criteria, as specified in Section 01614 - Wind Design Criteria.
   4. Altitude, temperature and humidity:
      a. As specified in Section 01610 - Project Design Criteria.
      b. Provide all equipment and instrumentation fully rated for continuous operation at this altitude, temperature and humidity conditions with no additional derating factors applied.
      c. Provide additional temperature conditioning equipment to maintain all equipment and instrumentation in non-conditioned spaces or outdoors subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment manufacturer's guidelines:
         1) Provide all power wiring for these devices (e.g., heaters, fans, etc.), whether or not indicated on the Drawings.
   5. Area classifications:
      a. Furnish enclosures that match the area classifications as specified in Section 16050 - Common Work Results for Electrical.
   6. Site security:
      a. Abide by all security and safety rules concerning the Work on the Site, as specified in Section 01329 - Safety Plan.

1.08 SEQUENCING

A. General:
   1. As specified in Section 01756 - Commissioning.
   2. Testing requirements are specified in Section 01756 - Commissioning and Section 17950 - Commissioning for Instrumentation and Controls.
   3. Work restrictions and other scheduling requirements are specified in Section 01140 - Work Restrictions.
   4. Commissioning requirements as specified in Section 01756 - Commissioning.

B. Pre-submittal conferences:
   1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire project, equipment, control philosophy, schedules, and submittal requirements.
   2. The Owner, Contractor, instrumentation and control subcontractor, electrical subcontractor, and all manufacturers furnishing major pieces of equipment must attend, including but not limited to:
      a. Vendor control panels.
      b. Variable frequency drives.
      c. Source testing:
   3. 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.
   4. Before the delivery and installation of control panels, PLCs, control system equipment, and other PCS components at the job site, but after the procurement and assembly of components, perform Source Test.
   5. Schedule the Source Test after receiving approval of the Source Test procedures submittal.
   6. Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
   7. 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 01756 - Commissioning.

D. Installation testing:
   1. As specified in Section 01756 - Commissioning.
   2. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
   3. Acceptance of the PCIS Installation testing must be provided in writing by the Owner before the performance testing may begin.

E. Training:
   1. As specified in Section 01756 - Commissioning.

F. Functional testing:
   1. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
   2. Loop validation test.

3. As specified in Section 17950 - Commissioning for Instrumentation and Controls.
    a. Notify the Owner of scheduled tests a minimum of 21 days before the estimated completion date of installation and wiring of the PCIS.
    b. Complete loop validation testing a minimum of 5 days before the pre-commissioning phase of the project.
    c. Loop validation certifications:
        1) After the field device loop tests have been successfully completed as specified in Section 17950 - Commissioning for Instrumentation and Controls for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, Vendor, and the Owner's representative with test data entered, together with a clear and unequivocal statement that all instrumentation, including all control and signal wiring, has been successfully calibrated, inspected, and tested.
            a) Acceptance of the PCIS Installation Testing must be provided in writing by the Engineer before the Process Operational Period may begin.

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.

1.09 SCHEDULING (NOT USED)

1.10 WARRANTY

A. Provide additional warranty as specified in the individual Instrumentation and Control Specifications that extends beyond the Correction Period, as specified in General Conditions and Supplementary Conditions.

1.11 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.

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 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. Provide additional spare parts specified in other sections of the Instrumentation and Control Specifications.

D. Submit all special tools and spare parts, suitably wrapped and identified, before Process Operational Period commences.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide similar items from a single manufacturer throughout the PCIS portion of the Project.

B. Allowable manufacturers are specified in individual instrument and equipment specifications.

2.02 SYSTEM DESCRIPTION

A. General requirements:
   1. The Work includes everything necessary for and incidental to executing and completing the instrumentation and control system work indicated on the Drawings and specified in the Specifications and reasonably inferable there from including but not limited to:
      a. Preparing hardware submittals for field instrumentation.
      b. Design, develop, and draft loop drawings, control panel designs, and all other drawing submittals specified in the Instrumentation and Control Specifications.
      c. Prepare the test plan, the training plan, and the spare parts submittals.
      d. Procure all hardware.
      e. Perform bench calibration and verify calibration after installation.
      f. Oversee, document, and certify loop testing.
      g. Oversee, document, and certify system.
      h. Installation Testing.
      i. Oversee and document Functional Testing.
      j. Conduct the Process Operational Period and the Instrumentation and Controls Process Performance Testing.
      k. Prepare operation and maintenance manuals.
      l. Conduct training classes.
      m. Provide Record Drawings and Loop Drawings associated with Instruments and equipment:
         1) As specified in the Contract Documents.
         2) For Owner furnished items.
         3) For interfaces with existing equipment.
      n. Resolve signal, power, or functional incompatibilities between the PCS and interfacing devices.
      o. 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. The Owner will provide the configuration and programming for parts of the PLC and PC based control system, as described below.
    a. The following PLCs will be programmed by the Owner:
        1) RTU-RECLAIM PS.
        2) RTU-SCREEN
    b. The CCS consisting of personal computers and software that will be configured by the Owner.
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. Where demolition is indicated on the Drawings, the electrical subcontractor is responsible for disconnecting equipment electrical connections and rendering the equipment safe. The ICSC is responsible for physically removing all instrumentation to be demolished and return it either to the Owner or dispose of it as directed by the Owner's representative. The ICSC shall be responsible for any program modifications needed based on the demolition of the equipment, both for the loops directly and indirectly affected.
7. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment.
    a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before performing any Work.
    b. Provide and document interface with, modifications to, upgrade, or replacement of existing circuits, power systems, controls, and equipment.
8. Revise in a manner as directed by the Engineer all I/O and addressing that the Engineer determines to be unacceptable as a result of a lack of Contractor coordination between Contract Documents and all suppliers.
9. Defective Work:
    a. As specified in General Conditions.

B. Operating facility:
    1. As specified in Section 01140 - Work Restrictions.
    2. Portions of this existing facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
        a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction to meet the requirements of the Owner.

b. As weather and facility demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
c. Where portions of the Work are in existing facilities and require interface to existing circuits, power systems, controls and equipment, perform comprehensive and detailed field investigations of existing conditions. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.

3. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
4. Where shown or specified, replace existing field instruments with new.
5. Contractor is responsible for the integrity and measurement accuracy of all loops.
6. Any defect found in existing equipment is the responsibility of the Owner. Contractor is not responsible for defects on existing Owner components.
7. The standards of documentation, instrument tagging, cable and conductor termination, terminal identification and labeling that apply to the new installation apply equally to the existing installation.

2.03 EXISTING PRODUCTS (NOT USED)

2.04 MATERIALS

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

B. Provide materials complying with the applicable industrial standard as specified in the Contract Documents.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. Furnish all meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of submittal of the shop drawings unless otherwise specified to match existing equipment.

B. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of within 0.5 percent of full scale and a minimum repeatability of within 0.25 percent of full scale.

C. Signal transmission:
1. Analog signals:
a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
b. Furnish electrical analog signals outside control panels that are 4 to 20 milliamperes 24 VDC, except as indicated.
c. Electrically or optically isolate all analog signals from other signals.

d. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
e. Maintain the total 4-to-20 milliamperes loop impedance to 10 percent below the published value at the loop operating voltage.
f. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.

2. Pneumatic signals:
   a. All pneumatic signals: 3-to-15 pounds per square inch gauge.
3. Signal performance and design criteria:
   a. Stability:
      1) After Controls have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.
   b. Response:
      1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.
   c. Agreement:
      1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
   d. Repeatability:
      1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.
   e. Sensitivity:
      1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.
   f. Performance:
      1) All instruments and control devices shall perform in accordance with the manufacturers' specifications.

D. Discrete circuit configuration:
   1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
   2. Alarm contacts: Fail to the alarm condition.
   3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.

E. Grounding:
   1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
   2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable.
   3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
   4. Terminate the signal cable shield on a dedicated grounding terminal block.
   5. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

2.08 ACCESSORIES

A. Nameplates:
   1. Provide a nameplate for each controller, instrument transducer, instrument power supply, solenoid, or any other control device located either in the field or within panels.
   2. All nameplates shall be of identical style, color, and material throughout the facility.
   3. Device nameplates shall include:
      a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
         1) Device tag and loop number ID (e.g., FIT-60.011).
         2) PLC ID (e.g., PLC-11).
         3) Power information (e.g., PCM-11, 120 VAC).
      b. White lettering on a black background, laminated plastic.
   4. All instruments shall be equipped with Type 316 stainless steel nameplate with the instrument tag stamped in 3/8-inch letters and connected to the instrument using Type 316 stainless steel wire.

2.09 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL

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

B. Arrange with all manufacturers of the equipment and fabricators of panels and cabinets, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
   1. Equipment includes the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices.

C. Source Test is specified in Section 17950 - Commissioning for Instrumentation and Controls.

PART 3 EXECUTION

3.01 EXAMINATION

A. 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.

B. Provide a complete instrumentation and control system:
   1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, and process control and instrumentation system.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Equipment locations indicated on the Drawings may change due to variations in equipment size or minor changes made by others during construction:
   1. Verify all dimensions as indicated on the Drawings:
      a. Actual field conditions govern all final installed locations, distances, and levels.
   2. Review all information indicated on the Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
   3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.

B. Perform all related Electrical Work in accordance with the applicable sections of the Electrical Specifications.

C. The PCIS configurations are diagrammatic:
   1. The locations of equipment are approximate unless dimensioned.
   2. Where Project conditions require, make reasonable changes in locations and arrangements.

D. Field instruments installation:
   1. Install field instruments as specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer's instructions.
   2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
      a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
      b. Provide sun shields for all field electronic instruments located outdoors.
   3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
      a. Type of flexible conduit required for the area classification:
         1) Area classification as specified in Section 16050 - Common Work Results for Electrical.
      b. Maximum length of 18 inches.
   4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
      a. Special cable applications shall be in accordance with the NEC.
   5. Verify the correctness of each installation:
      a. Polarity of electric power and signal connections.
   6. Ensure all process connections are free of leaks.
   7. Provide a power disconnect switch for each 120 VAC powered instrument which does not have a built-in power disconnect:
      a. Disconnect enclosure suitable for the area classification:
         1) As specified in Section 16050 - Common Work Results for Electrical.

