



**WEBER BASIN WATER CONSERVANCY DISTRICT
LAYTON, UTAH**

**DAVIS NORTH WATER TREATMENT PLANT
SOLIDS DEWATERING IMPROVEMENT PROJECT**

ENGINEER PROJECT NO. 203356

CONTRACT/TECHNICAL SPECIFICATIONS

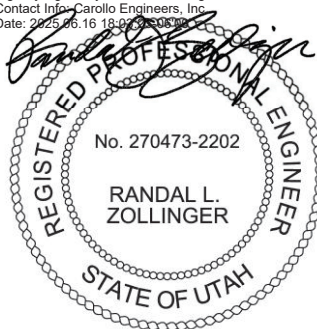
BID SUBMITTAL

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WEBER BASIN WATER CONSERVANCY DISTRICT

DAVIS NORTH SOLIDS DEWATERING UPGRADE

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COMMON WORK RESULTS FOR HVAC

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PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. General prescriptive, design, and performance requirements for products and mechanical equipment used to heat, ventilate, cool, or otherwise condition or distribute indoor air.
 - 2. Specific requirements for ductwork accessories:
 - a. Dampers and damper operators.
 - b. Diffusers, grills, and registers.
 - 3. Specific requirements for refrigerant piping.

1.02 REFERENCES

- A. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
 - 1. 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
 - 2. 270 - Sound Rating of Outdoor Unitary Equipment.
 - 3. 340/360 - Performance Rating of Commercial and Industrial Unitary Air Conditioning and Heat Pump Equipment.
 - 4. 430 - Performance Rating of Central Station Air-handling Unit Supply Fans.
- B. Air Movement and Control Association International, Inc. (AMCA):
 - 1. 11 - Certified Ratings Program Operating Manual.
 - 2. 210 - Laboratory Methods for Testing Fans for Certified Aerodynamic Performance Rating.
 - 3. 211 - Certified Ratings Program — Product Rating Manual for Fan Air Performance.
 - 4. 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
 - 5. 311 - Certified Ratings Program — Product Rating Manual for Fan Sound Performance.
 - 6. 500 - Laboratory Methods of Testing Dampers for Rating.
 - 7. 511 - Certified Ratings Program Product Rating Manual for Air Control Devices.
- C. 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.
- D. American National Standards Institute (ANSI):
 - 1. Z21.47 - Gas Fired Central Furnaces (except Direct Vent Central Furnaces).
- E. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
 - 1. Standard 15 - Safety Standard for Refrigeration System.
 - 2. Standard 52.2 - Methods of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
- F. American Society of Mechanical Engineers (ASME):
 - 1. RTP-1 - Reinforced Thermoset Plastic Corrosion-Resistant Equipment.

- G. ASTM International (ASTM):
1. B32 - Standard Specification for Solder Metal.
 2. B75 - Standard Specification for Seamless Copper Tube.
 3. B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
 4. B813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.
 5. B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fitting.
 6. C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
 7. D1784 - Standard Classification System and Basis for Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
 8. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
 9. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
 10. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
 11. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
 12. D2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
- H. National Bureau of Standards: NBS PS15-69 - Custom Contact-Molded Reinforced-Polyester Chemical-Resistant Process Equipment.
- I. National Electrical Manufacturers Association (NEMA):
1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- J. National Fire Protection Association (NFPA):
1. 70 - National Electrical Code (NEC).
 2. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.
- K. National Roofing Contractors Association (NRCA).
- L. International Association of Plumbing and Mechanical Officials (IAPMO):
1. IS 3 - Installation Standard for Copper Plumbing Tube, Pipe, and Fittings.
- M. Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
- N. Underwriters Laboratories, Inc. (UL):
1. 555 - Standard for Fire Dampers.
 2. 555C - Standard for Safety Ceiling Dampers.
 3. 555S - Standard for Smoke Dampers.
 4. 900 - Standard for Air Filter Units.
 5. 60335-2-40 - Safety Standard for Household and Similar Electrical Appliances.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination.
 - 1. Provide roof mounted HVAC equipment information required in the preparation of roofing drawings, including, but not limited to:
 - a. Location.
 - b. Size.
 - c. Weight.
 - d. Anchoring and support details.

1.04 SUBMITTALS

- A. Where items in this Section are components of equipment or systems specified in other sections, include data for this Section's components with the equipment or system Submittal.
- B. When products are specified in this Section but are not referenced in other Technical Sections, submit:
 - 1. As specified in Section 01_33_00 - Submittal Procedures.
 - 2. Product data:
 - a. Sufficient to substantiate specified requirements.
 - 3. Description of coating system and instructions for field touch up and re-coating.

PART 2 PRODUCTS

2.01 GENERAL

- A. Technical Sections product requirements supersede conflicting requirements in this Section.
- B. As specified in Section 01_60_00 - Product Requirements.
- C. Electrical:
 - 1. Components and assemblies.
 - 2. Carry UL listing marking.
 - 3. In accordance with NEC requirements.
- D. Fans:
 - 1. Rated and labeled in accordance with AMCA 210 and AMCA 211.
 - 2. Belt drive systems:
 - a. Adjustable for minimum within 5 percent speed change.
 - b. Rated for 150 percent of maximum motor horsepower.
- E. Unitary air conditioners and heat pumps:
 - 1. Rated in accordance with AHRI 210/240 or 340/360, AHRI 270, and AHRI 430.
 - 2. In accordance with ASHRAE Standard 15.
 - 3. Heating: Certified in accordance with ANSI Z21-47.
 - 4. Refrigerant:
 - a. Fully charged with R-454B.
 - b. Compliant with ASHRAE 15.

- c. HFO refrigerant with global warming potential (GWP) of 700 or less.
- d. Must have a refrigerant monitoring system and be rated in accordance with UL 60335-2-40.

F. Filters:

- 1. Media: UL 900 listed.

G. Insulation and adhesives: In accordance with NFPA 90A requirements for flame spread and smoke generation.

H. Roof curbs: Supplied by the manufacturer of the product requiring the curb.

I. Factory coating: For equipment with factory coatings, manufacturer to supply 2 containers (each about a pint) of the paint for Contractor/Owner touch up.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. General:

- 1. Environmental conditions as specified in Section 01_81_50 - Design Criteria.
- 2. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 23_09_13 - Instrumentation and Control Devices for HVAC.

B. Fans:

- 1. Sharply rising pressure characteristics throughout the operating range and beyond the efficiency peak.
- 2. Peak operating points to be as close as possible to the maximum efficiency and whose operating range is within the normal fan selection range.
- 3. Bearings rated in accordance with ABMA 9 or 11 for a L10 life rating of not less than 50,000 hours.
- 4. Total sound power levels in the 8 octave band range in accordance with AMCA 301, not to exceed the lesser of the following or the sones level indicated on the Drawings.

Sound Power Level, decibels levels referenced to 10 to 12 watts								
Frequency, Hz	63	125	250	500	1,000	2,000	4,000	8,000
General	100	98	94	88	84	84	78	75

- 5. Shall be in accordance with AMCA 11 and bear the AMCA Certified Ratings Program seal for air performance and sound performance according to AMCA 211 and AMCA 311.

C. Unitary air conditioners and heat pumps:

1. Outdoor noise levels in the 8 octave band ranges, as measured in accordance with AHRI 270 shall not exceed the following:

Octave Bands								
Unit Nominal Capacity (Tons)	63	125	250	500	1,000	2,000	4,000	8,000
0 to 5	64	70	71	74	74	71	67	67
6	79	85	78	74	71	73	66	59
7-1/2 to 10	64	70	73	79	82	78	74	67
12 and larger	84	88	84	83	84	78	72	68

2. Capable of starting and cooling from 45 to 125 degrees Fahrenheit ambient outdoor air temperature and exceeding the maximum load criteria of AHRI 210/240 or 340/360.
3. Heat pumps capable of starting and heating at or above 0 degrees Fahrenheit outdoor ambient air temperature.
4. Minimum cooling, Energy Efficiency Ratio (EER) and Integrated Energy Efficiency Ratio (IEER), as rated in accordance with AHRI 210/240 or 340/360 for split systems and packaged units is as follows:

Equipment Type	Net Cooling Cap (Btu per hour)	EER ⁽¹⁾	IEER ⁽²⁾
Space Constrained, Air Cooled	<30,000	11.7	N/A
Small Duct, High Velocity, Air Cooled	<65,000	12.1	N/A
Air Cooled	<65,000	13.4	N/A
Air Cooled	>65,000 and <135,000	11.2	14.8
Air Cooled	>135,000 and <240,000	11.0	14.2
Air Cooled	>240,000 and <760,000	10.0	13.2
Air Cooled	>760,000	9.7	12.5
Notes: (1) Deduct 0.2 degrees from the required EER for units with a heating section other than electric resistance heat. (2) IEER is only applicable to equipment with capacity control in accordance with AHRI 340/360.			

5. Units with heating capabilities: Meet or exceed the following:
 - a. Annual fuel utilization efficiency: 80 percent.
 - b. Steady state efficiency: 80 percent.

D. Filters:

1. Efficiency: 45 to 50 percent dust spot efficiency when rated in accordance with ASHRAE Test Standard 52.2.
- 2.

2.03 DIFFUSERS, GRILLES, AND REGISTERS

- A. Provide diffusers, grilles, and registers manufactured by the same manufacturer.

- B. Provide style and size as indicated on the Drawings.
- C. Components: Include specified style with frame, clips, connectors, and other accessories necessary for mounting.
- D. Supply diffuser, grille, and register styles:
 - a.
 - 2. SR-3, Supply Register Style 3:
 - a. Manufacturers: One of the following or equal:
 - 1) Kees, Inc.
 - 2) Krueger.
 - 3) Metal Industries, Inc., (MetalAire).
 - 4) Titus Manufacturing Corp, 272FL.
 - 5) Tuttle and Bailey.
 - b. Type: Aero-blade series (3/4-inch) with aluminum border.
 - c. Installation: When duct mounted is indicated on the Drawings, provide 4-inch drop frame.
 - d. Faceplate:
 - 1) Removable grille with double deflection blades spaced at 3/4 inch.
 - 2) Front blades parallel to long dimension.
 - 3) Gasket at frame.
 - e. Core:
 - 1) Adjustable vanes.
 - 2) Rectangular or round neck to match ducting.
 - f. Damper:
 - 1) Opposed blade volume control damper suitable for use with ducting type.
 - 2) Adjustable through the face of the unit.
 - g. Materials: Aluminum frame, core, damper, and faceplate.

2.04 SCREENS

- A. Required on all fans and louvers unless otherwise indicated on the Drawings.
- B. Characteristics and features:
 - 1. Bird screen: 1/2-inch mesh by 14 gauge.
 - a. For exhaust applications.
 - 2. Insect screens: 18 by 14 mesh.
 - a. For intake applications.
 - 3. Screens and frames, same material as ductwork, hood, louver, fan, or equipment connected to screen.
 - 4. Screens secured in frames.

2.05 FLEXIBLE CONNECTORS

- A. Provide flexible duct connectors at connections to fans and other air movement equipment as indicated on the Drawings.
- B. FL-2, Duct to Duct Flexible Connection:
 - 1. Manufacturers: The following or equal:
 - a. Ventfabrics, Ventel.

2. Fabric for flexible connections exposed to chemicals shall be glass fabric coated with Teflon™ and suitable for a temperature range of -10 to 500 degrees Fahrenheit and shall have a weight of at least 14 ounces per square yard and a thickness of 0.014 inch.

2.06 REFRIGERANT PIPING

- A. Seamless copper tube:
 1. Type:
 - a. Straight lengths: ASTM B75, USN Alloy C12200, H55 Temper.
 - b. Coiled lengths: ASTM B280, USN Alloy C12200, O60.
 - c. Outside diameter sized, minimum wall thickness in accordance with ASTM B280 and ASTM B75.
 2. Non-VRF system:
 - a. Solder: ASTM B32, Alloy Grade Sb5.
 - b. Flux: ASTM B813.

2.07 CONDENSATE DRAIN PIPING

- A. PVC:
 1. PVC pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
 - a. Pipe and fittings: Extruded from Type I, Grade 1, Class 12454 B material in accordance with ASTM D1784.
 - b. PVC pipe: Schedule 80 unless otherwise indicated on the Drawings.
 2. Fittings:
 - a. Supplied by the pipe manufacturer.
 - b. Pressure fittings: In accordance with ASTM D2466 or ASTM D2467.
 - c. DWV fittings: In accordance with ASTM D2665.
 3. Solvent cement: In accordance with ASTM D2564:
 - a. Manufacturers: The following or equal:
 - 1) Primer: IPS Corp Type P-70™.
 - 2) Cement: IPS Corp Type 724™ cement or cement certified by the manufacturer for chemical service.

2.08 PIPE INSULATION

- A. General:
 1. As specified in Section 01_60_00 - Product Requirements.
 2. Insulation thicknesses: In inches as specified in the following table.
 - a. Thickness shown is nominal.
 - b. Manufacturing tolerance of 15 percent variation is permissible.

Table 1. Required Insulation Thicknesses (Inches)		
Service Temperature Range ⁽¹⁾	Nominal Pipe Diameters	
	1 Inch and Less	1.25 to 2 Inches
100 to 200 degrees Fahrenheit	1.5	1.5
40 to 100 degrees Fahrenheit	0.5	1.0
Notes:		

Table 1. Required Insulation Thicknesses (Inches)		
Service Temperature Range⁽¹⁾	Nominal Pipe Diameters	
	1 Inch and Less	1.25 to 2 Inches
(1) As specified in Table 2. Insulation Schedule, at the end of this Section.		

B. Insulation, Type 1:

1. Manufacturers: One of the following or equal:
 - a. Aeroflex USA Inc., Aerocel® AC.
 - b. Armacell®, AP Armaflex.
2. Insulation material: Closed cell elastomeric insulation.
3. Minimum temperature range: -40 degrees Fahrenheit to 220 degrees Fahrenheit.
4. K-factor at 75 degrees Fahrenheit: Not more than 0.27 Btu-inch/hour-square feet-degrees Fahrenheit.
5. Fire ratings:
 - a. Flame spread: 25 or less.
 - b. Smoke density: 50 or less for insulation thicknesses up to 1.5 inches.
6. Joints: Seal with the manufacturer's recommended contact adhesive to form a continuous water barrier.

C. Insulation jackets:

1. Type 1:
 - a. Manufacturers: One of the following or equal:
 - 1) Johns Manville, Zeston® 2000 PVC.
 - 2) Proto Corp., LoSMOKE PVC.
 - 3) Speedline® Corp., Smoke-Safe™ PVC.
 - b. Material: Ultraviolet-resistant polyvinyl chloride jacketing, 20-mil minimum thickness.
 - c. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
 - d. Color: White.
 - e. Overlap: 1 inch minimum at joints and fittings.
 - f. Joint seal: PVC solvent welded or adhesive as recommended by the manufacturer.
 - g. Fittings: Factory made with full thickness insulation.

D. Vapor barriers:

1. Type 1:
 - a. Material: White Kraft paper bound to aluminum foil in accordance with ASTM C1136, Type 1.
 - b. Permeability: 0.02 perms or lower.
 - c. Maximum flame spread rating: 25.
 - d. Edge seal: Pressure-sensitive tape lap seal.
 - e. Circumferential joints: 4-inch wide tape or 4-inch overlap with adhesive seal.
2. Type 2:
 - a. Manufacturers: One of the following or equal:
 - 1) Benjamin Foster, No. 30-76.
 - 2) Childers Products, CP10/11 Vi-Acryl.
 - 3) Foster Products, 36-10/46-10 Weatherite.

- 4) Insul-Coustic, No. I.C.-580.
- b. Material: Mastic.

E. Insulation schedule:

Table 2. Insulation Schedule					
Service Designation⁽¹⁾	Location⁽²⁾	Insulation Type	Jacket Type	Service Temp. °F⁽³⁾	Vapor Barrier
HVAC Refrigerant	Interior or Exterior	1	1	40 to 200	Required
HVAC Condensate	Interior or Exterior	1	1	Below 60	Required
Notes: (1) Refer to the Pipe Schedule in Section 40_05_00.01 - Common Work Results for General Piping for service designations. (2) Insulation jackets are not required for interior installations that are concealed. See definitions for description of concealed locations. (3) Unless noted otherwise, use service temperature range provided in this table to establish insulation thickness as required by Table 1.					

2.09 EQUIPMENT NAMEPLATES

- A. Provide a nameplate with the following markings, plainly visible after installation:
 - 1. Manufacturer's name, trademark, or other descriptive marking to identify specific equipment.
 - 2. Where equipment is electrically powered:
 - a. Supply voltage, phase, frequency, and full-load current.
 - b. Power source or circuit ID.
 - c. Short-circuit current rating based on one of the following:
 - 1) Rating of a listed and labeled assembly.
 - 2) Rating established utilizing an approved method.

2.10 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

- A. As specified in Section 01_60_00 - Product Requirements.
- B. Inspect fasteners for proper tightness.
- C. Ship units in one piece (or modular, if required), factory assembled, piped, internally wired, and factory tested.
- D. Provide:
 - 1. Filters: 2 extra (3 total) sets per each unit with filters.
 - 2. Sheaves and belts: 1 set for change-out for final balance per unit installed.
 - 3. Belts: 1 extra set for each unit installed as determined by final balance.
- E. Provide a 2-year supply of maintenance products as specified in the manufacturer's maintenance literature.

PART 3 EXECUTION

3.01 GENERAL

- A. Technical Sections execution requirements supersede conflicting requirements in this Section.
- B. As specified in Section 01_60_00 - Product Requirements.
- C. Inspect fasteners for proper tightness.
- D. Provide temporary closures for openings designed for airflow.

3.02 INSTALLATION

- A. Examine and verify details and sections as indicated on the Drawings, ascertain adequacy, and determine conflicts in dimensions and clearances.
 - 1. Take measurements and verify dimensions to ascertain fit of installation.
 - 2. Ascertain structural sufficiency to support installation.
 - 3. Ascertain that supports and openings are correctly located; otherwise cut new openings where required.
 - 4. Confirm specified thermostat or other controls are compatible with specified equipment.
- B. Install in accordance with the manufacturer's instructions.
 - 1. Electrical products installation in accordance with NFPA 70 NEC.
 - 2. If there are conflicts, the NEC supersedes the manufacturer's instruction.
 - a. Notify the Engineer of conflicts.
- C. Equipment supports and anchoring:
 - 1. General:
 - a. Set equipment so that connecting flanges, screwed connections, or flexible connections will meet without strain or distortion.
 - b. Equipment may not be grouted, nor equipment anchors finally tightened, until all service connections to equipment are complete and in satisfactory alignment with no strain transmitted to the equipment.
 - 2. Equipment supported on concrete slab:
 - a. Install equipment and secure in place as recommended by the manufacturer, as indicated on the Drawings, and as shown in approved anchoring details for that equipment.
 - b. Examine pads or supports and make required repairs, using means acceptable to the Engineer, prior to installation of equipment. Confirm:
 - 1) Correctly sized, regular, and even pads.
 - 2) Correct anchor bolt sizes and locations.
 - c. Accurately align and level equipment over stainless steel shims and wedges placed near anchor bolts.
 - d. Tighten anchor bolts against shims and wedges and re-check for level and alignment before placing grout.

- e. Place grout under equipment frame or base.
 - 1) Install non-shrink grout as specified in Section 03_60_00 - Grouting, unless otherwise required by the equipment manufacturer or indicated on the Drawings.
 - 2) Before grouting, install block outs around anchor bolts and shims to prevent grouting in those areas.
 - 3) Finish grout and cure for not less than 3 days.
 - 4) After initial curing, loosen anchor bolts and fill block outs with non-shrink cement grout.
 - 5) Finish and cure grout at block outs for not less than 3 days.
 - f. Tighten anchors against grout.
 - 3. Equipment supported on roof curb:
 - a. Install in accordance with the NRCA manual.
- D. Equipment and ducts:
- 1. Remove dust and debris before installation.
 - 2. Protect from dust and debris by covering openings with tape or plastic during installation and until equipment is operated.
 - 3. Adjust alignment of ducts to resolve conflicts with the work of other trades.
 - 4. Install and wire unitary air conditioners, controls, and thermostats in accordance with the manufacturer's recommendations.
 - 5. Provide flexible duct and flexible piping connections at connections to unitary air conditioners.
 - a. FL-1 and FL-2, Flexible Connections:
 - 1) Install at building expansion joints and as indicated on the Drawings.
 - 2) Install with collar and metal band to form airtight joints.
 - 3) Install with minimum 4 inches of slack in fabric.
 - 4) Install with minimum 3 inches of specified material on each side of fabric.
 - 5) Exterior locations: Install sheet metal weather cover over fabric.
 - 6) Duct alignment shall be a maximum of 1/2-inch offset.
 - 7) Minimum/maximum gap shall be 2 inches and 6 inches.
 - 8) Lap longitudinal joints and glue in accordance with the manufacturer's recommendations.
 - 6. Lubrication lines and fittings:
 - a. Support and protect lines from source to point of use.
 - b. Fittings:
 - 1) Bring to outside of equipment in manner such that fittings are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
 - 2) Mount together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
 - 7. Remove dust and debris from ductwork and equipment at completion of installation.
 - 8. Set grilles, dampers, and diffusers to achieve flows and flow patterns indicated on the Drawings.
- E. Refrigerant piping:
- 1. Support copper tubing as specified in Section 40_05_07.01 - Pipe Supports and Section 40_05_07.03 - Preformed Channel Pipe Support System.

2. Clean copper lines with high-pressure air after first disconnecting piping at instruments, filters, pressure reducers, valve operators, and other special devices.
 3. Installation of copper tubing:
 - a. In accordance with ASTM B828 and IAPMO IS 3.
 - b. In straight runs, supported at intervals close enough to avoid sagging.
 - c. Make cuts square with a tubing cutter or with a 32-tooth hacksaw.
 - 1) Provide a sizing tool to correct distortions.
 4. Ream the inside of the tubing and remove burrs from the outside, holding the end of the tubing downward and preventing chips and fillings from entering the tubing.
 5. Perform flaring with a flare block and yoke type screw feed flaring tool:
 - a. After removing the tubing from the flare block, inspect both surfaces of the flare for splits, cracks, or other imperfections.
 - b. Where there are imperfections, cut off the imperfect flare and prepare a new flare.
 6. Insulate piping as specified in Section 22_42_01 - Plumbing systems.
- F. Gas, water piping, drains, and venting in accordance with the authority having jurisdiction and applicable codes.
- G. Completed equipment installations must have confirmation that:
1. Equipment is properly assembled.
 2. Equipment moves or rotates in the proper direction.
 3. Shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
 4. No unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
 5. Installation meets the requirements for intended use as well as the specified vibration and noise tolerances.