E. Process sensing lines and air tubing:
    1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
    2. Provide supports for rigid tubing at intervals of not more than 3 feet.
    3. Slope horizontal runs of instrument tubing at a minimum of 1/16-inch per foot to allow for draining of any condensate.
    4. Bends:
        a. Make bends for parallel lines symmetrical.
        b. Make bends without deforming or thinning the walls of the tubing.
    5. Square-cut and clean all ends of tubing before being inserted in the fittings.
    6. Provide bulkhead fittings at all panels requiring pipe and/or tubing entries.
    7. Use stainless steel tubing for all piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
        a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.

F. Equipment tie-downs:
    1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the Site.
    2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.

G. Existing instrumentation:
    1. Clean, recondition and re-calibrate each existing instrument to be reused, removed, or reinstalled using an authorized service facility of the instrument manufacturer.
    2. Provide certification of this Work before reinstallation of each instrument.

H. Instrument tagging:
    1. As specified in Section 16075 - Identification for Electrical Systems.
    2. Provide all field-mounted instruments with nameplates:
        a. Nameplates engraved with the instrument’s full tag number as indicated on the Drawings:
            1) Affix tags with stainless steel wire fasteners.
    3. Provide all back of panel instruments with nameplates:
        a. Engraved with the instrument’s full tag number as indicated on the Drawings:
    4. Provide all front of panel instruments with a nameplate:
        a. Engraving to include the following:
            1) Instrument’s full tag number.
            2) Service description.
        b. Nameplates:
            1) Secure nameplates to the panel with stainless steel screws.
            2) Use an accepted adhesive if screws would violate the NEMA or other ratings of the enclosure.

I. Cable and conductor termination:
    1. Terminate all cables and conductors on terminal blocks.

2. Terminal block enclosures:
   a. Suitable for the area classification as specified in Section 16050 - Common Work Results for Electrical.

J. Surge protection:
   1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments and the panel.
   2. Individually fuse each 4 to 20 milliamperes direct current loop with a 1/2-ampere fuse between power supplies and receiver surge protectors.
   3. Provide voltage surge protection for 4 wire transmitters and analyzers:
      a. Protect both power source and signal loop.

K. Scope and responsibilities:
   1. Refer to the following table for procurement and installation scope and responsibilities for the owner, design engineer, contractor, integrator, and programmer.

Item No.	Task	Responsible Parties					Service or Equipment Supplied By
		Owner (O)	Design Engineer (DE)	Contractor (C)	Integrator (I)		
1.00	**I&C Design Update**						
1.01	Owner-furnished equipment procurement.	L	A				O
1.02	Equipment and package system procurement.			L			C
1.03	Equipment and package system submittal preparation.			L			C
1.04	Equipment and package system submittal review.	A	L				DE/O
1.05	Update I&C design to incorporate any changes, if changes approved by Owner during the submittal processes, for equipment and/or package systems.	A	L		A		DE
2.00	**HMI Application Programming**						
2.01	HMI software application programming.	L					O
2.02	HMI graphical user interface.	L					O
3.00	**Integration**						
3.01	Instrumentation specifications and procurement.			A	L		I

Item No.	Task	Responsible Parties					Service or Equipment Supplied By
		Owner (O)	Design Engineer (DE)	Contractor (C)	Integrator (I)		
3.02	I&C design update to reflect approved Vendor submittals (if required).	A	L	S	S		
4.00	***Field Local Control Panels (LCPs)***						
4.01	LCP procurement and fabrication.			A	L		I
4.02	LCP installation.			A	L		I
5.00	**Instruments and Control Valves**						
5.01	Submittal and datasheets.			A	L		I
5.02	Procurement.			A	L		I
5.03	Installation.			A	L		I
5.04	Setup and/or calibration.			A	L		I
8.00	**Process Start-Up**						
8.01	Pre-operation and component test.	A	A	A	L		I
8.02	Loop checkout.	A	A	A	L		I
8.03	System Acceptance Test (SAT).	A	A	A	L		I
8.04	Operational testing.	A	A	A	L		I
8.05	Commissioning testing.	L	A	A	A		O
9.00	**Process Closeout**						
9.01	Redline drawings and/or electronic files submittal to Owner.			A	L		I
9.02	As-builts (record set) - Update all drawings.			A	L		I
9.03	Operation and maintenance manuals.			A	L		I

Item No.	Task	Responsible Parties					Service or Equipment Supplied By
		Owner (O)	Design Engineer (DE)	Contractor (C)	Integrator (I)		
9.04	Operational testing and commissioning sign-off forms.	W	W	A	L		I
9.05	Training.	W		A	L		I
9.06	Commissioning (process performance testing).	L	A	A	A	S	O
Key: L – Lead, A – Assist, S – Support, W – Witness							

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Owner Training:
   1. Demonstration requirements are specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.08 FIELD QUALITY CONTROL

A. Inspection:
   1. Allow for inspection of PCIS installation as specified in Section 01450 - Quality Control.
   2. Provide any assistance necessary to support inspection activities.
   3. Engineer inspections may include, but are not limited to, the following:
      a. Inspect equipment and materials for physical damage.
      b. Inspect installation for compliance with Drawings and Specifications.
      c. Inspect installation for obstructions and adequate clearances around equipment.
      d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
      e. Inspect equipment nameplate data to verify compliance with design requirements.
      f. Inspect cable terminations.
      g. Inspect/witness instrument calibrations/verifications.

4. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Commissioning for Instrumentation and Controls.

B. Instrument Installation Inspection:
   1. Provide any assistance necessary to support inspection activities.
   2. Inspections may include, but are not limited to, the following:
      a. Inspect equipment and materials for physical damage.
      b. Inspect the installed arrangement, lay lengths, orientation, piping obstructions, etc., that could affect the instruments accuracy or repeatability.
      c. Inspect installation for compliance with Drawings and Specifications.
      d. Inspect installation for obstructions and adequate clearances around equipment.
      e. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
      f. Inspect equipment nameplate data to verify compliance with design requirements.
      g. Inspect cable terminations.
      h. Inspect/witness instrument calibrations/verifications.
   3. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Commissioning for Instrumentation and Controls.
   4. Field acceptance testing: (Functional Testing) is specified in Section 17950 - Commissioning for Instrumentation and Controls. Additional general requirements are specified in Section 01756 - Commissioning.

C. Installation supervision:
   1. Ensure that the entire PCIS is installed in a proper and satisfactory manner. At a minimum, the ICSC shall provide the following services:
      a. Installation resources:
         1) Coordinate with the Contractor regarding installation requirements of the Contract Documents.
      b. Provide technical assistance to installation personnel by telephone:
         1) Furnish installation personnel with at least 1 copy of the accepted submittals, including all installation details.
      c. Periodic inspections during the construction period.
      d. A complete check of the completed installation to ensure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
      e. Field verify accuracy and calibration of all instruments.

3.09 ADJUSTING

A. Control valves:
   1. Stroke all control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
   2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.

B. Make all revisions necessary to the control system software, as directed by the Engineer.
   1. It is understood that the Contractor knows and agrees that changes will be required in the control system software during the Source Testing, Functional Testing, Process Operational Period, Process Start-Up, and during the Project Correction Period.

3.10 CLEANING

A. As specified in Section 01770 - Closeout Procedures.

B. Vacuum clean all control panels and enclosures before process start-up and again after final completion of the project.

C. Clean all panel surfaces.

D. Return to new condition any scratches and/or defects.

E. Wipe all instrument faces and enclosures clean.

F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
   1. Neatly coil and label all spare wiring lengths.
   2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

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

3.11 PROTECTION

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

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17206

LEVEL MEASUREMENT: ULTRASONIC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Ultrasonic level instruments.

B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Specific definitions:
   1. FDT: Field Device Tool.
   2. DTM: Device Type Manager.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

D. Manufacture instruments facilities certified to the quality standards of ISO Standard 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and Servicing.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Ultrasonic level sensor with 4-wire remote transmitter:
      a. Endress+Hauser, Prosonic S FDU Series Sensor with FMU Series Transmitter.
      b. Siemens, Echomax Series sensor with HydroRanger 200 Series Transmitter.

2.02 MANUFACTURED UNITS

A. Ultrasonic level measurement with 4-wire remote transmitter:
   1. General:
      a. Continuous non-contact level measurement device with remote transmitter using ultrasonic echo sensing. The transducer generates an ultrasonic pulse in the range of 12 to 50 kHz and measures the time required for the pulse to travel to the process surface and return. The distance is calculated from the send and receive times. Each 4-wire level transmitter system includes, but is not limited to:
         1) Ultrasonic transducer.
         2) Signal cable.
         3) Transmitter.

2. Performance requirements:
    a. Accuracy:
        1) 0.25 percent of range.
    b. Repeatability:
        1) 0.1 percent of range.
3. Ultrasonic transducer:
    a. Encapsulated in chemical- and corrosion-resistant material as indicated on the Instrument Data Sheet or Instrument Index.
    b. Class I Division 1 for transducer only.
    c. Operating temperature range: -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius).
    d. Operating relative humidity range: 5 to 95 percent.
    e. Functions:
        1) Temperature compensation.
    f. Mounting: As indicated in the Contract Documents.
    g. Sensors shall be rated for NEMA 6P submergence. Sensors shall have mechanical decoupling between sensor membrane and outer housing. Sensors shall be provided with automatic build up compensation to provide self-cleaning when condensation may occur. Sensors shall be provided with internal heating elements and separate power supplies for these elements when freezing condensation may occur.
4. Transmitter:
    a. Level-indicating transmitter:
        1) Indicator: Liquid crystal display with approximately 0.50-inch display scaled to read in engineering units.
        2) Sensitivity: Able to ignore momentary level spikes or momentary loss of echo and indicate loss of echo condition on indicating transmitter unit.
        3) Ability to allow for signal profiles and echo mapping:
            a) Provide manufacturer's software for re-mapping the signal.
    b. Functions:
        1) Level measurement.
        2) Tank volume.
        3) Flow measurement.
    c. Power supply:
        1) 120 VAC.
        2) Power consumption: 36 VA maximum.
    d. Outputs:
        1) Isolated 4 to 20 milliamperes DC.
        2) Relay outputs:
            a) Minimum 6 Form A or Form C contacts.
            b) Rated 5 amps at 250 VAC.
            c) Programmable.
        3) Enclosure: NEMA Type 4X.
        4) Mounting: As indicated in the Contract Documents.
        5) Operating temperature range from -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius); relative humidity of 10 to 100 percent.
        6) Power supply shall be 90-253 VAC, or 10.5-32 VDC.
        7) The transmitter shall have automatic volume calculation for horizontal or vertical tanks with 32 point linearization; pre-programmed linearization tables for flumes and weirs; back water detection for submerged flow conditions; sludge detection; synchronization of

pulses between two ultrasonic units used in same tank; automatic sensor detection; alternating pump control; rake/screen control.

8) There shall be at least 3 integral totalizers and 3 daily counters with the ability for simultaneous measurement of level and flow in storm water overflow basin with only 1 sensor; EE prom memory backup; temperature compensation; average, difference and sum calculations.

2.03 ACCESSORIES

A. Mounting brackets: As indicated on the Drawings.

B. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to manufacturer's standard at a facility that is traceable to NIST.
   1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

B. Turn on turbulent surface software feature for all installations measuring surfaces lacking a placid surface. This would include but not be limited to level measurements in mixed media filters and potentially wet wells.

3.06 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be as indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

Level Transmitter

PROJECT INFORMATION

PLANT JORDAN VALLEY WATER TREATMENT PLANT
PROJECT 10851A10
CUSTOMER JVWCD
LOCATION 15305 S 3200 WEST HERRIMAN, UT

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

SPECIFICATION NUMBER 17206
DRAWING NUMBER 00N02
SERVICE ULTRASONIC LEVEL METER
MEASURING PRINCIPLE ULTRASONIC
PLC RTU-RECLAIM PS
TYPICAL DETAILS NL174

CONNECTION

PROCESS CONNECTION NPT

FLUID

LEVEL RANGE 0-26.5 FT
TEMPERATURE N/A

ELEMENT

ELEMENT TAG NO. LE-4350
ELEMENT HAZ. MATERIALS N/A
SUBMERGENCE DETECTION NO
HEATED ELEMENT NO
ENCLOSURE CLASS NEMA 4X
ELEMENT MATERIAL MFR. STD.
TEMPERATURE COMP. NO

TRANSMITTER

TRANSMITTER TAG NO. LIT-4350
MOUNTING REMOTE
POWER 120VAC-1P
AMBIENT TEMPERATURE N/A
SURGE PROTECTION NO
HAZARDOUS APPROVALS N/A
ENCLOSURE CLASS NEMA 4X
OUTPUT 4-20 MA
MEASUREMENT APPL LEVEL

NOTES

[*]

Level Transmitter

PROJECT INFORMATION

PLANT JORDAN VALLEY WATER TREATMENT PLANT
CUSTOMER JVWCD
PROJECT 10851A10
LOCATION 15305 S 3200 WEST HERRIMAN, UT

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

SPECIFICATION NUMBER 17206
DRAWING NUMBER 00N05
SERVICE SLUDGE LAGOON 1 OVERFLOW LEVEL
MEASURING PRINCIPLE ULTRASONIC
PLC RTU-SCREEN
TYPICAL DETAILS NL187, NM107, EM202

CONNECTION

PROCESS CONNECTION NPT

FLUID

LEVEL RANGE 0-7 FT
TEMPERATURE N/A

ELEMENT

ELEMENT TAG NO. LE-4355
ELEMENT HAZ. MATERIALS N/A
SUBMERGENCE DETECTION NO
HEATED ELEMENT NO
ENCLOSURE CLASS NEMA 4X
ELEMENT MATERIAL MFR. STD.
TEMPERATURE COMP. NO

TRANSMITTER

TRANSMITTER TAG NO. LIT-4355
MOUNTING REMOTE
POWER 120VAC-1P
AMBIENT TEMPERATURE N/A
SURGE PROTECTION NO
HAZARDOUS APPROVALS N/A
ENCLOSURE CLASS NEMA 4X
OUTPUT 4-20 MA
MEASUREMENT APPL LEVEL

NOTES

[*]

Level Transmitter

PROJECT INFORMATION

PLANT JORDAN VALLEY WATER TREATMENT PLANT
PROJECT 10851A10
CUSTOMER JVWCD
LOCATION 15305 S 3200 WEST HERRIMAN, UT

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

SPECIFICATION NUMBER 17206
DRAWING NUMBER 00N05
SERVICE SLUDGE LAGOON 2 OVERFLOW LEVEL
MEASURING PRINCIPLE ULTRASONIC
PLC RTU-SCREEN
TYPICAL DETAILS NL187, NM107, EM202

CONNECTION

PROCESS CONNECTION NPT

FLUID

LEVEL RANGE 0-7 FT
TEMPERATURE N/A

ELEMENT

ELEMENT TAG NO. LE-4356
ELEMENT HAZ. MATERIALS N/A
SUBMERGENCE DETECTION NO
HEATED ELEMENT NO
ENCLOSURE CLASS NEMA 4X
ELEMENT MATERIAL MFR. STD.
TEMPERATURE COMP. NO

TRANSMITTER

TRANSMITTER TAG NO. LIT-4356
MOUNTING REMOTE
POWER 120VAC-1P
AMBIENT TEMPERATURE N/A
SURGE PROTECTION NO
HAZARDOUS APPROVALS N/A
ENCLOSURE CLASS NEMA 4X
OUTPUT 4-20 MA
MEASUREMENT APPL LEVEL

NOTES

[*]

Level Transmitter

PROJECT INFORMATION

PLANT JORDAN VALLEY WATER TREATMENT PLANT
PROJECT 10851A10
CUSTOMER JVWCD
LOCATION 15305 S 3200 WEST HERRIMAN, UT

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

SPECIFICATION NUMBER 17206
DRAWING NUMBER 00N05
SERVICE SLUDGE LAGOON 3 OVERFLOW LEVEL
MEASURING PRINCIPLE ULTRASONIC
PLC RTU-SCREEN
TYPICAL DETAILS NL187, NM107, EM202

CONNECTION

PROCESS CONNECTION NPT

FLUID

LEVEL RANGE 0-7 FT
TEMPERATURE N/A

ELEMENT

ELEMENT TAG NO. LE-4357
ELEMENT HAZ. MATERIALS N/A
SUBMERGENCE DETECTION NO
HEATED ELEMENT NO
ENCLOSURE CLASS NEMA 4X
ELEMENT MATERIAL MFR. STD.
TEMPERATURE COMP. NO

TRANSMITTER

TRANSMITTER TAG NO. LIT-4357
MOUNTING REMOTE
POWER 120VAC-1P
AMBIENT TEMPERATURE N/A
SURGE PROTECTION NO
HAZARDOUS APPROVALS N/A
ENCLOSURE CLASS NEMA 4X
OUTPUT 4-20 MA
MEASUREMENT APPL LEVEL

NOTES

[*]

Level Transmitter

PROJECT INFORMATION

PLANT JORDAN VALLEY WATER TREATMENT PLANT
PROJECT 10851A10
CUSTOMER JVWCD
LOCATION 15305 S 3200 WEST HERRIMAN, UT

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

SPECIFICATION NUMBER 17206
DRAWING NUMBER 00N03
SERVICE ULTRASONIC LEVEL METER
MEASURING PRINCIPLE ULTRASONIC
PLC RTU-RECLAIM PS
TYPICAL DETAILS NL174

CONNECTION

PROCESS CONNECTION NPT

FLUID

LEVEL RANGE 0-26.5 FT
TEMPERATURE N/A

ELEMENT

ELEMENT TAG NO. LE-4433
ELEMENT HAZ. MATERIALS N/A
SUBMERGENCE DETECTION NO
HEATED ELEMENT NO
ENCLOSURE CLASS NEMA 4X
ELEMENT MATERIAL MFR. STD.
TEMPERATURE COMP. NO

TRANSMITTER

TRANSMITTER TAG NO. LIT-4433
MOUNTING REMOTE
POWER 120VAC-1P
AMBIENT TEMPERATURE N/A
SURGE PROTECTION NO
HAZARDOUS APPROVALS N/A
ENCLOSURE CLASS NEMA 4X
OUTPUT 4-20 MA
MEASUREMENT APPL LEVEL

NOTES

[*]

SECTION 17316

FLOW MEASUREMENT: ROTAMETERS (VARIABLE AREA FLOWMETERS)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Rotameters (variable area flowmeters).

B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. ABB.
   2. Brooks.
   3. King Instrument Co.

2.02 MANUFACTURED UNITS

A. Rotameters:
   1. General:
      a. Variable area type flowmeters with local flow indication.
      b. Glass tube type.
   2. Performance requirements:
      a. Flow range:
         1) As specified in instrument data sheets or instrument index.
      b. Accuracy:
         1) Glass tube: Within 2.0 percent of range.
         2) Repeatability: 0.50 percent of range.
   3. Element:
      a. Flow tube:
         1) Glass tube: Borosilicate glass, or as required to be compatible with the process conditions.
      b. Turndown: 10 to 1.
      c. Process temperature:
         1) Glass tube: 32 to 200 degrees Fahrenheit.
      d. Maximum process pressure:
         1) Glass tube: 100 pounds per square inch gauge.
         2) Size tube for the largest of the following:
            a) 2.0 times the normal flow rate.
            b) 1.2 times the maximum flow rate.
            c) 4.0 times the minimum flow rate.
      e. Float:
         1) Design to provide the widest possible immunity band change for lowest pressure loss.

4. Components:
    a. Seals: O-rings or packing glands fully compatible with process fluid.
    b. Integral needle valve for flow control.
5. Other:
    a. Process connection:
        1) As indicated on the Mechanical Drawings.
    b. Mounting:
        1) Provide all necessary hardware for rotameter mounting.