END OF SECTION

SECTION 23_05_93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Testing air systems installed as part of this Contract.
 - 2. Testing existing air systems affected by the installation of new equipment.

1.02 REFERENCES

- A. Associated Air Balance Council (AABC):
 - 1. National Standards Total System Balance.
- B. National Environmental Balancing Bureau (NEBB):
 - 1. Procedural Standards for Testing, Adjusting, and Balancing Environmental Systems.
- C. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
 - 1. HVAC Systems - Testing, Adjusting, & Balancing.
- D. Testing, Adjusting, and Balancing Bureau (TABB):
 - 1. TAB Procedural Guide.

1.03 SUBMITTALS

- A. Resumes of proposed supervisor and personnel showing training and qualifications.
 - 1. Include courses, exams, or tests relating to HVAC testing - taken and passed.
- B. Testing plan:
 - 1. At least 30 days prior to starting field work.
 - 2. Set of report forms completed with design flow values and installed equipment pressure drops, and required cubic feet per minute for air terminals.
 - 3. Heating, ventilating, and air conditioning system schematic similar to Figure 6-1 in SMACNA HVAC Testing, Adjusting, & Balancing.
 - 4. Complete list of instruments proposed to be used, organized in appropriate categories, with data sheets for each showing:
 - a. Manufacturer and model number.
 - b. Description and use when needed to further identify instrument.
 - c. Size or capacity range.
 - d. Latest calibration date.
 - 5. Proposed schedule for testing and balancing.
- C. Report:
 - 1. Not more than 45 days prior to the Contractor's request for final inspection, submit the draft report on applicable reporting forms.

2. At least 15 days prior to the Contractor's request for final inspection, submit 3 copies of final reports incorporating the Engineer's comments on the draft report.
3. List of instruments used and last date of calibration of each.
4. Procedures followed for testing, adjusting, and balancing.
5. Identification and succinct description of systems included in report.
6. Initial balance test results made with dampers and air control devices in full open positions.
7. Description of final locations and sizes, including opening area and dimensioned configuration of orifices and other restrictions used to achieve final balanced flows.
8. Description of final location and opening positions of dampers, registers, louvers, and valves.
9. Schematics of systems included in report; use schematics as part of testing, adjusting, and balancing report to summarize design and final balanced flows.
10. Testing, adjusting, and balancing report forms.
11. Final field results established for system balancing, including airflow, fan speeds, and fan static pressures at the fan inlet and outlet.
12. Appendices.
 - a. Raw field data taken during testing.
 - b. Sample calculation sheet for each type of calculation made to convert raw field data to final results.
 - c. Initial air balance results with dampers and registers in full open position; include airflow at all inlets and outlet, initial fan speed, and fan suction and discharge pressures.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

- A. Work of testing, adjusting, and balancing of heating, ventilation, and air conditioning systems to be by an independent testing agency and a certified member in good standing with AABC, NEBB, or TABB.
- B. Field testing to be performed or directly supervised by personal who have passed a test and balance course or exam and is an AABC, NEBB, or TABB certified supervisor.

3.02 PREPARATION

- A. Prior to start of testing, adjusting, and balancing, verify that:
 1. System installation is complete in accordance with the requirements for completed equipment installations specified in Section 23_05_00 - Common Work Results for HVAC and capable of full operation.
 2. Outside conditions are within reasonable range relative to design conditions.
 3. Lighting fixtures are energized.

4. Special equipment such as computers, laboratory equipment, and electronic equipment are in full operation.
5. Requirements for preparation for testing and balancing have been met for elements of each system which require testing.

3.03 FIELD QUALITY CONTROL

- A. Test, adjust, and balance each separate complete heating, ventilating, and air conditioning systems.
 1. Include existing heating, ventilating, and air conditioning components when affected by the Work.
- B. Perform testing, adjusting, and balancing cycles until airflows meet acceptance criteria.
 1. Ascertain airflow balance between overall requirements and flow in individual supply and exhaust grilles.
- C. Initial testing, adjusting, and balancing:
 1. Test each system with dampers, grilles, orifices, and other variable airflow devices in their full open position; measure and report initial airflows, fan speed, and fan static pressures at fan inlet and outlet.
 2. Adjust total system flow downward or upward by adjusting fan speed until one inlet or outlet is at indicated flow and all other flows exceed indicated flows.
 3. Adjust fan speed by changing fan drives or sheaves as necessary.
- D. Subsequent testing, adjusting, and balancing:
 1. Perform adjustments by adjusting dampers, louvers, or size of orifices or plates.
 2. Measure and record air volume discharged at each inlet and outlet and adjust air inlets and outlets to design air volumes within 0 to 5 percent over design rates.
 3. Adjust fan speeds and motor drives within drive limitations, for required air volume.
 4. Measure air flow and static pressures and adjust air supply and exhaust fan units to deliver at least 100 to 105 percent of the design air volume.
 5. Measure and record static air pressure conditions on fans, including filter and coil pressure drops and total pressure across the fan.
 6. Evaluate building and room pressure conditions to determine adequate supply and return air conditions.
 7. Evaluate space and zone temperature of conditions to determine adequate performance of the systems to maintain temperatures without draft.
 8. Permanently mark final balance positions of balancing dampers.
- E. Develop heating, ventilating, and air conditioning system schematics similar to Figure 6-1 in SMACNA Testing, Adjusting, and Balancing.
- F. Accurately record the required data on AABC, NEBB, or TABB test and balance report forms.
- G. Measure amperage draw of fan and pump motors at final balance.

- H. Test primary source equipment in accordance with AABC, NEBB, or TABB procedures.
 - 1. Primary source equipment includes items listed in this Section not previously tested as part of this testing, adjusting, and balancing work.
 - 2. Complete appropriate AABC, NEBB, or TABB equipment test forms for each piece of equipment.
 - 3. Calculate cooling and heating capacities to show conformance with specified capacities.
 - 4. Adjust equipment as needed to deliver specified cooling and heating loads.
 - 5. Record final equipment performing characteristics and adjustment settings in the final design report.
- I. Testing, adjusting, and balancing acceptance criteria:
 - 1. Procedures successful and complete when heating, ventilating, and air conditioning systems and components are functioning properly and system air flows are within specified tolerances of design flows.

END OF SECTION

SECTION 23_09_13

INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Controls for heating, ventilating, and air conditioning (HVAC) systems.

1.02 REFERENCES

- A. CSA International (CSA).
- B. National Electrical Manufacturers Association (NEMA).
- C. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
 - 2. 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- D. Restriction of Certain Hazardous Substances (RoHS).
- E. Underwriters Laboratories, Inc. (UL):
 - 1. 13 - Standard for Safety Power-Limited Circuit Cables.
 - 2. 268A - Standard for Smoke Detectors for Duct Application.
 - 3. 508 - Standard for Industrial Control Equipment.
 - 4. 1479 - Fire Tests of Through-Penetration Firestops.
 - 5. 1685 - Standard for Safety Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_00 - Product Requirements.
- B. Product data:
 - 1. As specified in Section 23_05_00 - Common Work Results for HVAC.
- C. Shop Drawings:
 - 1. Manufacturer's information, including:
 - a. Catalog information clearly marked to show specific products, models, and sizes being furnished.
 - b. Component cut sheets.
 - 2. Control diagrams showing the interconnection of control components, including wiring terminal strip diagrams.
 - 3. Detail drawings showing control panel layout and dimensions, including control panel terminal strips for wiring to outside control devices and panels.

- D. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.

1.04 QUALITY ASSURANCE

- A. Control system shall be designed in accordance with UL and CSA standards.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_00 - Product Requirements and the manufacturer's instructions.

1.06 PROJECT OR SITE CONDITIONS

- A. Elevation and ambient conditions as specified in Section 01_81_50 - Design Criteria.

1.07 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.
- B. Special warranties: Warranty period begins at date of Project acceptance or first date of beneficial use by the Owner.
 - 1. One year parts and on-site labor for components, systems, and programming.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. General requirements:
 - 1. Electrical components shall be UL-listed and meet the design and installation requirements of the NEC.
 - 2. Provide necessary electrical power and control systems, components, and wiring to make a complete functioning system.
 - 3. Comply with electrical sections for electrical power and control systems.
 - 4. System control functions to perform as described in Products.
 - 5. Materials: New, free from defects, and of the quality specified.
 - 6. Common manufacturer: Provide components, component accessories, and devices, as much as possible, by the same manufacturer throughout the Work.
 - 7. Mount control components and devices in accessible locations for maintenance and as recommended by the manufacturer. Provide necessary manufacturer-approved mounting and configuration hardware for mounting and operation of control components and devices.

2.02 THERMOSTATS

A. General:

1. Thermostat types: Called out on the drawings by the letter T followed by a number.
 - a. This designation refers to the specified thermostat types specified in this Section.
 - b. Where no type is called out, provide one of the specified types that will match the controlled equipment requirements and provide a functioning system.
2. Manufacturers: One of the following or equal:
 - a. Honeywell, Tradeline, equivalent models.
 - b. Johnson Controls, model as specified with each type.
3. Thermostat cable:
 - a. Conductor: Number of conductors required to be determined by HVAC system, solid bare copper, 18/20 American Wire Gauge (up to 250 feet). Provide sufficient length to accommodate the thermostat locations as indicated on the Drawings.
 - b. Insulation: Heat and moisture resistant colored polyvinylchloride (PVC) or Polypropylene insulation.

Thermostat Terminal	Wire Color (Typical)	Function Description
R	Red	24 V Single Transformer - AC/Heat
Rc	Red	24 V for Dual Transformer - AC
Rh	Red	24 V for Dual Transformer - Heat
C	Black/Blue	Common 24 VAC Power Source
Y	Yellow	Primary Cooling
Y2	Light Blue/Yellow	Secondary Cooling
W	White	Primary Heating
W2	Brown	Secondary Heating
G	Green	Fan Relay
O	Orange	Reversing Valve

- c. Jacket: White or brown PVC.
- d. In accordance with:
 - 1) UL 13 in accordance with NEC Article 725.
 - 2) UL listed Type CL2, Sunlight Resistant.
 - 3) UL 1685 Vertical Tray. RoHS compliant.
- e. Temperature rating: 140 degrees Fahrenheit.
- f. Voltage rating: Up to 150 V.

B. T-2, Type 2 Thermostat, Cooling Only, Line Voltage:

1. Manufacturers: The following or equal:
 - a. Johnson Controls:
 - 1) Dry locations (no hose bibs or open water processes in room): Model A19BBC-2C in NEMA 1 enclosure.
 - 2) Wet locations (hose bibs or open water processes in room): Model A19QSC-1C in rain and dusttight enclosure.

2. Switch action: SPDT, close on rising temperature.
3. Sensing element: Coiled bulb and capillary.
4. Setpoint: 30 to 110 degrees Fahrenheit with knob adjuster and visible scale.
5. Electrical ratings: 16 A at 120 VAC, 9.2 A at 208 VAC.
6. Differential range:
 - a. Dry locations: 3 to 12 degrees Fahrenheit adjustable.
 - b. Wet locations: 5 degrees Fahrenheit fixed.

2.03 HVAC CONTROL DESCRIPTIONS

- A. Provide control systems that will maintain room or area comfort under changing ambient conditions and varying use. Descriptions in this Section are general in nature and do not cover every mode of operation.
- B. Sludge Pump Station HVAC Control Descriptions:
 1. Electrical Room:
 - a. The electrical room will be conditioned by two mini-split heat pump units. The units will operate in a lead-lag sequence controlled by staging their thermostat setpoints.
 - 1) The heating setpoint for the lead unit shall be 60 deg F (adjustable).
 - 2) The heating setpoint for the lag unit shall be 55 deg F (adjustable).
 - 3) The cooling setpoint for the lead unit shall be 85 deg F (adjustable).
 - 4) The cooling setpoint for the lag unit shall be 90 deg F (adjustable).
 2. Pump Room:
 - a. The pump room will be ventilated and heated only. The ventilation will be provided by a supply fan and a relief louver. The heating will be provided by two electric unit heaters.
 - 1) The supply fan will be provided with a Hand-Off-Auto selector switch.
 - a) In "Hand", the supply fan shall energize and continue to run.
 - b) In "Off", the supply fan shall de-energize and remain shut-off.
 - c) In "Auto", the supply fan shall be controlled by its Type 2 thermostat. The thermostat cooling setpoint shall be 85 deg F (adjustable).
 - d) The air supply will be interlocked with the exhaust louver.
 - e) The supply fan starter will be provided with a current sensor to send a running signal to the plant PLC/SCADA.
 - 2) The exhaust louver will be interlocked with the air supply fan. When the air supply fan energizes, the louver will actuate to "open" position. When exhaust fan de-energizes, the louver shall return to "closed" position.
 - 3) The electric unit heaters will be controlled by their manufacturer provided thermostats.
 - a) The heating setpoint for the unit heaters shall be 55 deg F (adjustable). When the temperature rises 3 degrees above the set point, the unit will de-energize.

2.04 ELECTRICAL MATERIALS

- A. Provide conduit as specified in Section 26_05_10 - General Requirements for Electrical, and Section 26_05_33 - Conduits.

- B. Provide control and instrumentation wire as specified in Section 26_05_18 - 600-Volt or Less Wires and Cables.

PART 3 EXECUTION

3.01 PREPARATION

- A. Before installation remove dust and debris from equipment and accessories.
- B. During installation and until equipment is operated, protect equipment and accessories from dust and debris.

3.02 INSTALLATION

- A. Install as indicated on the Drawings in accordance with NFPA 90A and the manufacturer's written instructions.
- B. Coordinate installation of HVAC control systems with other trades.
 - 1. Prior to installation, coordinate wiring and conduit requirements with the electrical subcontractor.
- C. Mount remote annunciator and test station on wall near smoke detector.
 - 1. Devices shall be easily accessible from floor level.
 - 2. Label annunciator and test station.
- D. Provide electrical work to support smoke detector.
 - 1. Coordinate with the electrical subcontractor.
- E. Install thermostat cable and HVAC control wiring as specified in:
 - 1. Section 26_05_00 - Common Work Results for Electrical.
 - 2. Section 26_05_18 - 600-Volt or Less Wires and Cables.
 - 3. Section 26_05_33 - Conduits.
- F. Sensor and control station mounting:
 - 1. Where not otherwise indicated, mount 5 feet above floor or walking level.
 - 2. Provide insulating back plates when mounting is on an exterior wall or a wall adjoining an unconditioned space.
 - 3. Shield outside thermostats or sensors from the sun. Provide thermostats with remote bulb and compensated capillary.
 - 4. Install locking covers where indicated on the Drawings.

3.03 FIELD QUALITY CONTROL

- A. Functional Testing:
 - 1. Witnessed.
 - 2. Test each control component and system as part of HVAC system testing, adjusting, and balancing as specified in Section 23_05_93 - Testing, Adjusting, and Balancing for HVAC.

END OF SECTION

SECTION 23_31_13

METAL DUCTWORK

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Metal ductwork.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- B. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
 - 1. HVAC Systems-Duct Design.
 - 2. HVAC Duct Construction Standards, Metal and Flexible.
 - 3. Seismic Restraint Manual: Guidelines for Mechanical Systems.
- C. Underwriters Laboratories, Inc. (UL):
 - 1. 181A - Closure Systems for Use with Rigid Air Ducts.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Duct and component material and details of construction.
 - 2. System layout, including floor and wall penetrations.
 - 3. Supports and anchoring details.
 - 4. Components used in the duct system, including turning vanes, dampers, flexible connections, and access doors.
- C. Shop Drawings.

1.04 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Materials:
 - 1. As specified in Section 01_60_00 - Product Requirements.

2. Ducts:
 - a. Aluminum: Aluminum alloy 3003 H14 in accordance with ASTM B209.
 3. Reinforcing: Formed or extruded angles matching ductwork material.
- B. Changes in duct size:
1. Use uniformly tapering sections.
 2. Taper not more than 1 inch in 5 inches of run unless otherwise indicated on the Drawings.
- C. Bends: With the exception of miter bends, inside radii of bends to be equal to or greater than the largest duct dimension.
- D. Existing conditions:
1. Field verify existing dimensions, elevations, and conditions prior to Shop Drawing preparation and fabrication.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Pressure allowance:
1. Sheet metal construction shall conform to a minimum pressure classification of 2 inches of water gauge, negative and positive pressure, unless otherwise indicated on the Drawings or specified.
 2. In accordance with the SMACNA Seismic Restraint Manual.
 - a. As specified in Section 01_81_50 - Design Criteria.
 - b. Hanger reinforcement:
 - 1) Ducts 18 inches and smaller in largest dimension: None.
 - 2) Ducts over 18 inches and under 30 inches in largest dimension:
 - a) 1-1/2 inches by 1-1/2 inches, 1-1/2 inches by 1/8-inch angles, 8 feet on center.
 - 3) Ducts 30 inches and larger in largest dimension:
 - a) 1-1/2 inches by 1-1/2 inches by 1/8-inch angles, 4 feet on center.
 3. In accordance with the SMACNA HVAC Systems-Duct Design manual.
 - a. Sheet metal thicknesses: The greater of the SMACNA design or:

Minimum Gauge (B&S) for 2-inch Water Gauge Static Pressure			
Diameter or Largest Dimension of Rectangular Duct (Inches)	Galvanized Steel	Stainless Steel	Aluminum
Up to 12	24	24	21
13, 14	22	22	20
15 to 18	20	20	18
19, 20	18	18	16
21 to 26	16	16	15
Larger than 27	14	14	13

- b. Spacing of hangers and supports:
 - 1) In accordance with SMACNA but no greater than that indicated on the Drawings.

- 2) 8 feet on center for ducts 18 inches and smaller in the largest dimension.
- 3) 4 feet on center to ducts over 18 inches in the largest dimension.
- c. Support connections:
 - 1) In accordance with SMACNA unless indicated on the Drawings.
 - 2) As a minimum, all support connections to metal or wood roofs at roof framing members only.
 - 3) No penetrations through roof deck, roof membrane, or connections to roof membrane.

2.03 COMPONENTS

- A. Duct sleeves:
 - 1. Install where ducts pass through concrete or masonry walls and slabs.
 - 2. Size: 2 inches larger than the duct or duct with external insulation.
 - 3. Flanges: 4-inches wide.
- B. Access openings:
 - 1. Install in locations for access to dampers, fusible links, controllers, and similar devices.
 - 2. Size: 2 inches less than duct size.
 - 3. Doors:
 - a. Gauge not less than duct sheet.
 - b. Provide continuous hinge and latch on outside.
 - 4. Gasket: Along door periphery.
 - 5. Visual panel: 1/8-inch thick, clear Plexiglas.
- C. Turning vanes:
 - 1. Install at 90-degree bends.
 - a. Square-turn elbows, smooth radius elbows, and splitters.
 - 2. Material: Same as ductwork.
 - 3. Type:
 - a. Single-blade vanes for duct widths less than 36 inches.
 - b. Airfoil type vanes for duct widths of 36 inches and greater:
 - 1) No trailing edge.
 - 4. Mounted in side rails.
 - 5. Size: 2-inch blades for ducts up to 18 inches, 4-1/2 inch blades for larger ducts.
- D. Flexible connectors:
 - 1. Install at connections to air handling equipment and at other locations indicated on the Drawings.
 - 2. As specified in Section 23_05_00 - Common Work Results for HVAC.
- E. Splitter dampers:
 - 1. Provide at branch take-offs where necessary for balancing the system.

2.04 FABRICATION

- A. Fabricate ductwork to the configuration and outer dimensions indicated on the Drawings.

- B. Ductwork specified with insulation to be sized as indicated on the Drawings. Do not increase duct dimensions by thickness of insulation when internal insulation is specified.
- C. Do not utilize S clips, duct tape, or externally applied mastic on medium pressure duct systems.
- D. Do not use snap lock seams.

2.05 SHIPPING

- A. As specified in Section 01_60_00 - Product Requirements and Section 23_05_00 - Common Work Results for HVAC.

PART 3 EXECUTION

3.01 GENERAL

- A. As specified in Section 01_60_00 - Product Requirements and Section 23_05_00 - Common Work Results for HVAC.

3.02 INSTALLATION

- A. Hangers:
 - 1. Install as indicated on the Drawings.
 - 2. When hangers are not detailed, conform to SMACNA HVAC Systems - Duct Design and Seismic Restraint Manual standards and the following requirements:
 - a. Rectangular ducts concealed in ceiling spaces:
 - 1) Use metal strap hangers.
 - 2) Fasten to sides of duct with 2 screws.
 - 3) Fasten to bottom of duct with 1 screw.
 - b. Rectangular ducts in exposed areas:
 - 1) Install shelf angle trapeze hangers or Unistrut type hangers.
 - 2) Install sway bracing as required by seismic calculations, minimum 1 brace at right angle to each duct run.
 - c. Round ducts in exposed areas:
 - 1) Install 2 half-round bands with rods bolted to panels.
 - 2) Install sway bracing as required by seismic calculations, minimum 1 brace at right angle to each duct run.
- B. Provide closed-cell neoprene gaskets at flanged joints.
- C. Tapes and mastics used to seal ductwork shall be listed and labeled in accordance with UL 181A and shall be marked.

3.03 FIELD QUALITY CONTROL

- A. Inspect ductwork under operating conditions.
 - 1. Correct audible leaks and leaks that can be felt with the hand.

END OF SECTION

SECTION 23_34_01

FANS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Fans, motors, and accessories.

1.02 REFERENCES

- A. Abbreviations:
 - 1. As used in this Section and on the Drawings, abbreviations and Fan Schedule headings have the following meaning:
 - a. EF or EXF: Exhaust fan.
 - b. Hp: Fan motor horsepower.
 - c. SF or SPF: Supply fan.
 - d. Size: Nominal fan blade or wheel diameter in inches.
 - e. SP or ESP: Fan external static pressure in inches water column.
 - f. Type: Fan type as specified in this Section.
 - g. V/Ph: Fan motor voltage and power phases.
- B. Standards:
 - 1. Air Movement and Control Association International, Inc. (AMCA).
 - 2. American Bearing Manufacturers Association (ABMA):
 - a. 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - b. 11 - Load Ratings and Fatigue Life for Roller Bearings.
 - 3. ASTM International (ASTM):
 - a. A108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
 - b. D4167 - Standard Specification for Fiber Reinforced Plastic Fans and Blowers.
 - c. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
 - 4. National Fire Protection Association (NFPA):
 - a. 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
 - 5. National Roofing Contractors Association (NRCA).
 - 6. Occupational Safety and Health Administration (OSHA).

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Roof coordination as specified in Section 23_05_00 - Common Work Results for HVAC.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Materials.
 - 2. Primary and ancillary equipment.
 - 3. Sound power level in each of 8 octave bands and overall sones.
 - 4. Fan system layout, mechanical, electrical power, and control diagrams.
 - 5. Supports, vibration isolators, and seismic bracing calculations and details.
 - 6. Calculated fan vibration levels and field-testing method.
 - 7. Bearing life.
 - 8. Fan performance curves showing specified operating condition.
- C. Drawings:
 - 1. Component layout and identification.
 - 2. Views:
 - a. Front, side, rear elevations, and top and bottom views, with dimensions.
 - b. Connection locations, including electrical, mechanical, and other.
 - 3. Cut away drawings.
 - a. Parts list.
 - b. Material specification lists.
 - 4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
 - 5. Details for supports, isolators, and bracing.
- D. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
 - c. For wall mounted equipment weighing 125 pounds or more.
- E. Manufacturer's recommendations for handling, storage, and installation.
- F. Nameplate data.
- G. Vendor operation and maintenance manuals: Manufacturer's standard instruction manual for operation and maintenance.
- H. Provide manufacturers reports on factory testing.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 23_05_00 - Common Work Results for HVAC.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 23_09_13 - Instrumentation and Control Devices for HVAC.
- B. Roof curb:
 - 1. Factory fabricated to match fan material.
 - 2. Capable of supporting entire unit weight.
 - 3. Suitable for installing and connecting ductwork to curb.
 - 4. In accordance with NRCA standards.
 - 5. Extend a minimum of 8 inches above top of built up roofing.
 - 6. Curb shall be a minimum height of 12 inches.
 - 7. Flashing: In accordance with NRCA standards and roof manufacturer.

2.03 TYPE 3, CENTRIFUGAL FILTERED ROOF SUPPLY FANS

- A. Manufacturers: One of the following or equal:
 - 1. ACME.
 - 2. Greenheck.
 - 3. Loren Cook.
- B. Characteristics:
 - 1. Roof-mounted, centrifugal filtered supply fan.
 - 2. Forward-curved centrifugal fan wheel.
 - 3. Materials: Complete aluminum construction with a quick release hood cover.
 - 4. Fan bearings: Permanently lubricated ball bearing type.
 - 5. Belt drive rated for 150 percent of motor horsepower.
 - 6. Finishes: Provide 2.0 to 3.0-mils thick polyester powder coat or approved equal finish on fan and accessories.
- C. Accessories:
 - 1. Mounting brackets: Necessary for installation.
 - 2. Roof curb.
 - 3. Filter section:
 - a. Low velocity 2-inch thick pleated, washable filters of commercially available sizes.
 - b. Filter face velocity: Not to exceed 350 feet per minute nominal flow.
 - c. Provide filters of identical size for any one unit.
 - d. Filters: American Air Filter or equal.
 - 4. Insulated cover to prevent condensation.
 - 5. Backdraft damper.
 - 6. Provide other accessories as scheduled.

2.04 SOURCE QUALITY CONTROL

- A. Factory test fans listed on the Fan Schedule for proper operation, performance, and electrical controls.

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

- A. As specified in Section 01_60_00 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.
- B. Deliver units in 1 piece, factory assembled, internally wired, and lubricated.

PART 3 EXECUTION

3.01 GENERAL

- A. As specified in Section 01_60_00 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.04 TESTING

- A. Test equipment performance and balance equipment as specified in Section 23_05_93 - Testing, Adjusting, and Balancing for HVAC.

3.05 FIELD QUALITY CONTROL

- A. Verify equipment operation and unit vibration is within the manufacturer's submitted maximum.

3.06 SCHEDULES

- A. As indicated on the Drawings.

END OF SECTION

SECTION 23_81_44

HEAT PUMPS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Mini-split systems.

1.02 REFERENCES

- A. Abbreviations:
 - 1. MERV - Minimum Efficiency Reporting Values.
- B. Standards:
 - 1. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
 - a. Standard 15 – Safety Standard for Refrigeration Systems.
 - b. Standard 62.1 - Ventilation for Acceptable Indoor Air Quality.
 - 2. ASTM International (ASTM):
 - a. B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
 - 3. Federal Specification (FS):
 - a. Standard 141 - Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing.
 - 4. National Electrical Manufacturers Association (NEMA):
 - a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 5. Underwriters Laboratories, Inc. (UL):
 - a. 60335-2-40 - Safety Standard for Household and Similar Electrical Appliances.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Catalog cuts, bulletins, and brochures:
 - 1. Design features.
 - 2. Load capacities.
 - 3. Efficiency ratings.
 - 4. Dimensions.
 - 5. Weight: Shipping and operating.

- C. Shop Drawings:
 - 1. Component layout and identification.
 - 2. Views:
 - a. Front, side, rear elevations, and top and bottom views, with dimensions.
 - b. Connection locations, including electrical, mechanical, and other.
 - 3. Cut away drawings.
 - a. Parts list.
 - b. Material specification lists.
 - 4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
 - 5. Details for supports, isolators, and bracing.
- D. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. For equipment installed outdoors.
- E. Engineering data:
 - 1. Manufacturer's published data for compressor, evaporator coil, condenser, evaporator fan, refrigerant, and filter.
 - 2. Maximum equipment vibration levels and field-testing method.
 - 3. Sound power level in each of 8 octave bands and overall sones.
 - 4. Fan performance curves showing specified operating condition.
 - 5. Bearing life.
- F. Manufacturer's recommendations for handling, storage, and installation.
- G. Nameplate data.
- H. Seismic certification.
- I. Vendor operation and maintenance manuals: Manufacturer's standard instruction manual for operation and maintenance.

1.05 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.
- B. Special warranties:
 - 1. Refrigerant compressors and closed or sealed refrigerant systems warranty duration: Provide 5-year warranty.
 - 2. Evaporator and condensing coils warranty duration: Provide 5-year warranty.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_00 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.
- B. Supplied components of the unit shall be furnished and fully integrated by the unit system supplier:
 - 1. Provide piping, valves, dampers, sensors and wiring within the unit package.
 - 2. Provide a unit mounted control panel prewired on the unit to dampers and sensors within the unit.
- C. Motors:
 - 1. Totally enclosed.
 - 2. Voltage and number of phases as scheduled.
 - 3. Compressor motors:
 - a. Cooled by refrigerant gas passing through windings.
 - b. Provided with line break thermal and current overload protection.
 - 4. Fan and blower motors:
 - a. Permanently lubricated ball bearings.
 - b. Integral automatic reset thermal overload protection.
 - 5. Other requirements as specified.
- D. Electrical:
 - 1. Provide a single conduit connection in the unit for both power and control wiring.
- E. Refrigerant:
 - 1. Fully charged with R-454B.
 - 2. Compliant with ASHRAE 15.
 - 3. HFO refrigerant with global warming potential (GWP) of 700 or less.
 - 4. Must have a refrigerant monitoring system and be rated in accordance with UL 60335-2-40.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. As specified in Section 23_05_00 - Common Work Results for HVAC.
- B. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 23_09_13 - Instrumentation and Control Devices for HVAC.

2.03 MINI-SPLIT SYSTEM HEAT PUMPS

- A. Manufacturers: One of the following or equal:
 - 1. Daikin.
 - 2. Lennox.
 - 3. LG.
 - 4. Trane.
- B. Basis of design, model, and series: As indicated on the Drawings.

- C. Compressors:
 - 1. Fully hermetically-sealed, high-efficiency, reciprocating or rotary or scroll-type, with rubber grommet vibration isolation.
- D. Fans:
 - 1. Indoor air fan:
 - a. Direct driven with capacitor start motor; double inlet, forward curve sirocco fan.
 - b. Steel with corrosion resistant finish.
 - c. Statically and dynamically balanced.
 - d. Permanently sealed ball bearing type and permanently lubricated.
 - 2. Outdoor condenser fan:
 - a. Propeller type, direct drive.
 - b. Aluminum blades.
 - c. Dynamically balanced.
 - d. Permanently sealed ball bearing type and permanently lubricated.
 - 3. Evaporator and condenser coils: Seamless copper tubes with mechanically bonded aluminum plate fins.
 - 4. Provide corrosion resistant finish, suitable for marine environment.
- E. Refrigerant components:
 - 1. Refrigerant circuit, including:
 - a. Accumulator and filter/drier.
 - b. Expansion device.
 - c. Reversing valve.
 - d. Flow control valves.
 - e. Service and gauge connections on compressor suction and discharge, and liquid lines to charge, evacuate, and contain refrigerant.
- F. Controls and equipment safety features:
 - 1. Provide system controls for a complete functioning system:
 - a. High and low evaporator fan speed control for cooling and heating modes.
 - b. Fan only operation.
 - c. Space temperature condition setting.
 - 2. Equipment safety features:
 - a. Thermostatic base pan drain to prevent freeze up of the fan in collected condensate.
 - 3. Provide with a low ambient cooling option.
- G. Unit casing:
 - 1. Slide out design unit casing manufactured of high strength molded plastic with smooth finish.
 - a. Ducted ceiling suspended units:
 - 1) Slide out design unit casing manufactured of insulated galvanized steel.
 - b. Ceiling recessed cassette units:
 - 1) Space-saving ceiling-recessed cassette formed of galvanized steel.
 - 2. Outdoor casing shall be constructed from galvanized steel plate, finished with an electrostatically applied, polyester powder coating for corrosion protection.
 - 3. Weatherproof design, reinforced and braced for maximum rigidity.

4. Provided with:
 - a. Accessible filter rack for filters.
 - b. Non-corrosive drain pan in accordance with ASHRAE Standard 62.1.
 - c. Horizontal drain connection.
 - d. Mini condensate pump suitable to be powered from indoor/outdoor unit when not internal to the unit or as indicated on the Drawings.
 - e. Knockouts for power connections.

2.04 ACCESSORIES

- A. Sensors: As specified in Section 23_09_13 - Instrumentation and Control Devices for HVAC.
- B. Hail guard.
- C. Coil guard.

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

- A. As specified in Section 23_05_00 - Common Work Results for HVAC.

PART 3 EXECUTION

3.01 GENERAL

- A. As specified in Section 01_60_00 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 2. Install anchors of type and material indicated on approved anchoring designs.
 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. Insulate refrigerant and condensate piping as specified in Section 23_05_00 - Common Work Results for HVAC.

3.04 TESTING

- A. Test equipment performance and balance equipment as specified in Section 23_05_93 - Testing, Adjusting, and Balancing for HVAC.
 1. Test for outdoor sound power at levels.

3.05 FIELD QUALITY CONTROL

- A. Verify equipment installation operation and vibration is within the manufacturer's submitted maximum.

3.06 SCHEDULES

- A. As indicated on the Drawings.

END OF SECTION

SECTION 23_83_01

HEATING UNITS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Requirements for electric, gas fired, steam, hot water unit heaters and thermostats for heaters.

1.02 REFERENCES

- A. American Gas Association (AGA).
- B. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- C. Underwriters' Laboratories, Inc. (UL).

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Roof coordination as specified in Section 23_05_00 - Common Work Results for HVAC.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.05 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Catalog cuts, bulletins, and brochures:
 - 1. Design features.
 - 2. Load capacities.
 - 3. Efficiency ratings.
 - 4. Dimensions.
 - 5. Weight: Shipping and operating.
- C. Drawings:
 - 1. Component layout and identification.
 - 2. Views:
 - a. Front, side, rear elevations, and top and bottom views, with dimensions.
 - b. Connection locations including electrical, mechanical, and other.
 - 3. Cut away drawings:
 - a. Parts list.

- b. Material specification lists.
- 4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
- 5. Details for supports, isolators, and bracing.
- D. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For wall mounted equipment weighing 125 pounds or more.
- E. Engineering data:
 - 1. Manufacturer's published data for fan, burner, and filter.
 - 2. Maximum equipment vibration levels and field-testing method.
 - 3. Sound power level in each of 8 octave bands and overall Sones.
 - 4. Fan performance curves showing specified operating condition.
 - 5. Bearing life.
- F. Manufacturer's recommendations for handling, storage, and installation.
- G. Nameplate data.
- H. Seismic certification.
- I. Vendor operation and maintenance manuals: Manufacturer's standard instruction manual for operation and maintenance.

1.06 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_00 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. As specified in Section 23_05_00 - Common Work Results for HVAC.
- B. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 23_09_13 - Instrumentation and Control Devices for HVAC.

2.03 NATURAL GAS UNIT HEATERS (GUH)

- A. Manufacturers: One of the following or equal:
 - 1. Reznor, Type UDZ.

2. Trane Co., similar models.
 3. Sterling, similar models.
- B. Fan type: Aluminum non-surging propeller:
1. Including fan guards.
 2. Dynamically balanced.
 3. Permanently lubricated ball bearings.
 4. Automatic reset thermal overload protection.
- C. Heat exchanger characteristics:
1. Seam welded minimum 20-gauge aluminized steel tubes with minimum 18-gauge aluminized steel headers; provide non prorated 10-year exchanger warranty.
 - a. Provide stainless steel heat exchangers when indicated in the Heating Unit Schedules.
- D. Features:
1. Provide unit including casing, integral draft diverter, heat exchanger, horizontal adjustable louvers with stops to prevent full closure, motor and propeller fan assembly, burners, flue vent fan, controls, and suspension mounting.
 2. Burners, universal type manufactured of die-formed, aluminized steel with stainless burner port protectors. Burner orifices suitable for elevation as specified in Section 23_83_01 - Heating Units.
 3. Intermittent solid-state ignition control system with pilot burner, made of stainless steel.
 4. Flue pipes, 16-gauge, or heavier, galvanized steel, double walled, certified for zero clearance installation.
 5. Gas piping, black steel with unions to simplify assembly and disassembly.
 6. Bronze shutoff cocks.
 7. Cabinet manufactured of minimum 20-gauge galvanized steel.
 8. Provide concentric adapter kit for combustion with unit as indicated on the Drawings.
 9. Controls:
 - a. Pressure regulators.
 - b. Diaphragm gas valve; on units over 100 MBH input, provide 2-stage gas valve (50 percent and 100 percent fire) and 2-stage thermostat.
 - c. Safety pilot switch with 100 percent gas shutoff.
 - d. High temperature limit switch.
 - e. Fan time delay.
 - f. Hand shutoff valves for main burner and for pilot burner.
 - g. Provide thermostat as specified in this Section.
 - h. Provide control transformer suitable for 24-volt or 120-volt control as indicated in the Heating Unit Schedules.
- E. Finishes:
1. Casing finish backed enamel in manufacturer's standard color.
- F. Source quality control: Flame test burners:
1. Provide proof of test upon delivery.

2.04 THERMOSTATS FOR UNIT HEATERS

- A. Type: Wall mounted, heat only with fan AUTO-ON selector switch when fan part of unit and separate system ON-OFF selector switch.
- B. Dial or lever temperature setpoint adjustment with 45 to 90 degrees Fahrenheit setpoint range.
- C. Setpoint and temperature indication.
- D. Control voltage as indicated in the Heating Unit Schedules.
- E. Bi-metallic contacts suitable for 1- or 2-stage unit heater control as specified for the heater size or as scheduled.

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

- A. As specified in Section 01_60_00 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.

PART 3 EXECUTION

3.01 GENERAL

- A. As specified in Section 01_60_00 - Product Requirements with additional requirements in Section 23_05_00 - Common Work Results for HVAC.

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.04 TESTING

- A. Test equipment performance and balance equipment as specified in Section 23_05_93 - Testing, Adjusting, and Balancing for HVAC.

3.05 FIELD QUALITY CONTROL

- A. Verify equipment operation is within manufacturer's standards and that noise levels do not exceed levels specified.

3.06 SCHEDULES

- A. As indicated on the Drawings.

END OF SECTION

SECTION 26_05_00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Requirements for electrical:
 - a. Basic design and performance criteria.
 - b. Prescriptive requirements for common components.
 - c. Installation.
- B. Contract Drawings:
 - 1. Schematic diagrams:
 - a. Controls are shown as de-energized.
 - b. Add relays, where required, to provide 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.
 - c. Mount devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted.
 - 2. Plan drawings:
 - a. Electrical drawings show desired locations, arrangements, and components of the electrical Work in a diagrammatic manner.
 - b. Locations and sizes of equipment are approximate only.
 - 3. Installation details:
 - a. 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.
 - b. Not all typical installation details are referenced within the drawing set. Apply and use typical details where appropriate.

1.02 REFERENCES

- A. Abbreviations:
 - 1. FAT: Factory acceptance test that is also referred to as source test.
 - 2. ICSC: Instrumentation and controls subcontractor.
 - 3. PCIS: Process control and instrumentation system.
- B. Standards:
 - 1. American National Standards Institute (ANSI).
 - 2. National Electrical Manufacturers Association (NEMA):
 - a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 3. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
 - 4. Underwriters Laboratories, Inc. (UL).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. LCP: Local control panel: Operator interface panel that may contain pilot type control devices, operator interface devices, control relays, etc., and does not contain a PLC or RIO.
 2. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
 3. Space: Portion of a 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.
 - a. Furnish hardware to accommodate installation of future circuit breakers, instruments, relays, and controls.
 - b. Wire relay and circuit breaker control power and network connections to the compartment and provide terminations.
 - c. Space for future devices shall include:
 - 1) All necessary bus.
 - 2) Device supports and mounting equipment.
 - 3) Device connections to bus work.
 - 4) Wire troughs or raceway space.
 4. Spare: Portion of a switchgear, motor control center, panelboard, switchboard, or control panel that physically contains a device with no load connections to be made.
 5. Unequipped space: Portion of a switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.
 6. Vendor control panel (VCP): Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.

1.04 DELEGATED DESIGN

- A. Requirements for Delegated Design are specified in the Technical Sections.

1.05 SUBMITTALS (NOT USED)

1.06 QUALITY ASSURANCE

- A. General:
1. Furnish 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. Shipping precautions:
1. After completion of shop assembly and successful factory testing, pack equipment in protective crates, and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.

2. Place dehumidifiers, when required, inside the polyethylene coverings.
3. Skid-mount the equipment for final transport.
4. Provide lifting rings for moving without removing protective covering.
5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 1. Loop drawings:
 - a. Provide 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.
 2. Roof penetrations:
 - a. Show roof penetrations for electrical equipment and conduit on the roof drawing Submittal and include equipment information:
 - 1) Type.
 - 2) Size.
 - 3) Location.
 - 4) Configuration of individual penetrations or large penetrations for multiple conduits.
 - 5) Weight.
 - 6) Anchoring and support details.
- B. Meetings:
 1. As specified in Section 01_31_19 - Project Meetings.
- C. Sequencing and scheduling:
 1. Equipment anchoring: Project construction schedule must include an event for obtaining the anchor layout drawings from equipment manufacturers in adequate time for templates to be constructed and anchors to be cast-in-place.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide field wiring and terminations.
- B. Equipment mounting and anchoring:
 - 1. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load specified in Section 01_81_50 - 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 equipment that is supported higher than 4 feet above the floor, provide calculations for:
 - 1) 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) Design of equipment anchorage, supports, and connections based on calculated shear and tension forces.
 - 2. Anchorage of equipment to concrete or masonry:
 - a. Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
 - b. Unless otherwise indicated on the Drawings, select and provide anchors from the types specified in Section 05_05_24 - 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.
 - 3. 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.

2.03 MANUFACTURERS (NOT USED)

2.04 MATERIALS

- A. Enclosures:
 - 1. Provide enclosures for electrical, instrumentation, and control equipment, regardless of Supplier or Subcontractor furnishing the equipment, that meet the requirements of NEMA Standard 250.
 - a. Provide metallic enclosures unless specifically indicated otherwise.
- B. 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. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
 4. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.
- C. Plant area electrical work requirements:
1. Provide electrical materials in accordance with the following table, unless otherwise specifically indicated on the Drawings:
 - a. Conduit installation requirements: As specified in Section 26_05_33 - Conduits.

Table 1. Electrical Material Requirements				
Plant Area	Environment: W = Wet D = Damp C = Clean/dry X = Corrosive H = Hazardous	NEMA Enclosure Type	Exposed Conduit Type (as specified in Section 26_05_33 - Conduits)	Support Materials
Dewatering Building	W,D	4	PCS	SST
Sludge Pump Station	W	4X SST	PCS	SST
Sludge Day Tanks	W,D	4X SST	PCS	SST
Electrical Room	C	1,12	GRC	GALV STL
Outdoor Areas	W	4X SST	PCS	SST
Notes: (1) Outdoor classified areas require dual rating of NEMA 4X and 7.				

PART 3 EXECUTION

3.01 EXAMINATION

- A. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
1. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work.
 2. Determine information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
 3. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Demolition:
1. As specified in Technical Sections or as indicated on the Drawings.

2. Disconnect utilities:
 - a. Disconnect electrical equipment.
 3. Remove and dispose of conduit, wire, electrical equipment, controls, etc., associated with the items and/or areas to be demolished as indicated on the Drawings unless otherwise indicated.
 4. Salvage electrical equipment as specified in Section 01_35_21 - Selective Alterations and Demolition.
 5. For each piece of equipment to be removed, remove ancillary components (e.g., instruments, solenoid valves, disconnect switches, etc.).
 6. Conduit:
 - a. Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:
 - 1) Remove exposed conduit to the point of encasement or burial.
 - 2) Cut conduit flush and plug or cap encased or buried conduit.
 - b. Where conduits are to remain in place and removal is not indicated on the Drawings:
 - 1) Cap conduit open ends.
 - 2) Re-label empty conduits as spare.
 7. Remove wire back to the source for conduits to be removed or abandoned in place.
 8. Provide new nameplates for modified electrical distribution equipment, motor control centers etc., to identify equipment and circuits that are no longer used as spares.
 9. Provide new typewritten schedules for modified panelboards.
- B. Equipment:
1. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.
- C. Provide NEC required working space in front of electrical equipment as if it could be worked on energized.
- D. Circuits of different service voltage:
1. Voltage and service levels:
 - a. Medium voltage: Greater than 1.0 kV.
 - b. Low voltage:
 - 1) Power and controls: 120 V to 480 V.
 - c. Instrumentation: Less than 50 VDC.
 2. Install different service voltage circuits in separate raceways, boxes, manholes, and hand holes.
 3. Low voltage and instrumentation circuits may be installed in a common metallic box, wireway, or cable tray with a grounded divider as indicated on the Drawings.
- E. Conductors shall not pass through equipment they are not terminating in unless indicated on the Drawings or approved by the Engineer.

3.04 FIELD QUALITY CONTROL

- A. 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 excessively long used, as well as spare, wire and cable lengths, as directed by the Engineer.
- B. Inspection activities conducted during construction do not satisfy the inspection or testing requirements specified in Section 26_08_50 - Field Electrical Acceptance Tests.
- C. Provide on-site assistance for troubleshooting and correcting electrical issues discovered during installation and testing for the Project.