2.03 ACCESSORIES (NOT USED)

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
    1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.08 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

Rotameter

SPECIFICATION: 17316

PROJECT INFORMATION

PLANT JORDAN VALLEY WATER TREATMENT PLANT

CUSTOMER JVWCD

PROJECT 10851A10

LOCATION 15305 S 3200 WEST HERRIMAN, UT

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

Tag:	P&ID				
FI-4358	00N02	**SERVICE:** SEAL WATER ROTAMETER			
		FLUID: WATER	**TYPICAL DETAILS:** [*]	**FLOW RANGE:** 0-5 GPM	
		MEASURING PRINCIPLE: VARIABLE AREA FLOW	**PRESSURE:** 125 PSI	**VISCOSITY:** N/A	
		LINE SIZE: [*]	**TEMPERATURE:** N/A	**SEAL MATERIAL:** EPDM	
		LINE MATERIAL: [*]	**PROCESS CONN.:** F-NPT	**TUBE MATERIAL:** BOROSILICATE GLASS	
		PROCESS CONN. MAT'L: F-NPT			
Tag:	**P&ID**				
FI-4368	00N02	**SERVICE:** SEAL WATER ROTAMETER			
		FLUID: WATER	**TYPICAL DETAILS:** [*]	**FLOW RANGE:** 0-5 GPM	
		MEASURING PRINCIPLE: VARIABLE AREA FLOW	**PRESSURE:** 125 PSI	**VISCOSITY:** N/A	
		LINE SIZE: [*]	**TEMPERATURE:** N/A	**SEAL MATERIAL:** EPDM	
		LINE MATERIAL: [*]	**PROCESS CONN.:** F-NPT	**TUBE MATERIAL:** BOROSILICATE GLASS	
		PROCESS CONN. MAT'L: F-NPT			
Tag:	**P&ID**				
FI-4439	00N03	**SERVICE:** SEAL WATER ROTAMETER			
		FLUID: WATER	**TYPICAL DETAILS:** [*]	**FLOW RANGE:** 0-5 GPM	
		MEASURING PRINCIPLE: VARIABLE AREA FLOW	**PRESSURE:** 125 PSI	**VISCOSITY:** N/A	
		LINE SIZE: [*]	**TEMPERATURE:** N/A	**SEAL MATERIAL:** EPDM	
		LINE MATERIAL: [*]	**PROCESS CONN.:** F-NPT	**TUBE MATERIAL:** BOROSILICATE GLASS	
		PROCESS CONN. MAT'L: F-NPT			
Tag:	**P&ID**				
FI-4449	00N03	**SERVICE:** SEAL WATER ROTAMETER			
		FLUID: WATER	**TYPICAL DETAILS:** [*]	**FLOW RANGE:** 0-5 GPM	
		MEASURING PRINCIPLE: VARIABLE AREA FLOW	**PRESSURE:** 125 PSI	**VISCOSITY:** N/A	
		LINE SIZE: [*]	**TEMPERATURE:** N/A	**SEAL MATERIAL:** EPDM	
		LINE MATERIAL: [*]	**PROCESS CONN.:** F-NPT	**TUBE MATERIAL:** BOROSILICATE GLASS	
		PROCESS CONN. MAT'L: F-NPT			

SECTION 17401

PRESSURE/VACUUM MEASUREMENT: DIAPHRAGM SEALS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Diaphragm seals.

B. Provide all seals identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Additional requirements:
   1. Product data:
      a. Manufacturer's installation instructions.
      b. Seal type.
      c. Body materials.
      d. Diaphragm material.
      e. Fill fluid type.
      f. Seal size.
      g. Options.
      h. Process connection.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify the compatibility with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.

c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Diaphragm seals:
   1. 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.
      b. Mansfield and Green:
         1) Flushing connection: Type SG.
      c. Wika:
         1) Type L990.10.

2.02 MANUFACTURED UNITS

A. Diaphragm seals:
   1. General:
      a. Diaphragm seal and pressure instrument shall be assembled by pressure instrument manufacturer and shipped as an assembly.
   2. Requirements:
      a. Seal type:
         1) Metallic diaphragm: Welded to upper housing.
         2) Elastomer diaphragm: Bonded to upper housing.
      b. Process connection: 1-inch NPT.

c. Instrument connection: 1/2-inch NPT.
d. Material Construction: Type 316 Stainless Steel.
e. Provide 1/4-inch flushing connection in diaphragm lower housing or provide flushing ring.
f. Flush port plug: Same material of construction as diaphragm lower housing.
g. Provide fill/bleed connection.
h. Mounting: As indicated in the Contract Documents.
i. Provide Type 316 stainless steel armored capillary for all remote installations.
j. Nuts and bolts: Type 316 stainless steel.
k. Materials of construction:
    1) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures greater than 15 pounds per square inch:
        a) Diaphragm: Type 316 stainless steel.
        b) Lower housing: Type 316 stainless steel.
        c) Upper housing: Manufacturer's standard.
        d) Fill fluid: Silicone oil.

2.03 ACCESSORIES (NOT USED)

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation System.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

C. Do not use Teflon thread seal tape on pressure instruments with silicone oil fill fluid.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING (NOT USED)

3.06 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17402

PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Valve manifolds and instrument valves.

B. Provide all valves identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Additional requirements:
   1. Product data:
      a. 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 17050 - Common Work Results for Process Control and Instrumentation Systems.

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 17050 - Common Work Results for Process Control and Instrumentation Systems.

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 17050 - Common Work Results for Process Control and Instrumentation Systems.
   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 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. 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. Gauge valve:
   1. One of the following or equal:
      a. Anderson Greenwood.
      b. Hex Valve.

2.02 MANUFACTURED UNITS

A. 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.

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 17050 - Common Work Results for Process Control and Instrumentation Systems.

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 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of all valves.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.06 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Demonstrate performance of all valves to the Engineer before commissioning.

3.08 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17403

PRESSURE/VACUUM MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure/vacuum switches.

B. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Additional requirements:
   1. Product data:
      a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Mechanical type pressure switch: One of the following or equal:
   1. Ashcroft, B Series Type 400.
   2. United Electric Controls Series 400.
   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) Single-pole double-throw (SPDT).
3) Rated at 5 A, 125/250 VAC.
4) Automatic reset type.
h. Enclosure: Epoxy coated:
1) NEMA Type 4X.
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 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals:
1. Diaphragm seal and pressure switch shall be assembled by manufacturer and shipped as an assembly.

C. Furnish gauge valves as specified in Section 17402 - Pressure/Vacuum Measurement: Instrument Valves.

D. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Factory calibrate each 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 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments specified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

Pressure Switch

SPECIFICATION: 17403

PROJECT INFORMATION

PLANT JORDAN VALLEY WATER TREATMENT PLANT

CUSTOMER JVWCD

PROJECT 10851A10

LOCATION 15305 S 3200 WEST HERRIMAN, UT

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

Tag:	P&ID						
PSH-4353	00N02	**SERVICE:**	PRESSURE SWITCH HIGH				
PE-4353		**FLUID:**	WATER	**HAZARDOUS APP:**	N/A	**POWER:**	[*]
		MEASURING PRINCIPLE:	PRESS SW	**ELEM. ENCL. CLASS:**	NEMA 4X	**POWER LOCATION:**	LOOP
		SET POINT:	40 PSIG OPEN	**ELEMENT MATERIAL:**	MFR. STD.	**OUTPUT:**	RELAY
		MOUNTING:	INTEGRAL	**SWITCH ENCL. CLASS:**	NEMA 4X	**RELAY FORM:**	SPDT
		TYPICAL DETAILS:	NP502	**ENCL. MATERIAL:**	MFR. STD.	**PLC:**	RTU-RECLAIM PS
		PRESSURE:	0-60 PSIG	**SURGE PROTECTION:**	NO	**MANUAL RESET:**	NO
		TEMPERATURE:	N/A	**BOTT. HOUSING MAT.:**	MFR. STD.	**SEAL TYPE:**	DIAPHRAGM
		CONN. MOUNTING:	BOTTOM	**INSTRUMENT VALVES:**	ISOLATION VALVE	**DIAPHRAGM/WET MAT:**	MFR. STD.
Tag:	**P&ID**	**SERVICE:**	PRESSURE SWITCH HIGH				
PSH-4354	00N02	**FLUID:**	WATER	**HAZARDOUS APP:**	N/A	**POWER:**	[*]
PE-4354		**MEASURING PRINCIPLE:**	PRESS SW	**ELEM. ENCL. CLASS:**	NEMA 4X	**POWER LOCATION:**	LOOP
		SET POINT:	40 PSIG OPEN	**ELEMENT MATERIAL:**	MFR. STD.	**OUTPUT:**	RELAY
		MOUNTING:	INTEGRAL	**SWITCH ENCL. CLASS:**	NEMA 4X	**RELAY FORM:**	SPDT
		TYPICAL DETAILS:	NP502	**ENCL. MATERIAL:**	MFR. STD.	**PLC:**	RTU-RECLAIM PS
		PRESSURE:	0-60 PSIG	**SURGE PROTECTION:**	NO	**MANUAL RESET:**	NO
		TEMPERATURE:	N/A	**BOTT. HOUSING MAT.:**	MFR. STD.	**SEAL TYPE:**	DIAPHRAGM
		CONN. MOUNTING:	BOTTOM	**INSTRUMENT VALVES:**	ISOLATION VALVE	**DIAPHRAGM/WET MAT:**	MFR. STD.
Tag:	**P&ID**	**SERVICE:**	SEAL WATER LOW PRESSURE SWITCH				
PSL-4356	00N02	**FLUID:**	WATER	**HAZARDOUS APP:**	N/A	**POWER:**	[*]
PE-4356		**MEASURING PRINCIPLE:**	PRESS SW	**ELEM. ENCL. CLASS:**	NEMA 4X	**POWER LOCATION:**	LOOP
		SET POINT:	5 PSIG CLOSE	**ELEMENT MATERIAL:**	MFR. STD.	**OUTPUT:**	RELAY
		MOUNTING:	INTEGRAL	**SWITCH ENCL. CLASS:**	NEMA 4X	**RELAY FORM:**	SPDT
		TYPICAL DETAILS:	NP503	**ENCL. MATERIAL:**	MFR. STD.	**PLC:**	RTU-RECLAIM PS
		PRESSURE:	0-60 PSIG	**SURGE PROTECTION:**	NO	**MANUAL RESET:**	NO
		TEMPERATURE:	N/A	**BOTT. HOUSING MAT.:**	MFR. STD.	**SEAL TYPE:**	DIAPHRAGM
		CONN. MOUNTING:	BOTTOM	**INSTRUMENT VALVES:**	ISOLATION VALVE	**DIAPHRAGM/WET MAT:**	MFR. STD.