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

- A. General:
 - 1. Clean and vacuum enclosures to remove metal filings, surplus insulation and any visible dirt, dust, or other matter before energization of the equipment or system start-up:
 - a. Use of compressors or air blowers for cleaning is not acceptable.
 - 2. Clean luminaries in the areas affected by the construction.

END OF SECTION

SECTION 26_05_09

LOW VOLTAGE MOTORS UP TO 500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Low voltage motors up to 500 horsepower (hp).

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. ASTM International (ASTM):
 - 1. B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
- C. 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).
- D. National Electrical Manufacturers Association (NEMA):
 - 1. MG 1 - Motors and Generators.
- E. Underwriters Laboratories Inc. (UL):
 - 1. 674 - Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Submit completed motor data sheets for each motor supplied:
 - 1. As specified in Attachment A - Motor Data Sheet.
 - 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. Manufacturer's storage recommendations.
 5. Torque, current, and power factor versus speed curves:
 - a. At 100 percent rated voltage for full voltage started and VFD-driven motors.
 - b. For motors on reduced voltage, start at 70, 80, 90, and 100 percent rated voltage.
 6. Accessories data:
 - a. Power factor correction capacitors:
 - 1) Size in KVAR for 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.
 7. Mechanical data:
 - a. Bearing design and bearing life calculations.
 - b. Resonant frequencies for VFD-driven motors 50 hp or greater.
 8. Motor grounding devices for VFD driven motors.
 - a. Shaft grounding rings.
 - b. High-frequency grounding straps.
- 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. Calculations:
1. Where Site conditions specified in Section 01_81_50 - Design Criteria exceed manufacturer's ratings, provide derating calculations for each motor.
- F. Quality Control Submittals:
1. Manufacturer's representative qualifications.
 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - a. With test reference standard identified.
- G. 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. In accordance with the requirements of the latest edition of NEMA MG 1, Part 31.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Store motors in accordance with the manufacturer's recommendations.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- 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.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in Section 01_81_50 - Design Criteria and as indicated on the Drawings.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. Baldor/ABB.
 - 2. General Electric.
 - 3. Toshiba.
 - 4. US Motors.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. 3-phase induction motors:
 - 1. Voltage:
 - a. 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. 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. 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 304 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: 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 the manufacturer's standard material for the specified rating.
9. Nameplates:
 - a. Provide 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 304 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.

- g. Provide oversized conduit boxes for VFD driven motors sized to accommodate the VFD cable termination and motor lead connection system.
- 12. Motor bearings:
 - a. Antifriction.
 - b. Regreasable and initially filled with grease for horizontal motors and vertical motors in accordance with the manufacturer's standard design, unless sealed bearings are provided as part of the standard motor construction.
 - c. Bearings and lubrication suitable for ambient temperature and temperature rise.
 - d. Suitable for intended application and have a rate for ABMA 9 or ABMA 11, 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 with non-wicking, non-hydroscopic material. Class F insulation.
- 15. Noise:
 - a. Maximum operating noise level in accordance with NEMA MG 1.
- B. Vertical motors:
 - 1. Enclosures:
 - a. Totally enclosed fan cooled (TEFC) for motors 200 hp and less installed outdoors.
 - b. Weather protected Type II (WP II) for motors greater than 200 hp installed outdoors.
 - c. Weather protected Type I (WPI) where installed indoors.
 - 2. Thrust bearings:
 - a. Selected for combined rotor and driven equipment loads.

- b. Coordinate with the driven equipment supplier for maximum vertical thrust of driven equipment.
 - 3. Anti-reverse ratchet.
- C. Motors driven by variable frequency drives:
 - 1. Compatible with the variable frequency drives specified.
 - 2. Inverter duty rated and labeled.
 - 3. Meet the requirements of NEMA MG 1, Part 31.
 - 4. Winding insulation meets the requirements of NEMA MG 1, Part 31.4.4.2.
 - 5. Capable of running continuously at 1/10th of full speed, with no harmful effects or overheating.
 - 6. Shaft grounding ring:
 - a. Designed specifically to protect bearings from capacitive EDM current and high frequency circulation current.
 - b. Provide 360 degrees circumferential conductive microfiber ring.
 - c. Provide a motor manufacturer-installed shaft grounding ring for each VFD-driven motor.
 - d. Aluminum frame and internal components.
 - e. Conductive microfiber brushes.
 - f. Maintenance free design.
 - g. Colloidal silver compound installed on shaft under the shaft grounding ring.
 - h. High frequency ground strap.
 - 1) AEGIS® HF, as manufactured by Electro Static, or equal.
 - i. Grounding ring:
 - 1) Installed inside motor housing on drive end (DE).
 - 2) Installed on exterior of motor housing on drive end with written permission from the Engineer.
 - j. Refer to the following table for specific requirements based upon the driven motor:

Motor Size	<100 hp	100 hp to 500 hp	>500 hp
Voltage	<600 VAC	<600 VAC	<600 VAC
AEGIS® Ring	SGR	SGR	PRO
Bearing Insulation	No	NDE	NDE & DE
Colloidal Sliver	Recommended	Required	Required
HF Grounding Straps	Required	Required	Required

Notes:

DE - drive end.
 HF - AEGIS® High Frequency Grounding Strap.
 NDE - non-drive end.
 PRO - AEGIS® PRO Series Shaft Grounding Rings.
 SGR - AEGIS® Shaft Grounding Ring Series.

- k. AEGIS® bearing protection ring, as manufactured by Electro Static Technology, or equal.
 - 7. Insulated bearings:
 - a. Provide the motor manufacturer's standard insulated sleeve or ceramic bearings.

- b. Motors 100 hp to 500 hp: Provide insulated bearing on non-drive end (NDE) of the motor the end opposite the shaft grounding ring as recommended by the motor manufacturer.
 - c. Motors larger than 500 hp: Provide insulated bearings on both the DE and NDE, and AEGIS® PRO Series shaft ground ring externally mounted on the DE.
- D. Motors installed in corrosive environments:
 - 1. Nameplate indicating conformance to IEEE 841.
 - 2. Stator double dipped in varnish and baked.
 - 3. Stator and rotor coated with corrosion resistant epoxy.
 - 4. Frame, brackets, fan guard and conduit box coated with minimum of 2 coats of epoxy paint.
 - 5. Withstand salt spray tests in accordance with ASTM B117.
- E. Single-phase motors:
 - 1. Capacitor start type rated for operation at 115 volts, 60 hertz, unless otherwise specified or as indicated on the Drawings.
 - 2. Totally enclosed fan cooled (TEFC) motors manufactured in accordance with NEMA MG 1.
 - 3. Ball bearings: Sealed.
 - 4. 1/2 hp or less fan motors:
 - a. Split-phase or shaded pole type when standard for the equipment.
 - b. Open type when suitably protected from moisture, dripping water, and lint accumulation.
 - 5. Wound rotor or commutator type single-phase motors only when their specific characteristics are necessary for application and their use is acceptable to the Engineer.
 - 6. Integral overload protection.
- F. Immersible motors:
 - 1. Meet all general requirements for 3-phase induction motors, except as modified in this Section.
 - 2. Inverter duty as indicated on the Drawings or in the driven equipment Specifications.
 - 3. Enclosure:
 - a. Cast iron.
 - b. Designed and constructed to meet or exceed IP67.
 - c. Epoxy paint finish:
 - 1) Withstands salt spray and corrosion tests in accordance with ASTM B117.
 - d. Furnished with lifting plates or lugs.
 - e. Vertical or horizontal mounting as required by the application.
 - 4. Conduit box:
 - a. Cast iron.
 - b. Bolted and sealed cover.
 - c. Rotatable in 90-degree increments.
 - d. Watertight gland or potable hub for power cable entry.
 - 5. Power cable:
 - a. Type SOOW or W cable, non-shielded.
 - b. Length as required for the installation.

6. Cooling blower:
 - a. As required by the motor manufacturer.
 - b. Washdown duty rated.
 - c. Constant speed.
7. Humidity moisture detector.

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

- A. Motor winding heaters:
 1. Provide 3-phase motors with belted or cartridge space heaters mounted within the motor enclosure.
 2. Space heater rating shall be 120 volts, single-phase, unless otherwise indicated on the Drawings.
 3. Power leads for heaters wired into conduit box.
 4. Installed within motor enclosure adjacent to core iron.
- B. Winding temperature detectors:
 1. Provide factory installed winding temperature detector with leads terminating in the conduit box:
 - a. Where required by the driven equipment Specification or as indicated on the Drawings.
 - b. RTD type, 2 per phase, 100-ohm platinum.
 2. Temperature switches with normally closed contacts as indicated on the Drawings.

2.09 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL

- A. Source Testing:
 1. Motors less than 250 hp:
 - a. Perform the 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.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install motors in accordance with the manufacturer's instructions.
- B. VFD driven motors:
 - 1. Install shaft grounding ring on VFD-driven motors in accordance with the manufacturer's instructions.
 - 2. Bond the motor frame to earth ground using a high frequency ground conductor.
 - a. If earth ground (either grounding electrode system or building steel) is within reach of the high frequency ground strap, the ground strap may be connected directly to the earth ground.

3.04 FIELD QUALITY CONTROL

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

END OF SECTION

ATTACHMENT A - MOTOR DATA SHEET

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 RISE _____	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 _____
*In accordance with NEMA MG 1, Part 31.			

SECTION 26_05_18

600-VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. Abbreviations:
 - 1. AWG: American wire gauge.
 - 2. BCCS: Bare copper-covered steel.
 - 3. CPE: Chlorinated polyethylene.
 - 4. FHDPE: Foam high-density polyethylene.
 - 5. FPE: Foam polyethylene.
 - 6. OD: Outside diameter.
 - 7. PVC: Polyvinyl chloride.
 - 8. XHHW: Cross-linked high heat water resistant insulated wire.
- B. Standards:
 - 1. ASTM International (ASTM):
 - a. B3 - Standard Specification for Soft or Annealed Copper Wire.
 - b. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - 2. CSA International (CSA).
 - 3. Insulated Cable Engineers Association (ICEA):
 - a. S-90-661 - Individually Unshielded Twisted Pair Indoor Cables for Use in Communication Wiring Systems.
 - 4. National Electrical Manufacturers Association/Insulated Cable Engineers Association (NEMA/ICEA):
 - a. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.
 - b. NEMA WC 66/ICEA S-116-732 - Standard for Category 6 and 6A, 100 Ohm, Individually Unshielded Twisted Pairs, Indoor Cables (With or Without an Overall Shield) for Use in LAN Communication Wiring Systems.
 - c. NEMA WC 70/ICEA S-95-658-1999 - Standard for Power Cables Rated 2,000 Volts or Less for the Distribution of Electrical Energy.
 - 5. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
 - b. 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
 - 6. Telecommunications Industry Association (TIA):
 - a. 568.2-D - Balanced Twisted-Pair Telecommunications Cabling and Components Standard.

- b. 569-B - Commercial Building Standards for Telecommunications Pathways and Spaces.
- 7. Underwriters Laboratories Inc. (UL):
 - a. 44 - Standard for Thermoset-Insulated Wires and Cables.
 - b. 1277 - Electrical Power and Control Tray Cables with Optional-Fiber Members.
 - c. 1666 - Standard for Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- 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.
 - 2. Wire and cable pulling plan:
 - a. Provide a pull plan sketch identifying each segment of the pulling calculations, mechanical pulling equipment, and wire/cable spool locations.
- 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 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.
 - c. Provide the wire and cable pulling plan identified under Shop Drawings with the cable pulling calculations Submittal.
- F. Cable lengths:
 - 1. Submit installed cable lengths using a conduit measuring tape for 3-phase circuits.

2. Submit installed lengths of cable for the following single-phase circuits:
 - a. Circuits feeding single-phase transformers.
 - b. Circuits feeding single-phase panelboards.

1.05 QUALITY ASSURANCE

- A. Wires and cables shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. General Site and Project conditions:
 1. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Color-coding:
 1. Color-coding shall be consistent throughout the facility.
 2. The following color code shall be followed for 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 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 120 VAC control wiring:
 - a. Power: Red.
 - b. Neutral: White.
 5. The following color code shall be followed for general purpose DC control circuits:
 - a. Grounded conductors: White with blue stripe.
 - b. Ungrounded conductors: Blue.
 6. Switch legs shall be violet. 3-way switch runners shall be pink.

7. Wires in intrinsically safe circuits shall be light blue.
8. Wire colors shall be implemented in the following methods:
 - a. Wires manufactured of the desired color.
 - b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
 - 1) Colored tape shall be wrapped to overlap half of the width of the tape.

2.02 DESIGN AND PERFORMANCE CRITERIA

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

2.03 MANUFACTURERS

- A. One of the following, or equal:
 1. 600-volt class wire and cable:
 - a. Okonite Co.
 - b. Prysmian General Cable.
 - c. Service Wire.
 - d. Southwire Co.
 2. 600-volt VFD cable:
 - a. Prysmian General Cable.
 - b. Service Wire.
 - c. Southwire Co.
 3. Instrumentation class wire and cable:
 - a. Alpha Wire Co.
 - b. Belden CDT.
 - c. Okonite Co.
 - d. Prysmian General Cable.
 - e. Rockbestos Surprenant Cable Corp.
 4. Network cables:
 - a. Belden.
 - b. CommScope.
 - c. General Cable.

2.04 MATERIALS

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

2.05 MANUFACTURED UNITS

- A. General:
 1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
 2. Permanently mark each wire and cable with the following at 24-inch intervals:
 - a. AWG size.
 - b. Voltage rating.
 - c. Insulation type.
 - d. UL symbol.
 - e. Month and year of manufacture.
 - f. Manufacturer's name.

3. Identify and mark wire and cable as specified in Section 26_05_53 - 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 derating factors, equal to or greater than rating of the overcurrent device.
 - 2) Provide #12 AWG minimum for power conductors.
 - 3) Provide #14 AWG minimum for control conductors.
 2. Provide Class B stranding in accordance with ASTM B8:
 - a. Provide Class C stranding where extra flexibility is required.
 3. Insulation:
 - a. XHHW-2.
 - b. 90-degree Celsius rating.
- C. 600-volt VFD cables:
 1. Conductor:
 - a. Provide Class B stranding in accordance with ASTM B3 and ASTM B8.
 - b. Copper conductor.
 2. Insulation:
 - a. Cross-linked Polyethylene, XLPE.
 - b. 90-degree Celsius rating.
 - c. RHW-2 or XHHW-2.
 - d. 2,000 volts.
 3. Ground:
 - a. Provide Class B compressed stranded bare copper in accordance with ASTM B3 and ASTM B8.
 - b. 3 symmetrically placed bare copper conductors in direct contact with shield.
 - c. Equivalent ground size 50 percent of the phase conductor size.
 4. Filler:
 - a. Cable sizes 8 and 6 use polypropylene filler.
 - b. Other cable sizes use paper filler.
 5. Metallic shield:
 - a. Overall 5 mil bare copper tape shield with 50 percent overlap.
 6. Outer jacket:
 - a. UL 1277 Type PVC.
 7. Cable tray rated, UL Type TC-ER.
- D. 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-mil double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
 - c. Shielding to be in contact with the drain wire.
- E. Network cables:
 - 1. Copper Ethernet cable:
 - a. Provide copper Ethernet cable types as indicated on the Drawings and Specifications.
 - b. General requirements:
 - 1) Cables shall meet the standards set by TIA-568.2-D and verified by third-party testing laboratory.
 - 2) Conductors:
 - a) 4 balanced twisted pairs.
 - (1) #22 to #24 AWG thermoplastic insulated solid copper conducts enclosed by a thermoplastic jacket. Copper clad aluminum is not allowed.
 - 3) Insulation:
 - a) Non-Plenum: Polyolefin.
 - b) Plenum: Fluoropolymer.
 - 4) Color coded per T568B.
 - 5) Outer jacket with ripcord.
 - 6) Shielding:
 - a) Provide F/UTP cables with drain wire for cables inside any equipment or enclosure with 480 VAC and above, outdoor installations, and where indicated on the Drawings.

- 7) Voltage rating:
 - a) At a minimum provide 300 VAC rated jacket.
 - b) 600 VAC rated jacket when cables are inside equipment or enclosures that contain 480 VAC power.
- 8) Approvals and listings:
 - a) Meets NEC requirements for each application.
 - b) Riser applications: Type CMR.
 - c) Plenum applications: Type CMP.
 - d) Limited-use applications: Type CMX.
- 9) Certification:
 - a) Provide Category 5e cables with ICEA S-90-661 certification.
 - b) Provide Category 6 cables with NEMA WC 66/ICEA S-116-732 certification.
 - c) Provide Category 6A cables with NEMA WC 66/ICEA S-116-732 certification.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

- A. Wire ties:
 - 1. One of the following, or equal:
 - a. Panduit, cable ties.
 - b. T&B, "Ty-Rap" cable ties.
- B. Wire markers:
 - 1. As specified in Section 26_05_53 - Identification for Electrical Systems.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Assembly and testing of cable shall be in accordance with the applicable requirements of NEMA WC 70/ICEA S-95-658-1999.
- B. Test type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install conductors only after the conduit installation is complete, and 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.
- B. Properly coat wires and cables with pulling compound before pulling into conduits:
 - 1. For #4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
 - a. Ideal Products.
 - b. Polywater Products.
 - c. 3M Products.
 - d. Greenlee Products.
 - e. Or equal, as recommended by cable manufacturer.
 - f. Do not use oil, grease, or similar substances.
- C. 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 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 the 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.
- D. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within the manufacturer's recommendations.
- E. Install and terminate wire in accordance with the manufacturer's recommendations.

- F. Neatly arrange and lace conductors in switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
 - 1. Do not lace wires in gutter or panel channel.
 - 2. Install 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 conductor strands are confined within the lug:
 - 1. Use ring type lugs if box lugs are not available on the equipment.
- H. Lighting circuits:
 - 1. Each circuit shall have a dedicated neutral.
- I. Splices:
 - 1. Provide continuous circuits from origin to termination whenever possible:
 - a. Obtain the 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 26_05_00 - 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 words "SPICE 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.
- J. Apply wire markers to wires at each end after being installed in the conduit and before meg-ohm testing and termination.

- 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 requirements as specified in Section 26_05_26 - Grounding and Bonding.
- L. Copper Ethernet cables:
1. In accordance with TIA-568.2-D.
 2. Pathways:
 - a. For initial installation, the maximum fill capacity for pathways (i.e., conduit, raceways, trays, baskets) is 40 percent. The maximum fill capacity of 60 percent is allowed to accommodate future additions after initial installation.
 - b. Conduit should be run in the most direct route possible with no more than two 90-degree bends between pull boxes and serve no more than 3 outlet boxes.
 3. Cable bend radius:
 - a. Proper cable bend radius control must be maintained throughout the pathways. Bend radius needs to be at a minimum 10 times the cable diameter.
 4. Cable pulling:
 - a. Provide cable pulling swivel system to prevent winding and tangling of rope and cables during pull.
 - b. Maximum pulling tension is not to exceed the manufacturer's recommendations. Cable installation should not in any way deform the cable jacket.
 - c. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 5. Cable management:
 - a. Organize and manage cables for quick and easy moves, adds and changes.
 6. Cable termination:
 - a. Install equipment outlet connector hardware (e.g., RJ45, M12, etc.), and connect to field equipment outlet (e.g., instrument, VFD, actuator, etc.).
 - b. Use shielded connectors as required by the installation.
 - c. Coordinate cable termination at copper patch panels with ICSC and General Contractor.
 7. Testing:
 - a. Copper Ethernet cable testing requirements as specified in Section 26_08_50 - Field Electrical Acceptance Tests.
 8. Separation from EMI sources:
 - a. In accordance with TIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.

- b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - 1) Electrical equipment rating less than 2 kVA: A minimum of 5 inches.
 - 2) Electrical equipment rating between 2 and 5 kVA: A minimum of 12 inches.
 - 3) Electrical equipment rating more than 5 kVA: A minimum of 24 inches.
 - c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - 1) Electrical equipment rating less than 2 kVA: A minimum of 2-1/2 inches.
 - 2) Electrical equipment rating between 2 and 5 kVA: A minimum of 6 inches.
 - 3) Electrical equipment rating more than 5 kVA: A minimum of 12 inches.
 - d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - 1) Electrical equipment rating less than 2 kVA: No requirement.
 - 2) Electrical equipment rating between 2 and 5 kVA: A minimum of 3 inches.
 - 3) Electrical equipment rating more than 5 kVA: A minimum of 6 inches.
 - e. Separation between communications cables and electrical motors and transformers, 5 kVA or HP and larger: A minimum of 48 inches.
- M. Signal cable:
 - 1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by a minimum of 12 inches.
- N. Submersible cable wells and cables for floating equipment:
 - 1. Provide Kellems grip or stainless steel wire mesh to support cable weight and avoid stress on insulation.
- O. 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 pull boxes, manholes and duct banks within 20-linear feet of locations indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

END OF SECTION

SECTION 26_05_20

FIBER OPTIC CABLE AND APPURTENANCES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Fiber optic cable.
 - 2. Fiber splices and terminations.
 - 3. Accessories.

1.02 REFERENCES

- A. Abbreviations:
 - 1. N/Cm: Newtons per centimeter.
 - 2. OLTS: Optical Loss Test Set (Tier 1 test).
 - 3. OTDR: Optical Time Domain Reflectometer (Tier 2 test).
- B. Standards:
 - 1. Bellcore Standards:
 - a. GR-409 - Generic Requirements for Indoor Fiber.
 - 2. Electronic Industry Association (EIA):
 - a. FOTP-25 - Impact testing of Fiber Optic Cables and Cable Assemblies.
 - b. FOTP-33 - Fiber Optic Cable Tensile Loading and Bending Test.
 - c. FOTP-41 - Compressive Loading Resistance of Fiber Optic Cables.
 - d. FOTP-81 - Compound Flow (Drip) Test for Filled Fiber Optic Cable.
 - e. FOTP-104 - Fiber Optic Cable Cyclic Flexing Test.
 - f. FOTP-181 - Lightning Damage Susceptibility Test for Fiber Optic Cables with Metallic Components.
 - 3. Insulated Cable Engineer's Association (ICEA):
 - a. S-83-596 - Optic Fiber Premises Distribution Cables.
 - b. S-87-640 - Optic Fiber Outside Plant Communications Cable.
 - c. S-104-696 - Indoor-Outdoor Optic Fiber Cable.
 - 4. TIA/EIA Standards:
 - a. 598 - Optical Fiber Cable Color Coding.
 - b. 11801 - Information technology - Generic cabling for customer premises.
 - 5. Underwriters Laboratories, Inc. (UL):
 - a. 1666 - Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.
 - b. 1685 - Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables.