Pressure Switch

SPECIFICATION: 17403

PROJECT INFORMATION

PLANT JORDAN VALLEY WATER TREATMENT PLANT

CUSTOMER JVWCD

PROJECT 10851A10

LOCATION 15305 S 3200 WEST HERRIMAN, UT

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

Tag:	P&ID						
PSL-4366	00N02	**SERVICE:**	SEAL WATER LOW PRESSURE SWITCH				
PE-4366		**FLUID:**	WATER	**HAZARDOUS APP:**	N/A	**POWER:**	[*]
		MEASURING PRINCIPLE:	PRESS SW	**ELEM. ENCL. CLASS:**	NEMA 4X	**POWER LOCATION:**	LOOP
		SET POINT:	5 PSIG CLOSE	**ELEMENT MATERIAL:**	MFR. STD.	**OUTPUT:**	RELAY
		MOUNTING:	INTEGRAL	**SWITCH ENCL. CLASS:**	NEMA 4X	**RELAY FORM:**	SPDT
		TYPICAL DETAILS:	NP503	**ENCL. MATERIAL:**	MFR. STD.	**PLC:**	RTU-RECLAIM PS
		PRESSURE:	0-60 PSIG	**SURGE PROTECTION:**	NO	**MANUAL RESET:**	NO
		TEMPERATURE:	N/A	**BOTT. HOUSING MAT.:**	MFR. STD.	**SEAL TYPE:**	DIAPHRAGM
		CONN. MOUNTING:	BOTTOM	**INSTRUMENT VALVES:**	ISOLATION VALVE	**DIAPHRAGM/WET MAT:**	MFR. STD.

Tag:	P&ID						
PSL-4437	00N03	**SERVICE:**	SEAL WATER LOW PRESSURE SWITCH				
PE-4437		**FLUID:**	WATER	**HAZARDOUS APP:**	N/A	**POWER:**	[*]
		MEASURING PRINCIPLE:	PRESS SW	**ELEM. ENCL. CLASS:**	NEMA 4X	**POWER LOCATION:**	LOOP
		SET POINT:	5 PSIG CLOSE	**ELEMENT MATERIAL:**	MFR. STD.	**OUTPUT:**	RELAY
		MOUNTING:	INTEGRAL	**SWITCH ENCL. CLASS:**	NEMA 4X	**RELAY FORM:**	SPDT
		TYPICAL DETAILS:	NP503	**ENCL. MATERIAL:**	MFR. STD.	**PLC:**	RTU-RECLAIM PS
		PRESSURE:	0-60 PSIG	**SURGE PROTECTION:**	NO	**MANUAL RESET:**	NO
		TEMPERATURE:	N/A	**BOTT. HOUSING MAT.:**	MFR. STD.	**SEAL TYPE:**	DIAPHRAGM
		CONN. MOUNTING:	BOTTOM	**INSTRUMENT VALVES:**	ISOLATION VALVE	**DIAPHRAGM/WET MAT:**	MFR. STD.

Tag:	P&ID						
PSH-4442	00N03	**SERVICE:**	PRESSURE SWITCH HIGH				
PE-4442		**FLUID:**	WATER	**HAZARDOUS APP:**	N/A	**POWER:**	[*]
		MEASURING PRINCIPLE:	PRESS SW	**ELEM. ENCL. CLASS:**	NEMA 4X	**POWER LOCATION:**	LOOP
		SET POINT:	40 PSIG OPEN	**ELEMENT MATERIAL:**	MFR. STD.	**OUTPUT:**	RELAY
		MOUNTING:	INTEGRAL	**SWITCH ENCL. CLASS:**	NEMA 4X	**RELAY FORM:**	SPDT
		TYPICAL DETAILS:	NP502	**ENCL. MATERIAL:**	MFR. STD.	**PLC:**	RTU-RECLAIM PS
		PRESSURE:	0-60 PSIG	**SURGE PROTECTION:**	NO	**MANUAL RESET:**	NO
		TEMPERATURE:	N/A	**BOTT. HOUSING MAT.:**	MFR. STD.	**SEAL TYPE:**	DIAPHRAGM
		CONN. MOUNTING:	BOTTOM	**INSTRUMENT VALVES:**	ISOLATION VALVE	**DIAPHRAGM/WET MAT:**	MFR. STD.

Pressure Switch

SPECIFICATION: 17403

PROJECT INFORMATION

PLANT JORDAN VALLEY WATER TREATMENT PLANT

CUSTOMER JVWCD

PROJECT 10851A10

LOCATION 15305 S 3200 WEST HERRIMAN, UT

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

Tag:	P&ID	SERVICE: PRESSURE SWITCH HIGH					
PSH-4443	00N03	**FLUID:**	WATER	**HAZARDOUS APP:**	N/A	**POWER:**	[*]
PE-4443		**MEASURING PRINCIPLE:**	PRESS SW	**ELEM. ENCL. CLASS:**	NEMA 4X	**POWER LOCATION:**	LOOP
		SET POINT:	40 PSIG OPEN	**ELEMENT MATERIAL:**	MFR. STD.	**OUTPUT:**	RELAY
		MOUNTING:	INTEGRAL	**SWITCH ENCL. CLASS:**	NEMA 4X	**RELAY FORM:**	SPDT
		TYPICAL DETAILS:	NP502	**ENCL. MATERIAL:**	MFR. STD.	**PLC:**	RTU-RECLAIM PS
		PRESSURE:	0-60 PSIG	**SURGE PROTECTION:**	NO	**MANUAL RESET:**	NO
		TEMPERATURE:	N/A	**BOTT. HOUSING MAT.:**	MFR. STD.	**SEAL TYPE:**	DIAPHRAGM
		CONN. MOUNTING:	BOTTOM	**INSTRUMENT VALVES:**	ISOLATION VALVE	**DIAPHRAGM/WET MAT:**	MFR. STD.

Tag:	P&ID	SERVICE: SEAL WATER LOW PRESSURE SWITCH					
PSL-4447	00N03	**FLUID:**	WATER	**HAZARDOUS APP:**	N/A	**POWER:**	[*]
PE-4447		**MEASURING PRINCIPLE:**	PRESS SW	**ELEM. ENCL. CLASS:**	NEMA 4X	**POWER LOCATION:**	LOOP
		SET POINT:	5 PSIG CLOSE	**ELEMENT MATERIAL:**	MFR. STD.	**OUTPUT:**	RELAY
		MOUNTING:	INTEGRAL	**SWITCH ENCL. CLASS:**	NEMA 4X	**RELAY FORM:**	SPDT
		TYPICAL DETAILS:	NP503	**ENCL. MATERIAL:**	MFR. STD.	**PLC:**	RTU-RECLAIM PS
		PRESSURE:	0-60 PSIG	**SURGE PROTECTION:**	NO	**MANUAL RESET:**	NO
		TEMPERATURE:	N/A	**BOTT. HOUSING MAT.:**	MFR. STD.	**SEAL TYPE:**	DIAPHRAGM
		CONN. MOUNTING:	BOTTOM	**INSTRUMENT VALVES:**	ISOLATION VALVE	**DIAPHRAGM/WET MAT:**	MFR. STD.

SECTION 17404

PRESSURE/VACUUM MEASUREMENT: GAUGES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure/vacuum gauges.

B. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. American Society of Mechanical Engineers (ASME):
   1. B40.100 - Pressure Gauges and Gauge Attachments.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Additional requirements:
   1. Product data:
      a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Ashcroft:
      a. Maximum pressure greater than or equal to 10 pounds per square inch: Model 1279.
   2. Wika.
   3. Ametek U.S. Gauge.

2.02 MANUFACTURED UNITS

A. General:
   1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.

B. Performance requirements:
   1. Pressure range:
      a. As specified in the Contract Documents.
   2. Accuracy:
      a. Grade 2A, as defined by ASME B40.100.
      b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
      c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.
   3. Element:
      a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon® tube.

b. Socket tips for bellows and Bourdon® tube:
1) Materials: Type 316 stainless steel.
c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
d. Wetted materials: Type 316 stainless steel.

4. Dial gauge:
a. Dial size: 4-1/2 inches.
b. Dial case material:
1) Maximum pressure less than 10 pounds per square inch:
a) Phenolic.
c. Provide safety gauge with safety blow out through the back or top of the unit.
d. Dial face: Gasketed shatterproof glass or polycarbonate.
e. Provide gauge locks on all pressure gauges directly connected to diaphragm seals.
f. Provide gauge locks where possible.
g. Connection and mounting:
1) Direct mounted and suitable for outdoor installation.
2) 1/2-inch NPT.
3) Connection material: Stainless steel.
h. Pointer: Externally adjustable.

2.03 ACCESSORIES

A. Pulsation dampeners and snubbers:
1. Provide pulsation dampener or snubber with each pressure gauge installed on discharge of positive displacement type pump.
2. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
3. Materials: Type 316 stainless steel.
4. Mount pulsation dampener or snubber integrally to the pressure gauge.
5. Connection: 1/2-inch NPT.