1.03 TERMINOLOGY

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Complete manufacturer's brochures that identify materials and options.
 - 2. Completed datasheets, including catalog number and source for determining catalog number.
 - 3. Manufacturer's installation instructions.
 - 4. Include the following:
 - a. Manufacturer's data on testing equipment used on this Project.
 - b. Manufacturer's specifications and datasheets for all fiber types.
 - c. Manufacturer's specifications and datasheets for all connectors, bulkheads, splicing kits, breakout devices, and appurtenances used in connecting and terminating fiber spans.
 - 5. Catalog data on testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the NIST.
 - 6. Manufacturer's test procedures and quality assurance procedures:
 - a. After review, the Engineer may require that additional tests be performed before installation.
- C. Shop Drawings:
 - 1. Interconnection cabling diagrams for the complete system, including every fiber in each cable.
 - 2. Drawings indicating locations of all pull boxes, including pull box identifiers and lengths.
 - 3. Submit optical power budget calculations for fiber segments. Include the following:
 - a. Minimum transmit power of active devices.
 - b. Minimum receive sensitivity.
 - c. Available power, in dBm.
 - d. Loss for each segment in dBm, including cable attenuation and connector losses. Use manufacturer's data for cable attenuation at the wavelength to be used. Assume 0.5 dB per connector.
 - e. Demonstrate that remaining power budget at each receiver is equal to or greater than 3.0 dBm.
- D. Calculations:
 - 1. Cable pulling calculations for conduit runs:
 - a. Indicate on the Submittal any additional pull boxes that are required, including pull box identifiers and a written description of the location.
- E. Installation instructions:
 - 1. Submit a cable pulling and splicing work plan that includes the following:
 - a. Pull tension calculations.
 - b. Detailed description of pull operation methods for conduit runs.
 - c. Tools and equipment to be used for cable installation and testing.
 - d. Physical location of equipment setup and type.
 - e. Exact locations of splice points.

- f. Safety and manual assist cable-pulling operations.
 - g. Detailed schedule for pulling and testing cables.
 - h. Name and qualifications of the supervisory personnel directly responsible for installation of the conduit system.
 - i. Sample fiber optic cable test sheets.
 - j. Signed test sheet results.
- F. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Installation as specified in Section 01_75_17 - Commissioning.
- G. Test reports:
 - 1. Submit results of specified tests to the Engineer.
 - 2. Submit 3 copies of test reports showing results of tests specified in this Section or in Section 26_08_50 - Field Electrical Acceptance Tests:
 - a. Test forms shall include the following information at a minimum:
 - 1) Test type.
 - 2) Test location.
 - 3) Test date.
 - 4) Wavelength.
 - 5) Index of refraction.
 - 6) Cable identification.
 - 7) Fiber type.
 - 8) Fiber number.
 - 9) Fiber color.
 - 10) Result of the value of the tested parameter.
 - 3. Furnish hard copy and electronic copy for OTDR traces.
 - 4. Submit certification that the fiber optic cable has passed each testing stage:
 - a. Submit separate documentation for each testing stage result.
- H. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
- I. Record documents:
 - 1. Furnish updated electrical drawings, network diagrams, and fiber cable block diagrams at the end of construction and submit as record drawings.

1.06 QUALITY ASSURANCE

- A. Furnish cable and appurtenances manufactured within 1 year of installation.
- B. Proof test optical fibers by the fiber manufacturer at a minimum load of 50 kpsi.
- C. Provide 100 percent attenuation testing for optical fibers:
 - 1. Include with each cable reel the attenuation of each fiber.
- D. Provide information on at least 5 successful fiber optic cable installations of comparable size and complexity in the past 3 years with name, address, and

telephone number of facility owner, name of project with completion date, and type of conduit system and length of cable pulled.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Package cable for shipment on wooden reels:
 - 1. Seal both ends of cable to prevent ingress of moisture.
 - 2. Place fiber cable assemblies on reels such that both cable ends are available for testing.
 - 3. Weatherproof cable reel markings shall include the following:
 - a. Manufacturer.
 - b. Date of manufacture.
 - c. Shipping date.
 - d. Cable identification.
 - e. Cable configuration/fiber count.
 - f. Cable length.
 - g. Gross weight.
 - h. Cable test date.
 - i. Handling instructions.
 - j. Direction to unreel.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Submit a cable pulling and splicing work plan a minimum of 45 days before the planned initiation of cable pulling. Cable pulling and splicing work plan must be approved a minimum of 15 days before pulling cable.
 - 2. Testing sequence:
 - a. Perform testing of each fiber in each cable as follows:
 - 1) At factory before shipment.
 - 2) At Project Site upon delivery.
 - 3) Submit copies of test results to the Engineer within 5 days after the delivery to the Site.
 - 4) After installation, before breakout and terminations.
 - 5) After installation is complete.
 - b. Submit test reports following each set of tests as specified in this Section.
- B. Scheduling:
 - 1. Schedule Engineer, 5 days before installation, to witness cable installations.
 - 2. Notify the Engineer and Owner a minimum of 15 days before post-installation testing.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Furnish a complete fiber optic network as indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Install fiber optic system components in accordance with the recommendations of the manufacturer.

2.03 MANUFACTURERS

- A. Acceptable manufacturers are indicated with each component type as listed in the remainder of this Specification.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

- A. General fiber cable requirements:
 - 1. Suitable for the installed environment.
 - 2. Color-coded fibers according to TIA/EIA-598.
 - 3. Color-coded buffer tubes according to TIA/EIA-598.
 - 4. Furnish buffer tubes of a single layer nylon construction or of a material with similar mechanical performance.
 - 5. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.
 - 6. Apply binders with sufficient tension to secure buffer tubes to the central member without crushing the buffer tubes:
 - a. Provide binders that are:
 - 1) Non-hygroscopic.
 - 2) Non-wicking (or rendered so by the flooding compound).
 - 3) Dielectric with low shrinkage.
 - 7. Provide a minimum of 1 ripcord under the cable sheath.
 - 8. Provide high tensile strength Aramid yarns, Kevlar, and/or fiberglass helically stranded evenly around the cable core:
 - a. No metallic elements whatsoever are allowed in non-armored cable.
 - 9. Jacket or sheath shall be free of holes, splits, and blisters.
 - 10. Mark jacket or sheath with:
 - a. Manufacturer's name.
 - b. "Optical Cable".
 - c. Year of manufacture.
 - d. Sequential meter marks.
 - e. Repeat markings every 1-meter.
 - f. Actual length of the cable to be within 1 percent of the length marking.
 - g. Marking must be in a contrasting color to the cable jacket.
 - h. Height of the marking:
 - 1) Approximately 2.5 millimeters.
 - 11. Shipping, storage, and operating temperature range of the cable shall be -40 degrees Celsius to 70 degrees Celsius.

12. General performance characteristics:
 - a. Rated tensile load of the cables:
 - 1) Indoor/outdoor:
 - a) Short term: 1,330 N.
 - b) Long term: 400 N.
 - b. Non-armored fiber optic cables: Compressive load withstand of 220 N/cm applied uniformly over the length of the cable.
 - c. Armored fiber optic cables: Compressive load withstand of 440 N/cm applied uniformly over the length of the cable.
 - d. Average increase in attenuation for the fibers: Less than or equal to 0.10 dB at 1,550 nm for a cable subjected to this load:
 - 1) With no measurable increase in attenuation after load removal.
 - e. Test in accordance with EIA FOTP-41, except that the load must be applied at the rate of 3 millimeters to 20 millimeters per minute and maintained for 10 minutes.
 - f. Capable of withstanding 25 cycles of mechanical flexing at a rate of 30 within 1 cycles/minute.
 - g. Average increase in attenuation for the fibers: Less than or equal to 0.10 dB at 1,550 nm at the completion of the test.
 - h. For armored cables, any visible cracks causing separation of the armor and propagating more than 5 millimeters constitutes failure.
 - i. Outer cable jacket cracking or splitting observed under 10X times magnification, constitutes failure.

B. Indoor/outdoor cable:

1. Cable construction:
 - a. General:
 - 1) Cable type: Indoor/Outdoor - Flame retardant, low smoke, zero halogen, UV resistant.
 - 2) Fiber count: 12 pairs.
 - 3) Buffer tube: Loose tube.
 - 4) Armoring: Plastic coated corrugated aluminum armor.
 - 5) Waterproofing: Water blocking layer.
 - 6) Strength member:
 - a) Loose tube: Utilize a central, nonmetallic strength member with a coefficient of thermal expansion similar to the fibers as the central anti-buckling member.
 - 7) Approvals and listings: UL 1666 and UL 1685.
 - 8) Design and test criteria: In accordance with ICEA S-104-696.
 - b. Testing:
 - 1) Fibers in the cable:
 - a) Proof test of 100 kpsi.
 - b) Each optical fiber: Bellcore GR-409 strip force testing.
 - c) No gaps are allowed between the coating material and the buffer material visible under a 50-power microscope.
 - c. Outer jacket material:
 - 1) Linear low-density polyethylene.
 - 2) Meet requirements of the NEC for use in indoor/outdoor areas (excluding plenums) without being enclosed in conduit.
 - 3) Flame retardant OFNR riser rated conforming to UL 1666.
 - 4) Printed with necessary UL marks and manufacturer identification.

- 5) Sequential printing of footage in 2-foot increments.
 - 6) With a ripcord incorporated under the cable jacket.
- C. Multimode fibers:
1. Fibers in the cable must be usable fibers and meet required specifications.
 2. Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.
 3. Multimode fiber characteristics:
 - a. Category: OM4 compliant with ISO/IEC 11801.
 - b. Jacket color: Aqua.
 4. 62.5 micro Multi-mode fiber between buildings.
 5. Orange in color
 6. SC type connectors
 7. Fiber to be terminated it Corning Duplex SC panels installed in a Corning enclosure.
- D. Indoor/outdoor:
1. Loose tube:
 - a. Corning Cable Systems, Freedm®.
 - b. CommScope, LazrSPEED/TerraSPEED.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

- A. Patch cords:
1. General:
 - a. Connector types to match supplied equipment and patch panel terminations.
 - b. Maximum length of patch cords: 25 feet.
 - c. Provide 2 spare patch cords (or 1 duplex patch cord) of each type used at each PLC or network cabinet.
 - d. Factory assembled and optically tested.
 - e. Provide mode-conditioning cords for multimode fibers operating at 1,310 nm.
 2. Manufacturers: One of the following or equal:
 - a. CommScope.
 - b. Corning Cable Systems.
- B. Fiber connectors:
1. As specified in Section 40_66_01 - Control Systems: Network Materials and Equipment.
- C. Fiber optic identification/warning tags:
1. Black letters on orange or yellow background.
 2. UV resistant polyethylene or other suitable material:
 - a. Manufacturers: The following or equal:
 - 1) Almetek.

2.09 SOURCE QUALITY CONTROL

- A. Source Testing:
 - 1. Before shipment and while on the shipping reel, test 100 percent of fibers for attenuation:
 - a. Copies of the results shall be:
 - 1) Maintained on file.
 - 2) Attached to the cable reel in a waterproof pouch.
 - 3) Submitted before the delivery of the cable to the jobsite to the Engineer for approval.
 - 2. Conduct the flex test in accordance with EIA FOTP-104 test condition I and III with a maximum sheave diameter of 20 times the cable OD.
 - 3. Verify that the cable withstands 25 impact cycles with:
 - a. Average increase in attenuation for fibers less than 0.20 dB at 1,550 nm.
 - b. No evidence of cracking or splitting.
 - c. Conduct test in accordance with EIA FOTP-25.
 - 4. Certify that the cable withstands a tensile load of 2,700 N (600 pounds):
 - a. Without exhibiting an average increase in attenuation of greater than 0.10 dB.
 - b. Test in accordance with EIA FOTP-33 using a maximum mandrel and sheave diameter of 560 millimeters.
 - c. Apply the load for 1 hour in test condition II.
 - 5. Certify that the cable withstands a simulated lightning strike:
 - a. Peak value of the current pulse greater than 105 kA.
 - b. Use a test current with a damped oscillatory maximum time-to-peak value of 15 μ s (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz.
 - c. Time to half-value of the waveform envelope 40 to 70 μ s.
 - d. Conduct the test in accordance with the EIA FOTP-181.
 - e. In addition to the analysis criterion set forth in EIA FOTP-181, the integrity of the buffer tubes (or analogous loose tube, i.e., core tube) and strength members must be intact after removal of the cable specimens from the test box.
 - 6. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify the condition of the conduit system before installation of the fiber optic cable or inner duct.
- B. Pass a test mandrel through fiber optic conduits prior to pulling fiber or installing inner duct.
 - 1. Run the mandrel in both directions.
- C. Examine materials and equipment before installation and verify they are free from physical damage and defects.

3.02 PREPARATION

- A. Equipment support and anchoring to structures:
 - 1. Prepare anchor setting template(s) and use to position anchors during construction of supporting structures.
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.
- B. Before fiber splicing terminating or testing activities, verify sufficient workspace is available to perform the activity without interferences from other trades.
- C. Pre-installation test:
 - 1. Upon arrival at the Site:
 - a. Inspect the cable and reel for damage.
 - b. Test fibers with an optical time domain reflectometer (OTDR) for fiber integrity.
 - c. Verify that the fiber lengths are consistent with the cable manufacture.
 - d. Verify that traces yield no point discontinuities.
 - 2. Complete test sequence and obtain approval from the Engineer of submitted test results before cable installation.

3.03 INSTALLATION

- A. Install fiber optic patch cords in open network trays or in dedicated conduits no longer than 25 feet in length.
- B. Install fiber optic cable in continuous lengths without intermediate splices, except where approved by the Engineer.
- C. Cable installation:
 - 1. Properly attach the fiber optic cable's strength elements to a 600-pound breakaway swivel containing tension or shear pins using Kellums pulling grips that are a minimum of 18 inches long.
 - 2. Certify that cable tensile limits do not exceed cable pull tension and bend limits using tension monitoring devices.
 - 3. Leave an extra loop of fiber optic cable in each pull box.
 - 4. Conform with the cable manufacturer's specifications, practices, and the following requirements:
 - a. When power equipment is used to install fiber optic cables, use low speeds and do not exceed a rate of 30 meters per minute.
 - b. Do not exceed the tensile and bending limitation for fiber optic cables under any circumstances.
 - c. Use large diameter wheels, pulling sheaves, and cable guides to maintain the specified bending radius.
 - d. Use commercial dynamometers or load cells to monitor pulling tension.
 - e. A nonfreezing type of swivel inserted between the pulling line and cable pulling grip to prevent twisting under strain.
 - f. Cable to be installed using a breakaway swivel.

5. Apply to conduits a lubricant at each conduit ingress and egress location during the pull operation:
 - a. Pour or pump lubricant into the end of the conduit at the feed location at a nominal application rate of 3 gallons per 1,000 feet of cable.
 - b. If the conduit is open at intermediate locations, then apply the appropriate proportion of lubricant at each opening.
 - c. Continuously lubricate the cable as it is being pulled by pouring or pumping the lubricant into the conduit at the feed location and at each intermediate location.
 - d. Station workers at each intermediate location as required.
 - e. Remove excess lubricant that has collected.
 - f. Remove and clean the surrounding area after cable installation.
6. Install using a hydraulic capstan or winch equipped with a recording running line dynamometer graph which measures and records pulling tensions:
 - a. Use pulling equipment with slip-load capability to allow the winch to maintain a constant pulling force without taking up the winch line.
 - b. Use pulling equipment equipped with a hydraulic bypass set so that a maximum tension of 600 pounds is not exceeded.
 - c. Use only equipment designed to prevent a preset pulling tension from being exceeded.
 - d. Fiber optic cable manufacturer to provide the pulling tension setpoint.
 - e. If during the pulling operation excessive tension is detected, cease operations and notify the Engineer.
7. Position the cable reel at the feed point in alignment with the raceway and in such a position that the cable can be passed from the top of the reel in a long, smooth bend into the raceway system:
 - a. Use of a cable feeder is required unless the cable is hand-pulled.
8. Supply bull wheels, blocks, split wheels, cable feeders, and necessary equipment required to provide a clean and safe operation:
 - a. Cable shall not be allowed to travel over any wheel or block that has a radius less than the minimum radius allowed by the cable manufacturer.
9. Minimize the use of snatch blocks and rollers to guide the cable into the conduit at the feed point:
 - a. Slack feed by hand the cable into the feed point and raceway without the use of rollers.
10. Tend the cable reel at all times and turn by hand to provide the required cable slack:
 - a. Under no circumstances shall the cable tension be allowed to turn the cable reel.
11. Use a rim roller, with a wheel radius greater than the minimum cable bending radius placed at the manhole or vault opening to prevent the cable from dragging on the manhole rim or steps.
12. Perform a continuous thorough visual inspection for flaws, breaks, and abrasions in the cable sheath as the cable leaves the reel and maintain a slow pulling speed to permit this inspection.
13. Damage to the sheath or finish of the cable is cause for rejecting the cable:
 - a. Replace any cable damaged in any way during installation.
14. If the cable becomes damaged during installation, stop operations and notify the Engineer immediately:
 - a. Engineer to determine whether to replace the entire reel of cable or to install a termination panel to eliminate the damaged section.

15. Document pulls by a graph which is annotated with the following information:
 - a. Reel number.
 - b. Pull point ID.
 - c. Date and time.
 - d. Explanations for abnormalities in readings or interruptions.
 - e. Sign-off by the Contractor and Engineer.
 16. Under no conditions shall the fiber optic cable be left exposed or unattended.
- D. After the cables are installed and spliced:
1. Rack the cables:
 - a. Loosely secure in racked position with wire ties.
 - b. Attach imprinted plastic-coated cloth identification/warning tags to each cable in at least 2 locations in each handhole/manhole.
- E. Ground armored fiber optic cables containing metallic members in accordance with NEC.
- F. Splices:
1. Provide field splices in a splice tray located in a waterproof splice enclosure:
 - a. Manufacturers: The following or equal:
 - 1) Tyco/Raychem, FOSC style splice enclosure.
 2. Loop the individual fibers a minimum of 1 full turn within the splice tray to avoid macro/micro bending.
 3. After completion of cable terminations, neatly dress cables.
 4. Protect splices with a thermal shrink sleeve.
 5. Provide fusion type fiber optic cable splicing meeting the following requirements:
 - a. Joins multimode or single mode fibers.
 - b. Establishes a permanent fusion splice.
 - c. Waterproof.
 - d. Re-enterable, rearrangeable, and reusable.
 - e. Splice loss less than 0.10 dB.
 - f. Protected by a splice enclosure.
 6. Requirement for outdoor fiber splice enclosures:
 - a. Seal.
 - b. Bond.
 - c. Anchor.
 - d. Protect fiber optic cable splices.
 - e. Stand-alone unit that does not require an outer enclosure.
 - f. Provide for a maximum of 6 cable entries in a butt-end configuration.
 - g. Used in aerial, underground, and direct buried applications.
 7. Requirement for indoor fiber splice enclosures:
 - a. Anchor.
 - b. Protect fiber optic cable splices.
 - c. Stand-alone unit that does not require an outer enclosure.
 - d. Suitable for the minimum number of splices at that location plus additional capacity for reconfigurations.
 8. Re-splice any splice that has a loss greater than 0.10 dB.
 9. Leave a minimum of 20 feet of fiber optic cable at each end of splice.

- G. Terminations:
 - 1. Terminate fiber inside a patch panel:
 - a. Direct landing to a switch, router hub, or PLC will not be allowed.
 - 2. Terminate outdoor cables using a breakout kit that seals the cable and provides physical protection for the fiber strands.
 - 3. Terminate indoor cables using factory assembled terminations pig tail spliced to the cable ends.
 - 4. Labeling:
 - a. Permanently label cable terminations. Use labels produced by a wire printer using pressure sensitive polyester labels.
 - b. Label patch panels as specified in Section 26_05_53 - Identification for Electrical Systems.
- H. Installation Verification:
 - 1. Furnish Manufacturer's Certificate of Installation Verification.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.
- B. Utilize personnel certified by the manufacturer with specific knowledge of the cable manufacturer's recommended installation procedures.
- C. General:
 - 1. Test results shall meet or exceed manufacturer specifications:
 - a. Test each fiber of each cable for breaks, abnormalities, and overall attenuation characteristics.
 - 2. Pre-installation tests and post-installation tests to be witnessed and signed off by the Engineer and Owner.
 - 3. Perform OLTS test with equipment capable and calibrated to show anomalies of 0.1 dB as a minimum:
 - a. Test multimode fibers at 850 nm and 1,300 nm.
 - b. Test single mode fibers at 1,310 nm and 1,550 nm.
 - 4. Perform OTDR tests on fiber cables less than 100 meters with the aid of a launch cable:
 - a. Adjust OTDR pulse width settings to a maximum setting of 1/1,000th of the cable length or 10 nanoseconds.
- D. Manufacturer's field service:
 - 1. Provide the services of a certified manufacturer's engineering representative for the fiber optic cable manufacturer at the jobsite to perform the following services:
 - a. Inspection, assistance during installation, and certification of proper installation:
 - 1) Submit a certificate of installation.
 - b. Assistance and witnessing of testing and any required troubleshooting.

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

- A. Clean fiber optic connectors after termination and before testing. After cleaning, cover unterminated connectors with a protective boot.
- B. At the completion of construction, touch up the finish on fiber patch panels and enclosures.

3.08 PROTECTION

- A. Protect the fiber system from physical damage and the encroachment of dust, before, during, and after installation.

END OF SECTION

SECTION 26_05_21

LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Wire connecting devices.
 - 2. Terminations.
 - 3. Splices.
 - 4. Power distribution blocks.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.
- B. CSA International (CSA):
 - 1. C22.2 - No. 197-M1983 (R2208) - PVC Insulating Tape.
- C. Underwriters Laboratories, Inc. (UL):
 - 1. 486A-B - Standard of Safety for Wire Connectors.
 - 2. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
 - 3. 1953 - Outline of Investigation for Power Distribution Blocks.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Catalog cutsheets.
 - 2. Installation instructions.

1.05 QUALITY ASSURANCE

- A. Materials shall be UL listed.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

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

2.03 MANUFACTURERS

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

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. Control connections:
 - 1. Use insulated ring type wire terminators for connections to 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) ABB, Sta-Kon.
 - 2. For process equipment connections, work from the manufacturer's drawings.
- B. Joints, splices, taps, connections, and terminations:
 - 1. 600-volt conductors:
 - a. Use solderless connectors.
 - b. Copper pigtail adaptors.
 - 1) For use on select applications as approved by the Engineer.
 - 2) 600 volt, 90 degrees Celsius rated.
 - 3) UL 486A/B listed.
 - 4) Manufacturers: One of the following or equal:
 - a) Burndy APY series.
 - b) ILSCO CPM series.
 - c. Use only plated copper alloy connectors or lugs:
 - 1) Aluminum connectors or lugs are not acceptable for copper conductors.

- d. 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.
 - e. For wire #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.
 - f. For wire #8 AWG and larger, use heavy duty copper compression connectors:
 - 1) Manufacturers: One of the following or equal:
 - a) ABB.
 - b) Burndy.
 - g. 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) ABB, 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.
- D. Power distribution blocks:
- 1. UL 1953 listed.
 - 2. Short circuit rating: Not less than the system maximum available fault current at the point of application.
 - 3. Provide fuses or circuit breakers in enclosure as required to meet the fault current requirements.
 - 4. Voltage rating: 600 VAC.
 - 5. IP 20 finger safe enclosure.
 - 6. Tin-plated aluminum or copper terminals suitable for copper conductors.
 - 7. Manufacturers: One of the following or equal:
 - a. Eaton CHDB series.
 - b. Rockwell Automation 1492 PD series.
 - c. Schneider Electric LB series.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Load connections:
 - 1. Connect loads to the circuits as indicated. Color-code branch circuits as specified in Section 26_05_18 - 600-Volt or Less Wires and Cables.
- B. Zero to 600-volt systems:
 - 1. Make 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 connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.

4. Number power and control wires before termination.
- C. Motor connections (600 volts and below):
1. Terminations on motor leads, including leads that are connected to accommodate the motor current, and the wires entering the motor terminal box from the power source, shall have ring type compression lugs or mechanical torqued insulated lugs.
 2. 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 the manufacturer.
 3. Wire markers shall be readable after boot installation.
 4. Manufacturers: One of the following or equal:
 - a. ABB, Blackburn Insulated multi-taps connectors.
 - b. NSI Industries, Polaris insul-tap connectors.
 - c. Raychem, MCK.
- D. Power distribution terminal blocks:
1. Connect fuses or circuit breakers on the line side of power distribution terminal blocks as required to meet short circuit requirements.

END OF SECTION

SECTION 26_05_26
GROUNDING AND BONDING

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. 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.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
- C. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 467 - Ground and Bonding Equipment.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Catalog cutsheets.

1.05 QUALITY ASSURANCE

- A. Grounding components and materials shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Ground equipment and raceway systems so that the completed installation is in accordance with applicable code requirements.
- B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:
 - 1. Grounding electrodes.
 - 2. Bonding jumpers.
 - 3. Ground connections.

2.03 MANUFACTURERS

- A. Compression connectors: One of the following or equal:
 - 1. ABB.
 - 2. Burndy.
 - 3. Erico.
 - 4. Harger.
 - 5. Panduit.
- B. Ground rods: One of the following or equal:
 - 1. Erico.
 - 2. Harger.
 - 3. Nehring.
- C. Ground cable: One of the following or equal:
 - 1. Erico.
 - 2. Harger.
 - 3. Nehring.
 - 4. Southwire.
- D. Precast ground well boxes: One of the following or equal:
 - 1. Brooks Products, 3-RT Valve Box.
 - 2. Christy Concrete Products, G12 Valve Box.

2.04 MATERIALS

- A. Ground rod:
 - 1. Minimum: 3/4-inch diameter, 10-feet long.
 - 2. Uniform 10 mil covering of electrolytic copper metallurgically bonded to a rigid steel core:
 - a. Copper-to-steel bond shall be corrosion resistant.

3. In accordance with UL 467.
 4. Sectional type joined by threaded copper alloy couplings.
 5. Fit the top of the rod with a threaded coupling and steel-driving stud.
- B. Ground cable:
1. Requirements:
 - a. Soft drawn (annealed).
 - b. Concentric lay, coarse stranded in accordance with ASTM B8.
 - c. Bare copper in accordance with ASTM B3.
 2. Size is as indicated on the Drawings, but not less than required by the NEC. Use the following type of wire unless otherwise indicated on the Drawings:
 - a. Size #6 AWG and smaller; solid conductor.
 - b. Size #4 AWG and larger; stranded conductor.
- C. Compression connectors:
1. Manufactured of high copper alloy specifically for the particular grounding application.
 2. Suitable for direct burial in earth and concrete.
 3. Identifying compression die number inscription to be impressed on compression fitting.
- D. Grounding electrode conductors:
1. Minimum size in accordance with the NEC.
- E. Main bonding jumpers and bonding jumpers:
1. Minimum size in accordance with the NEC.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

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

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.
- B. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
 - 1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.
- C. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
 - 1. Individually bond these raceways to the ground bus in the equipment.
- D. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.
- E. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.
- F. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.
- G. Duct bank ground system:
 - 1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.
 - 2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.
- H. Grounding at service (600 V or Less):
 - 1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.
- I. Ground connections:
 - 1. Connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using compression type grounding connectors as indicated on the Drawings, UL listed, and labeled for the application.
 - 2. Make ground connections in accordance with the manufacturer's instructions.
 - 3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.

- J. Grounding electrode system:
1. Ground ring:
 - a. Provide trenching and materials necessary to install the ground ring as indicated on the Drawings.
 - b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size as indicated on the Drawings.
 - c. Minimum burial depth 36 inches or as indicated on the Drawings.
 - d. Re-compact disturbed soils to original density in 6-inch lifts.
 2. Ground rods:
 - a. Locations as indicated on the Drawings.
 - b. Length of rods forming an individual ground array shall be equal in length.
 - c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
 - d. Pre-crimp ground rods, as recommended by the manufacturer, before crimping connector to ground rod.
 3. Metal underground water pipe:
 - a. Bond metal underground domestic water pipe to grounding electrode system.
 4. Metal frame of building or structure:
 - a. Bond metal frame of building or structure to grounding electrode system.
 5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
 6. Where grounding conductors are exposed and subject to physical damage, install in Schedule 80 PVC conduit for protection.
 7. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.
- K. Shield grounding:
1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
 2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable run.
 3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
 4. Terminate the signal cable shield on a dedicated grounding terminal block.
- L. Where indicated on the Drawings, install ground rods in precast ground wells.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.
- B. Ground system resistance (electrode to ground) of the completed installation, as determined by tests, shall be:
1. 5 ohms or less for industrial systems.
 2. 1 ohm or less for electrical buildings.
- C. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.05 ADJUSTING

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

END OF SECTION

SECTION 26_05_29
HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. American National Standards Institute (ANSI).
- 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.
 - 4. D635 - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
 - 5. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Anchor: Elements (including hardware) connecting hangers and supports to the structure.
 - 2. Hardware: Nuts, bolts, straps, clamps, threaded rod, etc.
 - 3. Supports: Preformed channel or other structural member on which the electrical equipment or raceway is mounted.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.

- B. Product data:
 - 1. Supports:
 - a. Materials.
 - b. Geometry.
 - c. Manufacturer.
 - 2. Hardware:
 - a. Materials.
 - b. Manufacturer.
- C. Shop Drawings:
 - 1. Dimensioned and scalable Shop Drawings of hangers and supports for distribution systems and equipment.
 - 2. Complete details for:
 - a. Member sizes and arrangement in hangers and support assemblies.
 - b. Connections between members in hangers and support assemblies.
 - c. Anchoring hangers and supports to structures.
 - d. Bracing for hangers and supports and anchoring of bracing to structures.
 - 3. Include data on connections, attachment hardware and construction to demonstrate that hangers and supports will satisfy the design loading, bracing, and anchoring criteria.
- D. Delegated Design Submittals:
 - 1. Hangers and supports - General:
 - a. Locations and conditions:
 - 1) Hangers and supports inside structures.
 - 2) Hangers and supports that resist cable pulling/rigging loads.
 - b. Required Submittals: Details with supporting calculations for:
 - 1) Support member arrangement, sizes, and connections.
 - 2) Bracing to resist cable pulling/rigging loads.
 - 3) Connections of hangers, supports, and bracing to the structure.
 - 4) Connections between supports and the equipment or raceway(s) thereon.
 - 2. Hangers and supports - Exterior and seismic conditions:
 - a. Locations and conditions:
 - 1) Hangers and supports at structures designated as Seismic Design Category (SDC) C, D, E, or F in Section 01_81_50 - Design Criteria.
 - 2) Hangers and supports for outdoor installations.
 - b. Required Submittals:
 - 1) Interior: Bracing to resist seismic design loads specified in Section 01_81_50 - Design Criteria.
 - 2) Exterior: Bracing to resist seismic, wind, and other environmental loads specified in Section 01_81_50 - Design Criteria.
 - 3. Hangers and supports anchored to concrete and masonry:
 - a. Locations and conditions:
 - 1) Post-installed mechanical anchors in tension.
 - 2) Post-installed adhesive-bonded all-thread rods in tension.
 - b. Required Submittals:
 - 1) Calculations demonstrating that anchors have a demand/capacity ratio (D/C) not greater than the following when anchor capacity is

adjusted for moisture conditions, anchor spacing and edge distances, and sustained loading conditions present at the location of installation.

- a) Post-installed mechanical anchors maximum: 85 percent.
- b) Post-installed adhesive-bonded anchors maximum: 75 percent.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Mount raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated supports unless otherwise indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Hangers and supports individually and as a system shall resist weights and code-required forces without deflections and deformations that would damage the supporting elements, the raceway or equipment supported, or the surrounding construction.
 - 1. Provide the necessary sway bracing to keep support structures from swaying due to lateral forces, including wire and cable pulling forces.
 - 2. Lateral deflection at top of slab mounted supports shall not exceed support height divided by 240, unless otherwise approved by the Engineer.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. Preformed channel:
 - a. Eaton B-line.
 - b. Power-Strut.
 - c. Robroy.
 - d. Tyco.
 - e. Unistrut.

2.04 MATERIALS

- A. Hot dip galvanized steel:
 - 1. Supports:
 - a. In accordance with ASTM A123 or A153.
 - b. Minimum zinc coating thickness of 2.5 mils.
 - c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
 - 2. Hardware:
 - a. Electro-galvanized.
 - b. In accordance with ASTM A153.
- B. Stainless steel:
 - 1. Supports:
 - a. In accordance with ASTM A240.
 - b. ANSI Type 316 material.
 - c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
 - 2. Hardware:
 - a. ANSI Type 316 material.
- C. PVC coated galvanized steel:
 - 1. Supports:
 - a. Hot dip galvanized steel as specified in this Section.
 - b. PVC coating thickness of 10 to 20 mils.
 - c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
 - 2. Hardware:
 - a. ANSI Type 316 material.
- D. Fiberglass:
 - 1. Supports:
 - a. Vinyl ester.
 - b. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
 - c. Flame spread rating of 25 or less in accordance with ASTM E84.
 - d. Tested in accordance with ASTM D635.
 - 2. Hardware:
 - a. Polypropylene.
 - b. Thermal plastic elastomer.
 - c. Fiberglass reinforced plastic.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

- A. Fabricated metal supports: As specified in Section 05_50_00 - Metal Fabrications.

2.08 ACCESSORIES

- A. Anchors:
 - 1. As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- A. Paint and finish structures as specified in Section 09_96_01 - High-Performance Coatings.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Use materials appropriate for the area as specified in Section 26_05_00 - Common Work Results for Electrical.
- B. General:
 - 1. Refer to the Drawings for details. Equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel.
 - 2. Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.
- C. Corrosion protection:
 - 1. Isolate dissimilar metals, except where required for electrical continuity.
 - a. Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.
- D. Anchoring methods:
 - 1. Solid concrete:
 - a. Anchor bolts, anchor rods or post-installed anchors as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
 - 2. Metal surfaces: Machine screws or bolts.
 - 3. Hollow masonry units:
 - a. Post installed anchors as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
 - 4. Wood and metal studs:
 - a. When supporting devices on metal or wood stud construction, bridge studs with preformed channel, and mount the devices to the channel.

- E. Recoat or seal drilled holes, cut or scratched surfaces or with products recommended by the manufacturer.
- F. Group raceway and position on racks to minimize crossovers.

END OF SECTION

SECTION 26_05_33

CONDUITS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. Abbreviations:
 - 1. FLX: Flexible metallic conduit.
 - 2. GRC: Galvanized rigid steel conduit.
 - 3. PCS: Polyvinyl chloride (PVC) coated rigid steel conduit.
 - 4. PVC: Polyvinyl chloride rigid nonmetallic conduit.
 - 5. SLT: Sealtight-liquidtight flexible conduit.
- B. Standards:
 - 1. American National Standards Institute (ANSI):
 - a. C80.1 - Electrical Rigid Steel Conduit.
 - 2. National Electrical Manufacturers Association (NEMA):
 - a. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
 - 3. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
 - 4. Underwriters Laboratories (UL), Inc.:
 - a. 1 - Flexible Metal Conduit.
 - b. 6 - Electrical Rigid Metal Conduit - Steel.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 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.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures and Section 26_05_29 - Hangers and Supports.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- 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. Furnish conduit routing plans for conduits before the installation of any conduit.
 - 2. Detail the intended routing of each conduit, conduit material and include supporting methods.
 - 3. Number conduits in accordance with the Contract Documents.
 - a. Provide conduit labels as specified in Section 26_05_53 - Identification for Electrical Systems.
- D. Delegated Design Submittals:
 - 1. As specified in Section 26_05_29 - Hangers and Supports.
- E. Certifications:
 - 1. Furnish PVC-coated conduit manufacturer's valid, unexpired certification for each installer.
- F. Record documents:
 - 1. Incorporate changes in conduit routing on electrical plan drawings.
 - 2. Dimension underground and concealed conduits from building lines.
 - 3. Furnish hard copy drawings.
- G. Installation drawings: Including individual conduit numbers, routing, sizes, cable sizes, and circuit numbers for each conduit.

1.06 QUALITY ASSURANCE

- A. Conduits, conduit bodies, and fittings shall be UL listed and labeled.
- B. Every installer of PVC-coated metallic conduit shall be certified by the manufacturer for installation of the conduit, and be able to present a valid, unexpired installer certification card prior to installation beginning.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Do not expose non-metallic conduit to direct sunlight.

- B. Do not store conduit in direct contact with the ground.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Before performing any trenching locate existing underground utilities:
 - a. As specified in Section 33_05_01 - Subsurface Utility Engineering.
 - b. Review of existing civil record drawings for recorded underground utilities.
 - 1) Determine underground utility horizontal and vertical location by at least one of the following methods:
 - a) Soft excavation.
 - b) Local utility location service, CALL BEFORE YOU DIG, or equal.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide conduits, conduit bodies, fittings, junction boxes, and necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.
- B. Provide location and protection of existing underground utilities, underground conduit trenching, conduit and backfill necessary for the complete installation of underground conduits.

2.03 MANUFACTURERS

- A. Galvanized rigid steel conduit:
 - 1. One of the following or equal:
 - a. Allied Tube and Conduit.
 - b. Western Tube and Conduit.
 - c. Wheatland Tube Co.
- B. PVC-coated rigid steel conduit:
 - 1. One of the following or equal:
 - a. Allied.
 - b. Calbond.
 - c. NEC, Inc. BlackGuard.
 - d. Ocal, Inc.
 - e. Robroy Ind.

- C. Sealtight-liquidtight flexible conduit:
 - 1. One of the following or equal:
 - a. AFC Cable Systems.
 - b. Anaconda.
 - c. Anamet.
 - d. Calbrite.
 - e. Electri-Flex Co.
 - f. Gibson.
 - g. Southwire.
- D. Rigid nonmetallic PVC conduit:
 - 1. One of the following or equal:
 - a. Cantex.
 - b. Carlon.
 - c. Triangle Conduit and Cable.
- E. Inner duct:
 - 1. One of the following or equal:
 - a. Carlon.
 - b. Endot Ind.
 - c. MaxCell.
- F. Conduit bodies:
 - 1. One of the following or equal:
 - a. Appleton.
 - b. Calbond.
 - c. Carlon.
 - d. Crouse-Hinds.
 - e. Gibson,
 - f. O-Z/Gedney.
 - g. Ocal, Inc.
 - h. Robroy Ind.
- G. Joint compound:
 - 1. As recommended by the conduit manufacturer.
- H. Galvanized rigid steel conduit expansion fittings:
 - 1. One of the following or equal:
 - a. Appleton.
 - b. Crouse-Hinds.
 - c. O-Z/Gedney.
- I. PVC-coated rigid steel conduit expansion fittings:
 - 1. One of the following or equal:
 - a. NEC, Inc. BlackGuard.
 - b. Ocal, Inc.
 - c. Robroy Ind.
- J. Conduit sleeve:
 - 1. One of the following or equal:
 - a. Appleton.

- b. Crouse-Hinds.
 - c. O-Z/Gedney.
- K. Conduit seals:
 - 1. One of the following or equal:
 - a. Appleton.
 - b. Crouse-Hinds.
 - c. O-Z/Gedney.
- L. Conduit through wall and floor seals:
 - 1. The following or equal:
 - a. O-Z/Gedney:
 - 1) Type "WSK."
 - 2) Type "CSM."

2.04 MATERIALS

- A. Provide conduit bodies, hubs, and other accessories consistent with the conduit type specified in the table below.

Conduit Type	Conduit Bodies and Covers	Fittings	Unions	Bushings and Hubs	Outlet Boxes
GRC	Malleable iron	Malleable iron	Malleable iron or zinc-plated steel	Malleable iron	Cast ferrous
PCS	PVC-coated malleable iron	PVC-coated malleable iron	PVC-coated steel	PVC-coated malleable iron	PVC-coated cast ferrous
SSC	Type 316 stainless steel	Type 316 stainless steel	Type 316 stainless steel	Stainless steel	Stainless steel

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

- A. GRC:
 - 1. 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. Steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, in accordance with to the requirements for Type GRC.
 2. Coated conduit NEMA Standard RN-1:
 - a. Galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
 3. Factory-bonded PVC jacket:
 - a. 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. 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. Urethane coating shall be uniformly and consistently applied to the interior of conduits and fittings:
 - a. Nominal thickness of 0.002 inch.
 - b. Conduits having areas with thin or no coating are not acceptable.
 - c. Threads shall be coated with urethane.
 5. 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. Conduit body, before PVC coating, shall be new, unused material and shall be in accordance with appropriate UL standards.
 - c. 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 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. PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
 - 1) Inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
 - 2) Sleeve shall provide a vapor- and moisture resistant seal at every connection.
 - 3) Fittings shall be Form 8 and supplied with plastic encapsulated stainless steel cover screws. Fittings shall be UL Type 4X. Fittings shall be from the same manufacturer as the conduit in order to maintain system continuity and warranty.

- C. SLT:
1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
 - a. General purpose:
 - 1) Temperature range: -20 to 80 degrees Celsius.
 - b. Oil-resistant:
 - 1) Temperature range: -20 to 60 degrees Celsius.
 2. Sunlight-resistant, weatherproof, and watertight.
 3. Core:
 - a. Galvanized steel for use with RGS and PCS.
 - b. Stainless steel for use with SSC.
 4. Overall PVC jacket.
 5. Smooth interior.
 6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 1-1/4 inch.
- D. PVC:
1. Extruded from virgin PVC compound:
 - a. Schedule 40 unless otherwise specified.
 - b. Schedule 80 extra-heavy wall where specified.
 2. Rated for 90 degrees Celsius conductors or cable.
 3. Rated for use in direct sunlight.
- E. Inner duct:
1. HDPE and fabric inner duct are considered interchangeable.
 2. HDPE inner duct:
 - a. High-density polyethylene.
 - b. Corrugated.
 - c. Resin properties:
 - 1) Density, g/cm³: 0.941 to 0.955.
 - 2) Melt index g/10-minute Condition E: 0.05 to 0.5.
 - 3) Flexural modulus, MPa (pounds per square inch): 80,000 minimum.
 - 4) Tensile strength at yield (pounds per square inch): 3,000 minimum.
 - 5) Environmental stress crack resistance condition B, F₁₀: 96 hours minimum.
 - 6) Brittleness temperature: -75 degrees Celsius.
 - d. Size: 1.25 inch.
 - e. Colors: Orange, .
 3. Fabric inner duct:
 - a. White polyester and nylon resin polymer textile.
 - b. Standard outdoor textile inner duct:
 - 1) 3-inch multi-cell inner duct containing pull tape in each cell.
 - c. Color-coded.
 - d. Pull tape:
 - 1) 1,250 pound.
 - 2) Synthetic fiber polyester, flat woven.
 - 3) Printed sequential footage marks.

- F. Conduit bodies:
 - 1. In accordance with Form 8, Mark 9, or Mogul design:
 - a. Mogul design in accordance with 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.
 - 2. 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. Positive metallic conduit end stop.
 - b. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
 - c. 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. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
 - b. Tin-plated copper grounding saddle for use with copper or aluminum conductors.
- D. Electrical unions:
 - 1. Construction:
 - a. Concrete tight, 3-piece construction for rigid metallic conduit.
 - b. 2-piece construction for PVC-coated conduit.
 - c. Rated for Class I, Division 1, Group D in hazardous areas.
- E. SLT fittings:
 - 1. Construction:
 - a. Malleable iron.
 - b. Stainless steel for use with SSC and stainless steel SLT.
 - c. Furnished with locknut and sealing ring.
 - d. Liquidtight, raintight, oiltight.
 - e. Insulated throat.
 - f. Furnish as straight, 45-degree elbows, and 90-degree elbows.
 - g. Designed to prevent sleeving:
 - 1) Verify complete bonding of the raceway jacket to the plastic gasket seal.
 - h. 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.

- i. 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. Conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.
- G. Sealing fittings:
 - 1. Construction:
 - a. 40-percent wire fill capacity.
 - b. PVC Coated Hazardous (Classified) Location fittings must be UL 1203 listed after the coating is applied and have a red metal tag attached to the fitting to signify compliance.
 - c. Type EYDX where drains are required.
 - d. Type EYSX where drains are not required.
 - e. UL 1203 listed for use in Class I, Division 1, Groups A, B, C, D; Class I, Division 2, Groups A, B, C, D; and Class II, Divisions 1 and 2, Groups E, F, and G.
 - 2. Sealing compound:
 - a. Fiber filler and cement as recommended by the sealing fitting manufacturer.
 - b. Approved for the conditions and use.
 - 1) Not affected by surrounding atmosphere or liquids.
 - c. Melting point shall be 200 degrees Fahrenheit minimum.
- H. PVC fittings:
 - 1. Materials:
 - a. Devices shall be made of PVC, using the same materials as used for Type PVC conduit.
 - b. Metal hardware shall be stainless steel.
- I. Through wall and floor seals:
 - 1. Materials:
 - a. Body: Casting of malleable or ductile iron with a hot-dip galvanized finish.