B. Provide diaphragm seals as specified in the Contract Documents and in Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals:
1. Diaphragm seal and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

C. Provide means for gauge isolation as specified in Section 17402 - Pressure/Vacuum Measurement: Instrument Valves:
1. Mount valve manifold integrally to the gauge.
2. Valve manifold and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

D. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

Pressure Gauge

SPECIFICATION: 17404

PROJECT INFORMATION

PLANT JORDAN VALLEY WATER TREATMENT PLANT

CUSTOMER JVWCD

PROJECT 10851A10

LOCATION 15305 S 3200 WEST HERRIMAN, UT

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

Tag:	P&ID				
PI-4357	00N02	**SERVICE:** SEAL WATER PRESSURE INDICATOR			
		FLUID: WATER	**CONNECTION TYPE:** 1/2 IN NPT	**BOTT. HOUSING MAT.:** 316L STAINLESS STEEL	
		TEMPERATURE: 32-70 DEG F	**ISOLATION SEALS:** N/A	**INSTRUMENT VALVES:** ISOLATION VALVE	
		MEASURING PRINCIPLE: DIRECT	**CASE MATERIAL:** PHENOLLIC	**DIAPHRAGM MAT.:** 316L STAINLESS STEEL	
		TYPICAL DETAILS: NP503	**DIAL SIZE:** 4-1/2"	**AMBIENT TEMP:** 32-70 DEG F	
		GAUGE RANGE: 0-60 PSI	**OPTIONS:** [*]		
Tag:	**P&ID**				
PI-4367	00N02	**SERVICE:** SEAL WATER PRESSURE INDICATOR			
		FLUID: WATER	**CONNECTION TYPE:** 1/2 IN NPT	**BOTT. HOUSING MAT.:** 316L STAINLESS STEEL	
		TEMPERATURE: 32-70 DEG F	**ISOLATION SEALS:** N/A	**INSTRUMENT VALVES:** ISOLATION VALVE	
		MEASURING PRINCIPLE: DIRECT	**CASE MATERIAL:** PHENOLLIC	**DIAPHRAGM MAT.:** 316L STAINLESS STEEL	
		TYPICAL DETAILS: [*]	**DIAL SIZE:** 4-1/2"	**AMBIENT TEMP:** 32-70 DEG F	
		GAUGE RANGE: 0-60 PSI	**OPTIONS:** [*]		
Tag:	**P&ID**				
PI-4438	00N03	**SERVICE:** SEAL WATER PRESSURE INDICATOR			
		FLUID: WATER	**CONNECTION TYPE:** 1/2 IN NPT	**BOTT. HOUSING MAT.:** 316L STAINLESS STEEL	
		TEMPERATURE: 32-70 DEG F	**ISOLATION SEALS:** N/A	**INSTRUMENT VALVES:** ISOLATION VALVE	
		MEASURING PRINCIPLE: DIRECT	**CASE MATERIAL:** PHENOLLIC	**DIAPHRAGM MAT.:** 316L STAINLESS STEEL	
		TYPICAL DETAILS: NP503	**DIAL SIZE:** 4-1/2"	**AMBIENT TEMP:** 32-70 DEG F	
		GAUGE RANGE: 0-60 PSI	**OPTIONS:** [*]		
Tag:	**P&ID**				
PI-4448	00N03	**SERVICE:** SEAL WATER PRESSURE INDICATOR			
		FLUID: WATER	**CONNECTION TYPE:** 1/2 IN NPT	**BOTT. HOUSING MAT.:** 316L STAINLESS STEEL	
		TEMPERATURE: 32-70 DEG F	**ISOLATION SEALS:** N/A	**INSTRUMENT VALVES:** ISOLATION VALVE	
		MEASURING PRINCIPLE: DIRECT	**CASE MATERIAL:** PHENOLLIC	**DIAPHRAGM MAT.:** 316L STAINLESS STEEL	
		TYPICAL DETAILS: NP503	**DIAL SIZE:** 4-1/2"	**AMBIENT TEMP:** 32-70 DEG F	
		GAUGE RANGE: 0-60 PSI	**OPTIONS:** [*]		

SECTION 17509

ANALYZERS: TURBIDITY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Turbidity analyzers (turbidimeters).

B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. CSA International (CSA).

C. United States Environmental Protection Agency (USEPA):
   1. Method 180.1 - Determination of Turbidity by Nephelometry.

1.03 DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Turbidimeters: Insitu type: The following, no equal:
   1. HACH - SOLITAX sensor with sc200 controller.

2.02 MANUFACTURED UNITS

A. Turbidimeters: Insitu type:
   1. General: Probe type turbidity sensor mounted directly in process piping or basin.
   2. Performance requirements:
      a. Range: 0 to 1,000 NTU.
      b. Accuracy:
         1) Within 3 percent of reading from 0 to 1,000 NTU.
      c. Resolution: 0.01 NTU.
      d. Repeatability:
         1) 0 less than 40 NTU within 10 percent.
         2) 40 to 1,000 NTU within 10 percent.
      e. Response time:
         1) Initial response in 1 minute.

2) 1 second adjustable.

3. Element:
   a. The turbidimeter shall be a microprocessor-based, continuous-reading, on-line nephelometric instrument. Each turbidity system shall consist of 1 sensor and 1 transmitter.
   b. Light shall be directed through the surface of the sample and the detector shall be immersed directly in the sample line, basin, or process pipe, eliminating windows and flow cells.
   c. Optical components shall be mounted in a sealed head assembly that can be removed easily for calibration/service, without disturbing sample or process flow.
   d. The turbidimeter body shall be constructed of stainless steel or corrosion-resistant PVC.
   e. Sample flow required: 250 to 750 milliliter per minute (4.0 to 11.9 gallons per hour). Maximum 3 meters per second flow velocity for direct mounting in process piping.
   f. Operating humidity: 5 to 95 percent non-condensing.
   g. Sample temperature: 0 degrees Celsius to 40 degrees Celsius (32 degrees Fahrenheit to 122 degrees Fahrenheit).
   h. Maximum total cable length: 200 meters (640 feet).
4. Transmitter:
   a. The graphical interface unit shall be a microprocessor-based device capable of functioning in a single sensor, and as a digital interface link between turbidimeters and other communication devices through a digital bus communications.
   b. The interface unit shall allow operators to control sensor and network functions with user-friendly, menu-driven software, and shall provide data logging of measurement data from up to 8 turbidimeters for 1 hour, 24 hours or 30 days, and the capability to transfer data to a computer or printer via an RS-232 serial input/output device.
   c. Operating temperature: 0 degrees Celsius to 40 degrees Celsius (32 degrees Fahrenheit to 104 degrees Fahrenheit).
   d. The interface unit and separate DC power supply shall be housed in NEMA Type 4X (indoor) industrial plastic enclosures.
   e. Microprocessor-based signal converter/transmitter:
   f. Electrical connections:
      1) 1/2-inch NPT female.
   g. Piping connections:
      1) 2-inch flange connection.
   h. Enclosures NEMA Type 4X/IP66.
   i. Power supply:
      1) 120 VAC.
      2) Power consumption: 7.5 VA maximum.
   j. Outputs:
      1) 2 Isolated 4 to 20 milliamperes DC.
      2) Relay outputs:
         a) 2 Form C contact.
         b) Rated 5 amps at 230 VAC.
         c) Programmable.

2.03 ACCESSORIES

A. Mounting brackets as required or as indicated on the Drawings.

B. Provide sunshades for outdoor installations.

C. Flushing solenoids for cleaning the probe as recommended by the manufacturer.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to manufacturer's standard at a facility that is traceable to the NIST.
   1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide manufacturer's services to perform installation inspection, start-up and calibration/verification.

3.05 ADJUSTING

A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.06 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

Analyzer Transmitter

PROJECT INFORMATION

PLANT JORDAN VALLEY WATER TREATMENT PLANT
PROJECT 10851A10
CUSTOMER JVWCD
LOCATION 15305 S 3200 WEST HERRIMAN, UT

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

SPECIFICATION NUMBER 17509
DRAWING NUMBER 00N01
SERVICE TURBIDITY
POWER LOCATION RTU-RECLAIM PS
MEASURING PRINCIPLE [*]
PLC RTU-RECLAIM PS
TYPICAL DETAILS [*]

FLUID

FLUID WATER
MEASUREMENT RANGE 0-4,000 NTU
SAMPLE FLOW N/A
SAMPLE pH
PRESSURE N/A
TEMPERATURE N/A
SAMPLE TEMPERATURE 40 - 80 DEG F

ELEMENT

ELEMENT TAG NO. AE-4440
ENCLOSURE CLASS NEMA 4X
CLEANING APPARATUS NO
PROCESS CONNECTION INSERTION
HAZARDOUS APPROVALS N/A
ELEMENT MOUNTING KIT

TRANSMITTER

TRANSMITTER TAG NO. AIT-4440
ENCLOSURE CLASS NEMA 4X
TRANS. MOUNTING REMOTE
POWER 120VAC-1P
SURGE PROTECTION NO
AIR CLEANING SYSTEM NO
SIGNAL OUTPUT AI
OUTPUT 4-20 MA
TRANS. HAZ APPROVALS N/A
RELAY OPTIONS YES
AMBIENT TEMPERATURE 60 DEG F

NOTES

[*]

SECTION 17903

SCHEDULES: I/O LIST

PART 1 GENERAL

1.01 SUMMARY

A. The I/O list is not a take-off list. Additional information is as indicated on the Drawings and specified in the Contract Documents. Where any discrepancies between this list and the P&ID drawings arise, the P&ID shall govern.

B. Abbreviations used in the I/O list are defined on the Drawings.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 I/O LIST

A. I/O list attached.

END OF SECTION

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PLC I/O Listing for RTU-RECLAIM PS

Drawing	Tag	I/O	Location	Description	Service	(E/F)
00N1.	A-4440	AI	RTU-RECLAIM PS	TURB		
00N2.	L-4350	AI	RTU-RECLAIM PS		ULTRASONIC LEVEL METER	
00N3.	L-4433	AI	RTU-RECLAIM PS		ULTRASONIC LEVEL METER	
00N4.	SB-4425	AI	RTU-RECLAIM PS	SPEED IN	EXISTING WASH WATER RECYCLE PUMP 1	
00N4.	SB-4426	AI	RTU-RECLAIM PS	SPEED IN	EXISTING WASH WATER RECYCLE PUMP 2	
RTU-RECLAIM Total AI Points = 5						
00N4.	SS-4425	AO	RTU-RECLAIM PS	SPEED OUT	EXISTING WASH WATER RECYCLE PUMP 1	
00N4.	SS-4426	AO	RTU-RECLAIM PS	SPEED OUT	EXISTING WASH WATER RECYCLE PUMP 2	
RTU-RECLAIM Total AO Points = 2						

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PLC I/O Listing for RTU-RECLAIM PS

Drawing	Tag	I/O	Location	Description	Service	(E/F)
00N2.	AUX1-4351	DI	RTU-RECLAIM PS	RUNNING	SLUDGE WET WELL PUMP 1	
00N2.	AUX1-4352	DI	RTU-RECLAIM PS	RUNNING	SLUDGE WET WELL PUMP 2	
00N4.	AUX1-4425	DI	RTU-RECLAIM PS	RUNNING	EXISTING WASH WATER RECYCLE PUMP 1	
00N4.	AUX1-4426	DI	RTU-RECLAIM PS	RUNNING	EXISTING WASH WATER RECYCLE PUMP 2	
00N3.	AUX1-4431	DI	RTU-RECLAIM PS	RUNNING	DECANT WET WELL PUMP 3	
00N3.	AUX1-4432	DI	RTU-RECLAIM PS	RUNNING	DECANT WET WELL PUMP 4	
00N2.	AUX2-4351	DI	RTU-RECLAIM PS	FAULT	SLUDGE WET WELL PUMP 1	
00N2.	AUX2-4352	DI	RTU-RECLAIM PS	FAULT	SLUDGE WET WELL PUMP 2	
00N4.	AUX2-4425	DI	RTU-RECLAIM PS	FAULT	EXISTING WASH WATER RECYCLE PUMP 1	
00N4.	AUX2-4426	DI	RTU-RECLAIM PS	FAULT	EXISTING WASH WATER RECYCLE PUMP 2	
00N3.	AUX2-4431	DI	RTU-RECLAIM PS	FAULT	DECANT WET WELL PUMP 3	
00N3.	AUX2-4432	DI	RTU-RECLAIM PS	FAULT	DECANT WET WELL PUMP 4	
00N2.	HSAR-4351	DI	RTU-RECLAIM PS	REMOTE	SLUDGE WET WELL PUMP 1	
00N2.	HSAR-4352	DI	RTU-RECLAIM PS	REMOTE	SLUDGE WET WELL PUMP 2	
00N4.	HSAR-4425	DI	RTU-RECLAIM PS	REMOTE	EXISTING WASH WATER RECYCLE PUMP 1	
00N4.	HSAR-4426	DI	RTU-RECLAIM PS	REMOTE	EXISTING WASH WATER RECYCLE PUMP 2	
00N3.	HSAR-4431	DI	RTU-RECLAIM PS	REMOTE	DECANT WET WELL PUMP 3	
00N3.	HSAR-4432	DI	RTU-RECLAIM PS	REMOTE	DECANT WET WELL PUMP 4	
00N1.	HSAR-4441	DI	RTU-RECLAIM PS	REMOTE	WEIR BOX DISCHARGE VALVE	
00N2.	PSH-4353	DI	RTU-RECLAIM PS		PRESSURE SWITCH HIGH	
00N2.	PSH-4354	DI	RTU-RECLAIM PS		PRESSURE SWITCH HIGH	
00N3.	PSH-4442	DI	RTU-RECLAIM PS		PRESSURE SWITCH HIGH	
00N3.	PSH-4443	DI	RTU-RECLAIM PS		PRESSURE SWITCH HIGH	
00N2.	PSL-4356	DI	RTU-RECLAIM PS		SEAL WATER LOW PRESSURE SWITCH	
00N2.	PSL-4366	DI	RTU-RECLAIM PS		SEAL WATER LOW PRESSURE SWITCH	
00N3.	PSL-4437	DI	RTU-RECLAIM PS		SEAL WATER LOW PRESSURE SWITCH	
00N3.	PSL-4447	DI	RTU-RECLAIM PS		SEAL WATER LOW PRESSURE SWITCH	

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PLC I/O Listing for RTU-RECLAIM PS

Drawing	Tag	I/O	Location	Description	Service	(E/F)
00N2.	TSH-4351	DI	RTU-RECLAIM PS	HIGH TEMP	SLUDGE WET WELL PUMP 1	
00N2.	TSH-4352	DI	RTU-RECLAIM PS	HIGH TEMP	SLUDGE WET WELL PUMP 2	
00N4.	TSH-4425	DI	RTU-RECLAIM PS	HIGH TEMP	EXISTING WASH WATER RECYCLE PUMP 1	
00N4.	TSH-4426	DI	RTU-RECLAIM PS	HIGH TEMP	EXISTING WASH WATER RECYCLE PUMP 2	
00N3.	TSH-4431	DI	RTU-RECLAIM PS	HIGH TEMP	DECANT WET WELL PUMP 3	
00N3.	TSH-4432	DI	RTU-RECLAIM PS	HIGH TEMP	DECANT WET WELL PUMP 4	
00N1.	ZSC-4441	DI	RTU-RECLAIM PS	CLOSED	WEIR BOX DISCHARGE VALVE	
00N1.	ZSO-4441	DI	RTU-RECLAIM PS	OPENED	WEIR BOX DISCHARGE VALVE	
RTU-RECLAIM Total DI Points = 35						
00N2.	MS-4351	DO	RTU-RECLAIM PS	RUN	SLUDGE WET WELL PUMP 1	
00N2.	MS-4352	DO	RTU-RECLAIM PS	RUN	SLUDGE WET WELL PUMP 2	
00N4.	MS-4425	DO	RTU-RECLAIM PS	RUN	EXISTING WASH WATER RECYCLE PUMP 1	
00N4.	MS-4426	DO	RTU-RECLAIM PS	RUN	EXISTING WASH WATER RECYCLE PUMP 2	
00N3.	MS-4431	DO	RTU-RECLAIM PS	RUN	DECANT WET WELL PUMP 3	
00N3.	MS-4432	DO	RTU-RECLAIM PS	RUN	DECANT WET WELL PUMP 4	
00N1.	ZCC-4441	DO	RTU-RECLAIM PS	CLOSE	WEIR BOX DISCHARGE VALVE	
00N1.	ZCO-4441	DO	RTU-RECLAIM PS	OPEN	WEIR BOX DISCHARGE VALVE	
RTU-RECLAIM Total DO Points = 8						

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PLC I/O Listing for RTU-SCREEN

Drawing	Tag	I/O	Location	Description	Service	(E/F)
00N5.	L-4355	AI	RTU-SCREEN		SLUDGE LAGOON 1 OVERFLOW LEVEL	
00N5.	L-4356	AI	RTU-SCREEN		SLUDGE LAGOON 2 OVERFLOW LEVEL	
00N5.	L-4357	AI	RTU-SCREEN		SLUDGE LAGOON 3 OVERFLOW LEVEL	
RTU-SCREEN Total AI Points = 3						

SECTION 17950

COMMISSIONING FOR INSTRUMENTATION AND CONTROLS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Testing requirements that apply to process control and instrumentation systems for the entire Project.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Electronics Industries Alliance (EIA).

C. Telecommunications Industry Association (TIA).

1.03 DEFINITIONS

A. As specified in Sections 01756 - Commissioning and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Specific definitions:
   1. Complete End-to-End Testing (CEET) - Signals are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
   2. Loop Validation Tests - Signals are tested from the field device to the PLC.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330 - Submittal Procedures.

B. General:
   1. Reference additional detailed test submittal scheduling and prerequisite requirements as specified in the Sequencing article of Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Overall test plan:
   1. Develop 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.
   2. Describe the test phases as they apply specifically to this Project and each process system.
   3. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.

4. Provide examples of proposed forms and checklists.

D. Test procedures:
   1. Provide a statement of test objectives for each test.
   2. Prepare specific procedures for each process system.
   3. 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.
   4. 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.
   5. Describe the expected role of the Engineer, as well as any requirements for assistance from Owner's staff.
   6. Provide the forms and checklists to be used.

E. Test forms:
   1. Submit completed calibration forms, test forms, and checklists.
      a. Test forms shall include the detailed test procedures, or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
      b. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
      c. Sample test forms at the end of this Section show the minimum required content.
         1) The sample test forms have not been customized for this Project.
         2) Contractor shall develop and submit test forms customized for the Project and meeting the specified test and submittal requirements.

F. Details on the simulator construction, components, and operation. Testing binders:
   1. Sub-system to be tested, provide and submit a test binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
   2. Fill out in advance headings and all other information known before the test.
   3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
   4. Include or list reference material and provide separately at the time of the test.
   5. Record test results and verify that all test requirements and conditions have been met.

G. Test reports:
   1. At the conclusion of each test, submit a complete test report, including all test results and certifications.
   2. Include all completed test binders, forms, and checklists.
   3. Submission, review, and acceptance of each test report is required before the start of the sub-system.

1.06 QUALITY ASSURANCE

A. Test personnel:
   1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Installation supervision:
   1. Provide as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. Commissioning as specified in Section 01756 - Commissioning.