- b. Grommet: Neoprene.
 - c. Pressure rings: PVC-coated steel.
 - d. Disc material: PVC-coated steel.
- J. Expansion/deflection couplings:
 - 1. Use to compensate for movement in any directions between 2 conduit ends where they connect.
 - 2. Shall allow movement of 3/4 inch from the normal in all directions.
 - 3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
 - 4. Constructed to maintain electrical continuity of the conduit system.
 - 5. Materials:
 - a. End couplings: Bronze or galvanized ductile iron.
 - b. Sleeve: Neoprene.
 - c. Bands: Stainless steel.
 - d. Bonding jumper: Tinned copper braid.
- K. Expansion couplings:
 - 1. Shall allow for expansion and contraction of conduit:
 - a. Permitting 8-inch movement, 4 inches in either direction.
 - 2. Constructed to maintain electrical continuity of the conduit system.
- L. Inner duct couplings and fittings:
 - 1. HDPE inner duct:
 - a. Couplings:
 - 1) Self-threading.
 - 2) Nonmetallic.
 - b. Fittings:
 - 1) Multi-access fitting:
 - a) 4 hole.
 - b) Sized for conduit containing inner duct.
 - 2) Duct plugs:
 - a) Sized for inner duct diameter.
 - b) Install in both ends of unused ducts.
 - 3) Split plugs:
 - a) Sized for inner duct and cable diameters.
 - b) Install at both ends of utilized ducts.
 - 2. Fabric inner duct:
 - a. Termination bags:
 - 1) Inflation-type bags for sealing and securing around one or more textile inner ducts and cables within 2-inch outside diameter or larger conduit.
- M. Conduit markers:
 - 1. As specified in Section 26_05_53 - Identification for Electrical Systems.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Before installing any conduit or locating any device box:
 - 1. Examine the complete set of Drawings and Specifications, and applicable Shop Drawings.
- B. 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.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. General:
 - 1. Conduit routing:
 - a. 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.
 - c) Install conduits and equipment in such a manner as to avoid obstructions and to preserve headroom and keep openings and passageways clear.
 - 3) 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.
 - 4) 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. 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) 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.

- c. Owner reserves the right to deduct the amount of applicable reimbursement, equivalent to the cost of the engineering effort required to show those unauthorized changes on as-built Drawings.
2. Use only tools recommended by the conduit manufacturer for assembling the conduit system.
3. Provide adequate clearances from high-temperature surfaces for conduit runs. Provide minimum clearances as follows:
 - a. Clearance of 6 inches from surfaces 113 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 the 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 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. Conduits may be run in concrete members or slabs with permission of the Engineer or as indicated on the Drawings:
 - a. Refer to the typical details for conduit spacing and size requirements.
10. When installing conduits through existing slabs or walls, make provisions for locating any possible conflicting items where the conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into the existing conduits, piping, cables, post-tensioning cables, etc.
11. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
12. Install conduits through wall and floor seals where indicated on the Drawings.
13. For new and existing underground and embedded conduits 1 inch and larger, 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.

14. Provide sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
 15. Install complete conduit systems before conductors are installed.
 16. Provide metallic conduits terminating in transformer, switchgear, motor control center, or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
 17. Underground conduits:
 - a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
 - 1) As specified in Section 26_05_44 - Duct Banks.
 - b. Make underground conduit size transitions at handholes and manholes.
 - c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.
 - d. Seal around conduit penetrations of below grade walls with a mechanical seal.
 18. Underground conduit trenching:
 - a. Perform trenching as specified in Section 31_23_35 - Trenching.
 - b. Trench must be uniformly graded with the bottom, rock free and covered with select material.
 - c. Damage occurring to existing ducts, conduits, cables, and other utilities during underground conduit installation shall be remediated to the satisfaction of the Owner.
 - d. Whenever possible, use the walls of the trench as forms for concrete encasement:
 - 1) Forms are required where the soil is not self-supporting.
- B. Equipment grounding conductors:
1. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
 - a. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
 - b. Provide a separate grounding conductor in each individual raceway for parallel feeders.
 2. Conductors shall be the same type and insulation as the circuit conductors:
 - a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
 3. Minimum size in accordance with the NEC.
- C. Lighting and receptacle conduits:
1. Provide conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings.
 2. Install conduits in accordance with the requirements of this Section unless otherwise indicated.
 3. Minimum conduit size:
 - a. 3/4 inch for exposed conduits.
 - b. 1 inch for underground or in-slab conduits.
 4. Provide conduit materials for the installed location as specified in Section 26_05_00 - Common Work Results for Electrical.

D. Conduit usage:

1. Exposed conduits:

a. Rigid conduit:

- 1) Install the rigid conduit type for each location as specified in Section 26_05_00 - 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.
 - b) Use Type NFC with PVC conduit.
- 2) Minimum size: 3/4 inch:
 - a) 1/2 when required for connection to instruments.
- 3) Maximum length:
 - a) Fixed equipment:

Conduit Trade Size	Flexible Conduit Length (inch)
3/4	18
1	18
1-1/4	18
1-1/2	18
2	36
2-1/2	36
3	36
3-1/2	38
4	40

b) Removable instruments or hinged equipment:

- (1) As required to allow complete removal or full movement without disconnecting or stressing the conduit.

2. Concrete-encased and embedded conduits:

a. Straight runs and bends less than 45 degrees:

- 1) Type PVC Schedule 40.

b. Bends with total deflection greater than 45 degrees:

- 1) PCS.

c. Entering and exiting duct bank, underground or embedded conduit runs a minimum 12 inches above and below grade, finished floor, or entering equipment:

- 1) PCS.

d. Minimum size:

- 1) 2 inch in duct banks.
- 2) 1 inch for in-slab conduits.
- 3) Provide conduit fittings to enlarge the conduit from the exposed size in the conduit schedule as required.

3. Direct-buried and sand-bedded duct bank conduits:

a. Type PCS.

b. Minimum size: 1 inch.

4. Below-slab conduits:
 - a. Type PCS.
 - b. Minimum size: 1 inch.
 5. Concrete capped, pea gravel-bedded duct bank conduits:
 - a. Type PVC40.
 - b. Minimum size: 1 inch.
 6. PVC-coated rigid metallic conduit:
 - a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.
 - b. Repair damage to PVC coatings with manufacturer supplied touchup compound or PVC Coating Repair Kit for PVC Coated Raceway Systems.
 7. GRC:
 - a. Conduit shall be cut square and reamed before threading.
 8. Inner duct (applicable for fiber optic cable only):
 - a. Install inner duct in conduits as indicated on the Drawings.
 - b. Each inner duct conduit shall be a separate color.
- E. Conduit joints and bends:
1. General:
 - a. Where conduit is underground, under slabs on grade, exposed to the weather, or in NEMA Type 4 or NEMA Type 4X locations, make joints liquidtight.
 - b. Keep bends and offsets in conduit runs to an absolute minimum.
 - c. Bends shall be symmetrical.
 - d. The following conduit systems shall use large-radius sweep elbows:
 - 1) Underground conduits.
 - 2) Conduits containing shielded cables.
 - 3) Conduits containing fiber optic cables.
 - e. Provide factory-made elbows for large-radius bends for conduits 1-1/4-inch trade size or larger.
 - f. Make field bends with a radius of not less than the requirements found in the NEC:
 - 1) Minimum bending radius of the cable must be less than the radius of the conduit bend.
 - 2) Make 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.
 - 3) For PCS conduit, field bends are permitted on conduits 1 inch and smaller. Manufactured elbows shall be used on conduits larger than 1 inch.
 - g. Replace 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 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 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 threaded connections.
 - g. Any exposed threaded surfaces must be cleaned and coated with a galvanizing solution so that 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 bends:
 - 1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

F. Conduit sealing and drainage:

- 1. 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 conduits between corrosive and non-corrosive areas.
 - e. Seal one end only of underground conduits at highest point with O-Z/Gedney sealing (non-hazardous) filling, or equal.
- 2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: Control panels, junction boxes, pullboxes, or low points of the conduit.

G. Hangers and supports:

- 1. General:
 - a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
 - 1) As specified in Section 26_05_29 - Hangers and Supports.

- 2) Provide support materials consistent with the type of conduit being installed as specified in Section 26_05_00 - 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. Finished areas:
 - a. Above suspended ceilings:
 - 1) Support conduit on or from the structure. Do not support conduit from hanging wires or suspended ceiling grid.
 - b. Concealed conduit on wood:
 - 1) Use 2-hole galvanized steel straps screwed or nailed to the wood or hammer-driven stamped galvanized-type supports having serrated or sawtooth edges on the driven portion and designed specifically for the size and type of conduit being supported. Drive these latter supports so that the conduit is tightly and rigidly supported. Replace any dented or damaged conduit.
 - c. In steel-stud construction:
 - 1) Tie conduit at maximum 4-foot intervals with No. 16 gauge double-annealed galvanized wire or conduit clips so that conduit cannot move from vibration or other causes.
- 3. Conduit on concrete or masonry:
 - a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
 - b. Use preset inserts in concrete when possible.
 - c. Use pipe spacers (clamp backs) in wet locations.
 - d. On plaster or stucco, use 1-hole malleable iron straps with toggle bolts.
- 4. Suspended conduit:
 - a. Use malleable-iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.
 - b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2 feet long, provide rigid sway bracing.
- 5. Supports at structural steel members:
 - a. Use beam clamps.
 - b. Drilling or welding may be used only as specified or with approval of the Engineer.
- 6. PVC-coated rigid metal systems:
 - a. Provide right-angle beam clamps and "U" bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide "U" bolts with PVC-encapsulated nuts that cover the exposed portions of the threads.
 - b. Securely fasten exposed conduits with Type 316 stainless steel clamps or straps.
- H. Expansion or expansion/deflection fittings:
 - 1. General:
 - a. Align expansion coupling with the conduit run to prevent binding.
 - b. Follow manufacturer's instructions to set the piston opening.

- c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
 - d. Furnish fittings of the same material as the conduit system.
 - 2. For metallic conduit, provide expansion or expansion/deflection couplings, as appropriate, where:
 - a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.
- I. Empty conduits:
 - 1. Provide a pull tape in each empty conduit more than 10 feet in length.
 - 2. Provide 1 empty 3/4-inch conduit for each 4 spare unused circuits or spaces of each flush-mounted branch circuit panelboard. Terminate empty 3/4-inch conduits in individual junction boxes that are accessible to enable extension of future branch circuits.
 - 3. Seal ends of conduits with approved, manufactured conduit seals, caps, or plugs immediately after installation:
 - a. Keep ends sealed until immediately before pulling conductors.
- J. Miscellaneous:
 - 1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer's instructions and as indicated on the Drawings.
 - 2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
 - a. Running threads and threadless couplings are not allowed.
 - 3. Replace any conduits installed that the Engineer determines do not meet the requirements of this Specification.
 - 4. Provide conduit housekeeping curb around embedded or below-grade conduits exiting or entering the slab, in accordance with the Typical Details.

END OF SECTION

SECTION 26_05_34

BOXES

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. Standard Specifications for Highway Bridges.
- B. ASTM International (ASTM):
 - 1. A47 - Standard Specification for Ferritic Malleable Iron Castings.
- C. Joint Industry Conference (JIC).
- D. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- E. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- F. Underwriters Laboratories, Inc. (UL):
 - 1. 514A - Metallic Outlet Boxes.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 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 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer.
 - 2. Materials.

3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - d. Weight.
 - e. NEMA rating.
 4. Conduit entry locations.
 5. Catalog cutsheets.
 6. Installation instructions.
- C. Shop Drawings:
1. Include identification and sizes of pullboxes.

1.06 QUALITY ASSURANCE

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

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide outlet boxes for wiring devices, security systems, junction, and pullboxes for use in the raceway systems, etc.
- B. Provide boxes as indicated on the Drawings and as needed to complete the raceway installation.
- C. Size pullboxes in accordance with NEC requirements and to provide sufficient room for any future conduits, components, and cables as indicated on the Drawings.

- D. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 26_05_00 - Common Work Results for Electrical.
- E. For boxes not indicated:
 - 1. Provide outlet boxes to match the exposed conduit system. Provide junction boxes and pull boxes as specified in Section 26_05_00 - Common Work Results for Electrical.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. Pressed steel boxes and concrete boxes:
 - a. ABB
 - b. Appleton.
 - c. Crouse-Hinds.
 - 2. Plastic and/or fiberglass boxes:
 - a. Carlon.
 - b. Hoffman.
 - c. Stahlin.
 - 3. Plastic coated boxes:
 - a. OCAL.
 - b. Rob Roy.
 - 4. Cast device boxes:
 - a. Appleton.
 - b. Calbrite.
 - c. Crouse-Hinds.
 - d. Gibson.
 - e. O-Z/Gedney.
 - 5. Floor outlet boxes with 1-inch conduit knockouts:
 - a. Hubbell, type B25 with S2530 coverplate.
 - b. Steel City, 640 Series.
 - c. Floor outlet boxes in open areas:
 - 1) Hubbell.
 - 6. Formed steel enclosures:
 - a. Hoffman.
 - b. Rittal
 - c. Stahlin.
 - 7. Stainless steel enclosures:
 - a. Hoffman.
 - b. Rittal.
 - c. Stahlin.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

- A. Pressed steel boxes:
 - 1. 1-piece galvanized pressed steel.
 - 2. Knockout type boxes.
 - 3. Minimum size 4-inch square by 2-1/8-inch deep.

- B. Concrete boxes:
 - 1. For outlets and pullboxes in concrete construction.
 - 2. Pressed steel or cast construction, concrete tight.
 - 3. Knockout sizes range from 1/2 inch to 1 inch.
 - 4. Depth as needed.
 - 5. Types:
 - a. 4-inch octagon.
 - b. 4-inch octagon ceiling boxes with hanging bars.
 - c. Gangable masonry boxes:
 - 1) 3-1/2-inch deep, 3-3/4-inch high, length as required:
 - a) 2-1/2-inch deep boxes may be used where wall thickness precludes the use of the deeper boxes.
 - 2) With partitions as needed.
- C. Cast device boxes:
 - 1. Construction:
 - a. With internal green ground screw.
 - b. Furnished with a suitable gasketed cover.
 - c. With integral cast mounting lugs when surface mounted.
 - d. Conduit sizes range from 3/4 inch to 1 inch.
 - e. Tapered threaded hubs with integral bushing.
 - 2. Aluminum (copper free) boxes:
 - a. High strength copper free 4/10 of 1 percent maximum alloy for use with aluminum rigid conduit.
 - 3. Malleable iron boxes:
 - a. In accordance with ASTM A47 Grade 32510.
 - 4. Stainless steel boxes:
 - a. Type 316 stainless steel for use with stainless steel conduit.
- D. Plastic coated cast device boxes:
 - 1. Construction:
 - a. With internal green ground screw.
 - b. Furnished with a suitable gasketed cover.
 - c. With integral cast mounting lugs when surface mounted.
 - d. Conduit sizes range from 3/4 inch to 1 inch.
 - e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
 - f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
 - g. With pressure sealing sleeve to protect the connection with conduit.
- E. Fiberglass boxes:
 - 1. NEMA Type 4X.
 - 2. Constructed of molded fiberglass reinforced polyester.
 - 3. Integral neoprene gasket on cover attached with an oil-resistant adhesive.
 - 4. Enclosures to have internal pads for mounting optional panels and terminal kits.
 - 5. Covers:
 - a. Screw cover enclosures:
 - 1) Covers held in place with captive, stainless steel, or Monel® screws.
 - 2) Covers attached to body with internal zinc-plated steel hinges.

- b. Quick release latches covers:
 - 1) Corrosion resistant fiberglass hinges.
 - 2) Spring loaded fiberglass latches with a Monel® or stainless steel bail attached with Monel® or stainless steel screws.
 - 3) With a Type 316 stainless steel padlock hasp.
 - 6. With external mounting feet.
- F. Formed steel enclosures:
 - 1. Steel:
 - a. NEMA Type 12.
 - b. Fabricated from 14-gauge steel, minimum.
 - c. 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 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.
 - b. Fabricated from 14-gauge Type 316 stainless steel.
 - c. 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 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.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 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.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. General:
 - 1. Provide outlet box materials to match the exposed conduit system as specified in Section 26_05_33 - Conduits.
 - 2. Solid type gang boxes:
 - a. For more than 2 wiring devices.
 - b. For barriered outlets.
 - 3. Support 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.
 - 4. Use cast boxes when box must support other devices.
 - 5. Boxes serving luminaires or wiring devices:
 - a. Use as pullboxes wherever possible.
 - 6. In finished areas:
 - a. Provide specific pull or junction boxes only as indicated on the Drawings or as directed.
 - 7. Fit cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
 - 8. In terminal boxes, furnish terminals as indicated on the Drawings with a minimum of 50 percent spare terminals:
 - a. Furnish wireways for discrete and analog/DC wiring.
 - b. Separate analog wiring from 120 V discrete or power wiring.

9. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.
- B. Outlet boxes:
1. Locate outlet boxes as indicated on the Drawings:
 - a. Adjust locations so as not to conflict with structural requirements or other trades.
 2. Use deep threaded-hub cast boxes:
 - a. In hazardous areas.
 - b. Where exposed to the weather.
 - c. In unheated areas.
 - d. Where subject to mechanical damage:
 - 1) Defined as exposed boxes less than 10 feet above the floor.
 - e. To act as a pullbox for conductors in a conduit system.
 3. Outlet boxes may be used as junction boxes wherever possible.
- C. Pullboxes and junction boxes:
1. Provide junction box materials and NEMA ratings as specified in Section 26_05_00 - Common Work Results for Electrical.
 2. Install pullboxes such that access to them is not restricted.
 3. Fire rated construction: Use materials and methods to comply with the listing requirements for the classified construction.
- D. Recessed boxes:
1. Support recessed boxes in suspended ceilings or stud partitions with galvanized steel box hangers of types made specifically for the purpose or attach directly to wood members or blocking.
 2. Secure hangers or boxes to wood with 1-inch-long cadmium-plated Type A pan head screws:
 - a. Fully or partially hammer-driven screws are not acceptable.

END OF SECTION

SECTION 26_05_44

DUCT BANKS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. PVC conduit spacers.
 - 2. Detectable underground marking tape.
 - 3. Pull line.
 - 4. Duct seal.
- C. Shop Drawings:
 - 1. Submit Site plan drawings of duct banks, including underground profiles indicating underground utilities.
 - 2. Submit cross section of each duct bank with dimensions.
 - 3. For duct bank routings crossing under building footers or foundations alternative to designed routings indicated on the Drawings:
 - a. Submit Shop Drawings detailing the new building footer crossing locations and plan drawings labeling equipment to be installed on top of the new routing for approval by the Project structural engineer.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.
- B. Field conditions and related requirements:
 - 1. Underground water table may be near or above the location of new duct banks.

2. Include cost for necessary dewatering, and cleaning equipment to perform Work in underground duct banks, pullboxes and manholes, before installation.

1.08 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 1. Before performing any trenching locate existing underground utilities:
 - a. As specified in Section 33_05_01 - Subsurface Utility Engineering.
 - b. Review of existing civil record drawings for recorded underground utilities.
 - 1) Determine underground utility horizontal and vertical location by at least one of the following methods:
 - a) Soft excavation.
 - b) Local utility location service, CALL BEFORE YOU DIG, or equal.
- B. Scheduling:
 1. Schedule a coordination meeting to adjust duct bank configurations and routing for each duct bank section after trenching and exposure of any underground utilities within the vicinity of the duct bank route. Meeting shall determine the final configuration of the duct bank before installation.

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Duct bank sections indicated on the Drawings are an initial arrangement and may need to be modified due to existing Site conditions, existing underground utilities, and infrastructure.
 1. Reorganize duct bank section with approval of the Engineer.
 2. Make changes required to accommodate duct bank configuration and routing changes due to field conditions.
 - a. Where changes in a duct bank configuration extend to a manhole or handhole, coordinate manhole/handhole blockouts and size with the new configuration.
- B. Provide location and protection of existing underground utilities, duct bank, trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.
- C. Provide reinforced concrete duct banks for conduits installed below grade, on the Site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

2.03 MANUFACTURERS

- A. Conduit spacers:
 - 1. One of the following or equal:
 - a. Cantex.
 - b. Osburn Associates, Inc.
- B. Detectable underground marking tape:
 - 1. One of the following or equal:
 - a. Blackburn Manufacturing Co.
 - b. Panduit.
- C. Pull line:
 - 1. One of the following or equal:
 - a. Arnco.
 - b. Greenlee.
 - c. Osburn Associates, Inc.
- D. Duct seal:
 - 1. The following or equal:
 - a. O-Z/Gedney type DUX.

2.04 MATERIALS

- A. Provide conduit as specified in Section 26_05_33 - Conduits.
- B. Provide reinforcing steel as specified in Section 03_20_00 - Concrete Reinforcing:
 - 1. Provide minimum Number 4 reinforcing steel.
- C. Concrete:
 - 1. Mix requirements as specified in Section 03_30_00 - Cast-in-Place Concrete.
 - 2. Provide a red-oxide conduit encasement coloring agent as specified in Section 03_30_00 - Cast-in-Place Concrete.

2.05 MANUFACTURED UNITS

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

3. Minimum pulling strength 1,200 pounds.
 4. Sequential footage markings.
- C. Detectable marking tape:
1. Locatable by a cable or metal detector from above the undisturbed grade.
 2. Aluminum core laminated between polyethylene film.
 3. 6-inch-wide red tape imprinted with black lettering stating "CAUTION - BURIED ELECTRIC LINE BELOW", or equivalent.
- D. Duct seal:
1. Non-hardening sealing compound.
 2. Flexible, can be applied by hand.
 3. UL Listed for use with installed conductors.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Duct banks:
1. Encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
 2. Damage minimization:
 - a. Conduit should not be left exposed in an open trench longer than is necessary.
 - b. Protect underground duct banks against damage during pouring of concrete or backfilling.
 3. Plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
 4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system at each end of the duct bank and every 20 feet to steel reinforcing bar:
 - a. Where duct bank terminates at structures with a grounding electrode, bond duct bank ground wire to the grounding electrode.
 - b. Where duct bank terminates at electrical equipment, bond duct bank ground wire to the equipment ground bus.
 - c. Where duct bank terminates at structure without either a grounding electrode or electrical equipment, provide ground rod adjacent to structure and bond duct bank ground wire to ground rod.
 5. Install underground ducts to be self-draining:
 - a. Slope duct banks away from buildings to manholes, handholes, or pullboxes.
 - b. Slope duct banks uniformly from manholes, handholes, or pullboxes to manholes, handholes, or pullboxes or both ways from high points between manholes, handholes, or pullboxes.
 - c. Slope a minimum of 1/4 inch per 10 feet.