B. Testing and training phase:
   1. Owner training:
      a. Demonstration requirements are specified in this Section.

Table 1			
Course Title	**Minimum Course Length (hours per session)**	**Personnel (Estimated Number of Students)**	**Minimum Number of Sessions**
Instrument Training	8	3	1

      b. 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.
   2. Recording training sessions:
      a. Record all training.
      b. Provide pre-recorded audio-visual presentations Produce audio-visual presentations by recording the actual training sessions of the Owner's personnel.
      c. Furnish digital video disk (DVD) format.
      d. These disks become the property of the Owner and cover, in detail, the training for the specific hardware and software of all the systems provided for the Project.
      e. Provide all the necessary cameras and recording equipment.
   3. Installation testing:
      a. Calibration:
         1) Performed by Contractor and ICSC.
         2) Calibrate and adjust all instruments, devices, valves, and systems, in conformance with the component manufacturer's instructions and as specified in these Contract Documents.
         3) Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
            a) Calibration for discrete devices:
               (1) Calibrate and adjust devices for reliable operation and to avoid nuisance tripping.
            b) Calibration for ultrasonic and radar level devices:
               (1) Provide Echo Transmission and signal quality on level transmitters including guided and unguided units.
                  (a) Submit printout of the actual transmission and parameters.
               (2) Adjust mounting, as required, to obtain accurate readings.
               (3) Post mounting: Provide any additional calibration required by manufacturer.

c) Calibrating analog transmitters:
(1) Components having adjustable features are to be set accurately for the specific conditions and applications of this installation.
(2) Test and verify that components and/or systems are within the specified limits of accuracy.
(3) Calibration points:
(a) Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to NIST.
(4) Field verify calibration of instruments including units that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
d) Analyzer calibration:
(1) Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical representatives.
(2) Submit completed instrument calibration sheets for every field instrument and analyzer.
(3) Calibration tags:
(a) Attach a calibration and testing tag to each instrument, piece of equipment, or system.
(b) Sign the tag when calibration is complete.
e) Calibration for industrial networking test equipment:
f) Submit calibration documentation.

b. Loop check:
1) Performed by the Contractor.
2) Cabling installed, terminated, and labeled.
3) Perform continuity check of wiring to each field device through intermediate devices to field terminals in the cabinet.
4) Complete loop check form for each device.
5) Submit loop check test results before proceeding to the next step.

c. Loop validation tests:
1) Performed by the Contractor, ICSC, and manufacturer's representative, working together, and witnessed by the Owner or Owner's representative.
2) Perform tests on the signal from each field device through intermediate devices to the I/O module on the PLC.
a) The PLC may or may not be connected to the network.
3) Engineer approval of the loop validation test submittal is required before proceeding to CEET.
4) Submit final documentation (including traces), using the approved test form, to the Engineer upon successful completion of the testing.

d. Complete End-to-End Testing (CEET):
1) Performed by Contractor, ICSC, and OWNER working together.
a) The participants need to be dedicated full-time to CEET.
b) Owner will provide staff to verify input signals at, and create output signals from, an HMI or Engineering Workstation.
c) Contractor and ICSC will be responsible for creating field signals and verifying proper operation of final control elements.

2) Prerequisites:
    a) CEET cannot begin until the successful completion of the preceding tests:
        (1) Calibration.
        (2) Loop check.
        (3) Loop validation tests.
3) Testing description:
    a) This testing is to ensure all I/O signals operate to the intent of the design from the field device to the HMI and all other auxiliary controls and indicators in the PCS.
    b) Connect PLC to the network to test signals from the field device through the PLC program, the network, and to the operator's HMI graphic screens. The outputs will be energized for a duration long enough to verify proper operation of the final control element.
    c) SCADA screens:
        (1) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
        (2) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
        (3) Retest any loop following any necessary corrections.
4) Check control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the HMI/SCADA system.
    a) Use actual process inputs wherever available.
    b) Issue commands from the HMI/SCADA system and verify proper responses of field devices.
        (1) Test SCADA system inputs from field device to SCADA system operator workstations.
            (a) Track responses through trend charts in the HMI/SCADA system.
        (2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.
5) Discrete device testing:
    a) Exercise each field device providing a discrete input to the HMI/SCADA system in the field and observe the proper operation shall be observed at the operator workstation:
        (1) Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
        (2) Exercise starters, relay contacts, switch contacts, and observe proper operation.
        (3) Calibrate and test instruments supplying discrete inputs and observe proper operation.
    b) Test each device accepting a discrete output signal from the HMI/SCADA. Perform the appropriate operator action at the

SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:

(1) Stroke valves through outputs from the HMI/SCADA system, and confirm proper directional operation. Confirm travel limits and any feedback signals to the HMI/SCADA system.

(2) Exercise motors starters from the HMI/SCADA system and verify proper operation through direct field observation.

(3) Exercise solenoids and other field devices from the HMI/SCADA system and verify proper operation through direct field observation.

6) Analog device testing:
   a) Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
   b) Apply provisional settings on controllers and alarm setpoints.
7) Analog input:
   a) Exercise each field device monitoring the analog signal, through the HMI/SCADA system.
      (1) Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
8) Analog output:
   a) Exercise each field device requiring an analog command signal, through the HMI/SCADA system.
      (1) Vary the output from the PLC HMI/SCADA system and measure the end device position, speed, etc. to confirm the proper operation of the device for the supplied analog signal.
      (2) Manually set the output from the HMI/SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
9) Submit completed test forms.
   a) Discrete instrument input devices:
      (1) Switch setting, contact action, and dead band.
      (2) Valve position switches:
         (a) Response in the PLC as the valve is stroked from the PLC.
         (b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
      (3) Operator interface switches (control stations and other pilot devices) and associated response.
      (4) Starter and drive auxiliary device contact response.
      (5) Response of all other discrete inputs to the PLC.
      (6) Test equipment used and associated serial numbers.
   b) Discrete output devices:
      (1) Observed response of field device to the discrete output from the PLC.

(2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.
(3) Test equipment used and associated serial numbers.

c) Analog input devices:
(1) Calibration range.
(2) Calibration data: Input, output, and error at each test value.
(3) Analog input associated PLC register address.
(4) Value in PLC register at each test point.
(5) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).
(6) Test equipment used and associated serial numbers.

d) Analog output devices:
(1) Calibration range.
(2) Test value at each test point.
(3) Analog output associated PLC register address.
(4) Control variable value at field device at each test point.
(5) Physical device response at each test point:
(a) Response to be actual valve position, or motor speed, etc.
(6) Test equipment used and associated serial numbers.

10) Failure testing:
a) Demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
(1) Equipment failure.
(2) Communications sub-system error.
(3) Power failure.
(4) Process equipment failure.
(5) High system loading conditions.

11) Engineer approval of the CEET submittals is required before proceeding to Functional Testing.

4. Functional testing:
a. General:
1) Testing to demonstrate proper operation of systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
2) Performed by Contractor, ICSC, manufacturer's representative, and Owner working together.
3) Additional tests are specified in other Instrumentation and Control Sections.
4) Follow approved detailed test procedures and check lists for Functional Test activities.

b. Loop tuning:
1) Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
2) Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay

rates. As a minimum, achieve 1/4-wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.

3) If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.
4) Functional validation sheets:
    a) Document each Functional test on an approved test form.
    b) Document loop tuning with a report for each loop, including 2 pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by Contractor and Engineer.
    c) Include on the form, functions which can be demonstrated on a loop-by-loop basis:
        (1) Loop number and P&ID number.
        (2) Control strategy, or reference to specification tested.
        (3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the Functional test. Otherwise, create new forms.
    d) For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
        (1) Specification page and paragraph of function demonstrated.
        (2) Description of function and/or text from specification.
        (3) Test procedures: use the FAT loop test checklist forms modified to meet the specific testing conditions of the Functional test.
5) Functional certification:
    a) Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.
        (1) Including all test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that all Functional test requirements have been satisfied.

C. Process Start-up Phase:
    1. Instrumentation and Controls Fine-Tuning:
        a. General:
            1) After the Process Operational Period, test PCIS system for additional 60 days as specified in this Section to identify issues and make corrections, as needed.
            2) 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.
            3) Test and use the entire process control system under standard operating conditions.

4) Exercise all system functions.
5) Log failure, any system interruption and accompanying component, subsystem, or program failure including time of occurrence, duration of each failure, failure classification, and cause:
    a) Provide a competently trained technician or programmer on call for the Project Site during all normal working days and hours from the start of the performance test until final acceptance of the system.
        (1) Response time to the Project Site: 24 hours or less, for a major failure.

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

8. FAT DOCUMENTATION AND RECORD

Panel Documentation

- ☐ As-built panel drawings showing actual panel construction and devices arrangement and c/w Bill of Material.
- ☐ Panel schematic and interconnection drawings.
- ☐ P&ID drawings and schematic drawings for the process area controlled by the panel that is to be tested.
- ☐ I/O list test forms of the process area to be tested.
- ☐ FAT procedure of the process area to be tested.
- ☐ Test record forms of the process area to be tested. Forms shall include area for signature of responsible test personnel.
- ☐ Hard copy of the PLC application program of the process area to be tested.
- ☐ Hard copy of the HMI/OIT graphic screens of the process area to be tested.

9. FAT TOOLS AND SOFTWARE

- ☐ Simulation software if required
- ☐ Digital volt meter Fluke 87
- ☐ Process meter Fluke 787
- ☐ Laptop computer with PLC application program
- ☐ Temporary SCADA computer with HMI software and applicable graphic screens
- ☐ Jumper wires

PROJECT NAME:		TEST DATE:	
FACILITY NAME:		TESTED BY:	
PROCESS AREA:		COMPANY:	
NETWORK ID:		PAGE:	
WITNESSED BY:		SIGNATURE:	

	INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

	☐ No	☐ Yes
INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?		

REMARKS: _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	SWITCHES **INSTALLATION AND CALIBRATION CHECKLIST**	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

	☐ No	☐ Yes
INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?		

FIELD CALIBRATION CHECK

CONTACT NO.	FUNCTION	FOR SIGNAL	CONTACT IS TO	AT SPECIFIED VALUE FOR		ACTUAL TRIP POINT WAS	
1	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
2	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
3	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
4	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	

NOTE: PERM IS ABBREVIATION FOR PERMISSIVE

	SWITCHES **INSTALLATION AND CALIBRATION CHECKLIST**	

REMARKS: _____

CHECKED BY (COMPANY) _____

SIGNATURE _____

DATE _____

ACCEPTED BY (COMPANY) _____

SIGNATURE _____

DATE _____

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? No Yes

INSTRUMENT TYPE ☐ TRANSMITTER ☐ CONTROLLER ☐ INDICATOR

☐ OTHER DESCRIPTION _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

BENCH CALIBRATION CHECK

INPUT RANGE = _____ 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?

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 _____