6. Where new duct banks join to existing manholes, handholes, or pullboxes, make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.
 7. Install pull line in spare conduits:
 - a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
 - b. Cap above ground spare conduit risers at each end with screw-on conduit caps.
- B. Trenching:
1. Perform as specified in Section 31_23_35 - Trenching.
 2. Trench must be uniformly graded with the bottom rock free and covered with select material.
 3. Whenever possible, use the walls of the trench as forms for concrete encasement:
 - a. Forms are required where the soil is not self-supporting.
 4. Damage occurring to existing ducts, conduits, cables, and other utilities during duct bank installation shall be remediated to the satisfaction of the Owner.
- C. Duct spacing:
1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 2 inches, unless otherwise indicated on the Drawings:
 - a. Separate medium voltage ducts a minimum of 7.5 inches on center.
 2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
 - a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
 - 1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
 - a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
 3. Spacers shall not be located at the center of a bend:
 - a. Locate spacer in the tangent, free of the coupling on fabricated bends.
 - b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.
- D. Terminating:
1. Use bell ends in duct at entrances into cable vaults.
 2. Make conduit entrances into cable vaults tangential to walls of cable vault.
 3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
 4. New manhole or handhole applications, provide a single opening or "window" per duct bank, sized to accommodate the duct bank envelope.
- E. Concrete:
1. Install concrete as specified in Section 03_30_00 - Cast-in-Place Concrete.

2. Provide tie wires as specified in Section 03_20_00 - Concrete Reinforcing to prevent displacement of the conduits during pouring of concrete:
 - a. Tie wire shall not act as a substitute for spacers.
 3. Install minimum 3-inch cover around conduit and rebar.
 4. Consolidation of encasement concrete around duct banks shall be by hand puddling. Mechanical vibrators are acceptable for use outside of the rebar cage.
 5. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.
- F. Marking tape:
1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.
- G. For conduit installations beneath building slabs:
1. Duct banks shall be continued under building slabs to the final destination of the conduits.
 - a. Construct separate duct banks as required.
 - b. Concrete for encasement under building slabs need not be colored red.
 - c. For duct banks crossing under building footers or foundations, install the top of the duct bank a minimum of 12 inches below the footer.
 - d. Where duct banks enter through building walls, foundation walls, stem walls, etc., make connections as indicated on the Drawings.
 - e. Where duct banks terminate with conduit risers entering building walls, install an expansion/deflection fitting or a flat-wise elbow (elbow parallel to building wall) in order to accommodate differential movement between the conduits and structure.
- H. Restore surfaces to their original condition as specified in Section 32_01_15 - Pavement Restoration and Rehabilitation unless otherwise specified.

3.04 FIELD QUALITY CONTROL (NOT USED)

3.05 ADJUSTING (NOT USED)

3.06 CLEANING

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

3.07 PROTECTION

- A. Provide shoring and pumping to protect the excavation and safety of workers.
- B. Protect excavations with barricades as required by applicable safety regulations.

END OF SECTION

SECTION 26_05_53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- B. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- C. Occupational Safety and Health Administration (OSHA).

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- 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.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Nameplates:
 - 1. Provide 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 to achieve an aesthetically consistent and coordinated system.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Nameplates:
 - 1. Provide for each piece of electrical equipment, device, control panel, and control panel components.
 - 2. Identical style, color, and material throughout the facility.
 - 3. Device nameplates information:
 - a. Equipment tag number as indicated on the Drawings.
- B. Wire numbers:
 - 1. Coordinate the wire numbering system with vendors of equipment so that every field wire has a unique number associated with it for the entire system:
 - a. Correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
 - b. 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. 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 specified in Section 26_05_33 - 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.

(ORIGIN LOC.)–(ORIGIN TERM.)/(DEST. LOC.)–(DEST. TERM.)

(ORIGIN LOC.)–(ORIGIN TERM.)
(DEST. LOC.)–(DEST. TERM.)

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

3. 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):

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).

4. **Case 1:** Vendor control panel (VCP) to process control module (PCM):

Field wire number/label: A-B/C-D:

A = Vendor control panel number without hyphen (VCP#)

B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)

C = Process control module number without hyphen (PCM#)

D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

Examples:

VCP#-10/PCM#-I: 1:01/01

VCP#-10/PCM#-O: 1:10/07

VCP#-10/PCM#-C0100

5. **Case 2:** Field instrument to process control module (PCM):

Field wire number/label: E-F/C-D:

C = Process control module number without hyphen (PCM#)

D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

E = Field mounted instrument tag and loop numbers without hyphen (EDV#)

F = Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

Examples:

TIT#-2,3/PCM#-I: 1:01.1

TSH#-1/PCM#-I: 2:01/00

6. **Case 3:** Motor control center (MCC) to process control module (PCM):

Field wire number/label: G-B/C-D:

B = Terminal number within Motor Control Center (manufacturer's or vendor's standard terminal number)

C = Process control module without hyphen (PCM#)

D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

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

Examples:

MMS#-10/PCM#-I: 1:01/01

MMS#-10/PCM#-O: 1:10/07

MMS#-10/PCM#-C0100

7. **Case 4:** Motor control center (MCC) to vendor control panel (VCP):

Field wire number/label: G-B/A-B:

A = Vendor control panel number without hyphen (VCP#)

B = Terminal number within motor control center or vendor control panel (manufacturer's or vendors standard terminal number)

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

Example:

MMS#-X2/VCP#-10

8. **Case 5:** Motor leads to a motor control center (MCC):

Field wire number/label: H-I/G-B:

B = Terminal number within motor control center (manufacturer's standard terminal number)

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

H = Equipment tag and loop number without hyphen (PMP#)

I = Motor manufacturer's standard motor lead identification (e.g., T1, T2, T3, etc.)

Example:

PMP#-T3/MMS#-T3

9. **Case 6:** Remote or separately mounted starter or variable frequency drive (VFD) to process control module (PCM):

Field wire number/label: J-B/C-D:

B = Terminal number within starter or variable frequency drive (manufacturer's standard terminal number)

C = Process control module number without hyphen (VCP#)

D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

J = Starter or variable frequency drive tag and loop number without hyphen (MMS#)

Examples:

MMS#-10/PCM#-I: 1:01/01

MMS#-10/PCM#-O: 2: 10/07

MMS#-10/PCM#-C0010

10. **Case 7:** Field bus trunk segment:

Field cable number/label: C/K-L/M; C/K-L/H; C/K-L/J:

C = Process control module without hyphen (PCM#)

K = Field bus cable type

L = Field bus segment number

M = Field Bus field network component without hyphen (PTB1) or

H = Equipment tag and loop number without hyphen (EMV#) or

J = Starter or variable frequency drive tag and loop number without hyphen (VFD60.0112)

Examples:

PCM#/PA-1A/PTB1PTB1/PA-1B/PTB2

PCM#/DN-1A/VFD#

PCM#/DP-2A/ EMV#

11. **Case 8:** Field bus spur (drop):

Field cable number/label: E/K-L/M:

E = Field mounted instrument tag and loop numbers without hyphen (FIT#)

K = Field bus cable type.

L = Field bus segment number

M = Field bus field network component without hyphen (PTB1), identify ports on the device.

Examples:

FIT#/PA-1C/PTB1-1

FIT#/PA-1D/PTB1-2

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

Example:

S MMS#-10/PCM#-C011

2.03 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) Brady.
 - 2) Kroy.

- 3) Panduit.
 - 4) Raychem.
- C. Conduit and raceway markers:
 - 1. Non-metallic: One of the following or equal:
 - a. Almetek: Mini Tags.
 - b. Lapp Group: Maxi System.

2.04 MATERIALS

- A. Nameplates:
 - 1. Colors:
 - a. Warning: White-center, red face.
 - b. Other: Black-center, white face.
 - 2. Laminated plastic engraving stock:
 - a. 3/32-inch thick material.
 - b. 2-ply.
 - 3. With chamfered edges.
 - 4. Lettering:
 - a. Block style engraved characters of adequate size to be read easily from a distance of 6 feet.
 - b. Minimum letter height: 1/8 inch.
- 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. Lettering:
 - a. Machine printed black characters on white tubing.
 - b. Minimum letter height: 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: 1/4 inch.
 - d. Adhesive labels are not acceptable.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Nameplates:

1. Attach to equipment with rivets, bolts, or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
2. Provide for each disconnecting means with the following:
 - a. Equipment served, voltage, and fuse size as required.
 - b. Identification of the circuit source that supplies the disconnecting means.
3. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.
4. 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.

B. Conductor and cable markers:

1. Apply before termination.
2. Heat-shrinkable tubing:
 - a. Shrunk using a heat gun that produces low temperature heated air.
 - b. 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.

C. Conduit markers:

1. Furnish and install markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:
 - a. 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, structure, manhole, or handhole.
 - 1) Marker shall be non-metallic with stainless steel hardware.
 - 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 the Engineer for punch list purposes.
7. Label intrinsically safe conduits in accordance with the requirements of the NEC.

8. Stainless steel tags and cable ties shall not be used in areas with high chlorine concentrations.
- D. Signs and labeling:
 1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
 - a. Fasten warning signs with round head stainless steel screws or bolts.
 - b. Locate and mount in a manner to be clearly legible to operations personnel.
 2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc., where the voltage exceeds 600 volts.
 3. Furnish and install warning signs on equipment that has more than one source of power.
 - a. Warning signs to identify every panel and circuit number of the disconnecting means of external power sources.
 4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
 - a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.
 5. Label service entrance equipment, switchgear, switchboards, MCCs, panelboards, and transfer switches with the available short circuit current, equipment label, and date of application in accordance with NEC. Coordinate with Section 26_05_74 - Electrical System Studies for available fault current data.

3.04 FIELD QUALITY CONTROL

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

END OF SECTION

SECTION 26_05_74

ELECTRICAL SYSTEM STUDIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Short-circuit fault analysis studies.
 - 2. Protective device coordination study.
 - 3. Machine and electrical system settings.
 - 4. Arc-flash hazard study.

1.02 REFERENCES

- A. American National Standards Institute (ANSI).
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 1584 - IEEE Guide for Performing Arc-Flash Hazard Calculations.
- C. National Fire Protection Association (NFPA):
 - 1. 70E - Standard for Electrical Safety in the Workplace.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Final electrical system study report: The delegated design final report that incorporates installed cable lengths, and all construction changes.
 - 2. Initial short-circuit fault analysis: An analysis done based on the Drawings and utility information. The purpose is to identify the available fault current at each piece of equipment to make sure it is properly rated.
 - 3. Modified: Equipment with load additions or with loads being removed that affect fault current, include new overcurrent protective devices that require settings and device coordination, or require additional/removal/replacement of arc flash labels.
 - 4. Preliminary electrical system studies:
 - a. If startup and sequencing occur before the final study is completed, perform a preliminary study as needed to determine temporary protective device settings.
 - b. Preliminary studies will not be reviewed by the Engineer but shall be submitted for record.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Signed and sealed electrical system study reports.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Credentials of the individual(s) performing the study and the individual in responsible charge of the study.
- C. General:
 - 1. Format and quantity:
 - a. 6 bound copies of all final reports.
 - b. 3 complete sets of electronic files on CD or DVD media, including the electrical system model(s), configuration files, custom libraries, and any other files used to perform the studies and produce the reports. Also provide an electronic version of the bound reports in PDF format.
 - 2. One-line diagrams:
 - a. The following information shall be included at a minimum:
 - 1) Motor horsepower.
 - 2) Transformer data:
 - a) kVA.
 - b) Configuration.
 - 3) Cable data:
 - a) Insulation.
 - b) Size.
 - c) Length.
 - b. Fully legible at 11-inch by 17-inch size.
- D. Initial short-circuit fault analysis:
 - 1. Based on the Contract Documents and electric utility information.
 - 2. Include a description of all operating scenarios.
 - 3. One-line diagrams.
 - 4. Indicate the estimated available short-circuit current at the line side terminals of each piece of equipment covered by the scope of the study.
 - a. Measure conductor lengths from the Drawings. Use of arbitrary short conductor lengths is not allowed.
 - b. Provide a list of assumptions used in the initial study.
- E. Delegated Design final studies and reports:
 - 1. Include the following sections at a minimum:
 - a. Copies of correspondence and data obtained from the electric utility company.
 - b. Letter certifying the inspection and verification of existing equipment and incorporation of applicable RFI's and change orders.
 - c. Short-circuit fault analysis:
 - 1) Modify the initial short-circuit fault analysis as follows:
 - a) Utilize the actual equipment provided on the Project.
 - b) Utilize conductor lengths based on installation.
 - c) Update one-line diagrams to show as-built conditions.
 - 2) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
 - 3) Normal system connections and those that result in maximum fault conditions.

- 4) Tabulation of circuit breaker, fuse, and other protective device ratings compared to maximum calculated short-circuit duties.
- 5) Fault current calculations for the cases run, including a definition of terms and guide for interpretation of computer software printouts.
- d. Protective device coordination study shall include:
 - 1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
 - 2) List requirements used in the selection and setting criteria for any protective devices.
 - 3) Manufacturer's time-current curves for circuit breakers, fuses, motor circuit protectors, and other protective devices for new equipment.
 - 4) TCCs graphically indicating the coordination proposed for the system on log-log graphs:
 - a) All TCCs shall be in color.
 - 5) Tabulation of relay, fuse, circuit breaker, and other protective devices in graphical form with a one-line diagram to display area coordination.
 - 6) Where coordination could not be achieved, an explanation shall be included in the report to support the statement along with recommendations to improve coordination. Recommended equipment modifications or settings shall be in a tabulated form.
 - 7) Protective device settings in a tabulated format.
- e. Include in the arc-flash hazard study:
 - 1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
 - 2) Normal system connections and those that result in maximum arc-flash conditions.
 - 3) Arc-flash raw data, calculations, and assumptions.
- f. Form and format of arc-flash labels.
 - 1) Label data:
 - a) Identifying the content of each label.
 - b) Identifying the location of each label.

F. Signature page identifying the name for the person entering the setting and a representative of the Contractor for each protective device requiring setting or adjustment.

G. Submit course outline for Owner Training.

1.06 QUALITY ASSURANCE

- A. Qualifications of the entity responsible for electrical system studies:
1. Short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall be performed with the aid of a digital computer program:
 - a. Point-to-point calculations are not acceptable.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. The individual performing the studies shall visit the site and collect necessary field data in order to perform and complete comprehensive electrical system studies.
2. Obtain, for all equipment, the required data for preparation of the study, including, but not limited to:
 - a. Transformer kilovolt-ampere (kVA), nameplate data, and impedances.
 - b. Generator impedances, kilovolt-ampere (kVA), and voltage.
 - c. Generator decrement curves.
 - d. Bus withstand ratings.
 - e. Cable and bus data.
 - f. Protective device taps, time dials, instantaneous pickups, and time-delay settings.
 - g. As-built lengths for new wire and cable installations covered by the studies.
 - h. Grounding schemes (solidly grounded or resistive grounded).
3. Obtain the electric utility information on the minimum and maximum available fault current, minimum and maximum utility impedances, utility protective device settings, including manufacturer and model number, interrupting ratings, X/R ratios, and model information one level above the point of connection:
 - a. Utility tolerances and voltage variations.
 - b. Coordinate with the utility for changes to their protective devices and settings to achieve a coordinated system between the utility and the Owner.
4. Obtain equipment layouts and configurations from the manufacturer's final Submittal requirements and project layout drawings as required.
5. Bus and conductor data:
 - a. Use impedances of the actual installed or specified conductors, unless otherwise indicated.
 - b. Use cable and bus impedances calculated at 25 degrees Celsius, unless otherwise indicated.
 - c. Use 600-volt cable reactance based on typical dimensions of actual installed or specified conductors, unless otherwise indicated.
 - d. Use bus withstand values for all equipment having buses.

B. Certification:

1. Submit written certification signed by the professional engineer conducting the study, equipment supplier, and electrical subcontractor, stating that the data used in the study is correct and captures all RFIs, as-builts, and change orders affecting the study.

C. Meetings:

1. Electrical system study meetings:
 - a. As specified in Section 01_31_19 - Project Meetings.
 - b. The individual conducting the electrical system studies leads the meeting.
 - c. Meet with the Owner and Engineer 3 times.
 - d. First meeting:
 - 1) Discuss the scope of the studies.
 - 2) Confirm electrical system operating modes.

- 3) Confirm assumptions to be used in the electrical system study with the Owner, including, but not limited to:
 - a) Maximum protective device fault clearing time.
 - 4) Discuss the Owner's operational requirements for both normal operation and maintenance.
 - e. Second meeting:
 - 1) Inform the Owner of the results of the study and impacts on normal operation and maintenance, including:
 - a) Protective device coordination problems and recommended solutions.
 - b) Explanation of the arc-flash hazard study results and its potential impact on operations.
 - c) Recommendations for reduction of arc-flash category levels, including reduction of protective device settings or changes in operational practices.
 - f. Final meeting:
 - 1) Prior to substantial completion.
 - 2) Discuss changes to the studies based on the previous meeting.
 - 3) Discuss with the Owner how changes to the electrical system may change the arc-flash hazard category.
- D. Sequencing:
 - 1. Below is an outline of the typical work sequence. Proposed changes to the work sequence may be reviewed and approved by the Engineer.
 - a. First system study meeting.
 - b. Submit the initial short-circuit fault analysis study before submittal of any electrical equipment.
 - 1) Only the initial short-circuit results will be reviewed.
 - c. Site visit to gather data on the existing facility systems for all studies:
 - 1) Make multiple trips as required to obtain data for the short-circuit fault analysis, protection device coordination, and arc flash hazard studies.
 - d. Conduct preliminary protective device coordination analysis and overcurrent device settings as required to accommodate project and sequencing.
 - e. Submit the draft short-circuit fault analysis, protective device coordination, and arc-flash hazard studies after the approval of all electrical equipment.
 - f. Second system study meeting for preliminary results.
 - g. Update the model with changes to the electrical system made during start-up and commissioning.
 - h. Final system study meeting.
 - i. Submit the final electrical system studies.
 - j. Label equipment with approved arc-flash labels.
 - k. Owner Training.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. General study requirements:

1. Scope:

- a. Short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall include all new and modified equipment in the power distribution system, including, but not limited to:
 - 1) Utility equipment (utility transformer and primary protective device).
 - 2) Available utility fault contribution current.
 - 3) All electrical equipment, including:
 - a) Dry-type transformers.
 - b) 240- and 208-volt panelboards.
 - 4) Generators.
 - 5) Motors.
 - 6) Vendor control panels.
 - 7) HVAC equipment.
- b. Study scenarios:
 - 1) Include all possible electrical system configurations, for example:
 - a) Operation on normal (utility) source.
 - b) Operation on generator source.
 - c) Main-breakers closed; tie-breaker open.
 - d) Either main-breaker open; tie-breaker closed.

2. Motors:

- a. Each motor shall be individually modeled:
 - 1) Grouping of motors for fault contribution current is not acceptable.
- b. Motors with variable frequency drives (VFDs) may be assumed to have no contribution to fault current, unless VFDs are equipped with bypass contactors.
 - 1) If VFDs are equipped with bypass contactors, perform the fault current and arc flash study assuming all of bypass contactors are in the closed position.

3. Use the equipment, bus, and device designations as indicated on the Drawings for all studies.

B. Short-circuit fault analysis study additional requirements:

- 1. Calculate 3-phase bolted fault, line-to-line fault, line-to-ground fault, double line-to-ground fault, short-circuit 1/2 cycle momentary symmetrical and asymmetrical RMS, 1-1/2 to 4 cycle interrupting symmetrical RMS, and 30-cycle steady-state short-circuit current values at each piece of equipment in the distribution system.
- 2. Evaluate bus bracing, short-circuit ratings, fuse interrupting capacity and circuit-breaker-adjusted interrupting capacities against the fault currents, and calculate X/R values:
 - a. Identify and document all devices and equipment as either inadequate or acceptable.
- 3. Calculate line-to-ground and double line-to-ground momentary short-circuit values at buses having ground-fault devices.

4. Provide calculation methods, assumptions, one-line diagrams, and source impedance data, including utility X/R ratios, typical values, recommendations, and areas of concern.
- C. Protective device coordination study additional requirements:
1. Furnish protective device settings for functions indicated on the Drawings, including, but not limited to:
 - a. Current.
 - b. Voltage:
 - 1) Provide settings for voltage relays based upon actual utility and generator tolerances and specifications.
 - c. Frequency:
 - 1) Provide settings for frequency relays based upon actual utility and generator tolerances and specifications.
 - d. Negative sequence.
 - e. Reverse power.
 - f. Bus differential.
 - g. Machine protection functions:
 - 1) Provide settings for motor and generator protective relays based on the manufacturer's recommended protection requirements.
 2. Provide log-log form time-current curves (TCCs) graphically indicating the coordination proposed for the system:
 - a. Include with each TCC a complete title and one-line diagram with legend identifying the specific portion of the system covered by the particular TCC:
 - 1) Typical TCCs for identical portions of the system, such as motor circuits, are acceptable as allowed by the Engineer.
 - b. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics:
 - 1) These details can be included on the TCC.
 - c. Include a detailed description of each protective device tap, time dial, pickup, instantaneous, and time delay settings:
 - 1) These details can be included on the TCC.
 3. TCCs shall include all equipment in the power distribution system where required to demonstrate coordination. Include utility relay and fuse characteristics, medium-voltage equipment protective relay and fuse characteristics, low-voltage equipment circuit breaker trip device characteristics, transformer characteristics, motor and generator characteristics, and characteristics of other system load protective devices:
 - a. Include devices down to the largest branch circuit and largest feeder circuit breaker in each motor control center, main breaker in branch panelboards, and fused disconnect switches.
 - b. Provide ground fault TCCs with adjustable settings for ground fault protective devices.
 - c. Include manufacturing tolerances and damage bands in plotted fuse and circuit breaker characteristics.
 - d. On the TCCs, show transformer full load currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and transformer damage curves.
 - e. Cable damage curves.

- f. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed based on the short-circuit fault analysis study.
 - g. Coordinate time interval medium-voltage relay characteristics with upstream and downstream devices to avoid nuisance tripping.
 - 4. When site generation (including cogeneration, standby, and emergency generators) is part of the electrical system, include phase and ground coordination of the generator protective devices:
 - a. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices.
 - 5. Suggest modifications or additions to equipment rating or settings in a tabulated form.
- D. Arc-flash hazard study additional requirements:
 - 1. Include the calculated arc-flash boundary and incident energy (calories/square centimeter) at each piece of equipment in the distribution system:
 - a. Perform study with 15 percent arcing fault variation in accordance with IEEE 1584.
 - b. Perform arc-flash calculations at minimum and maximum utility fault contributions.
 - c. Perform arc-flash calculations for both the line side and load side of the switchgear, switchboard, motor control center, and panelboard main breakers.
 - d. Perform arc-flash calculations for short-circuit scenarios with all motors on for 3 to 5 cycles and with all motors off.
 - 2. Provide executive summary of the study results:
 - a. Provide summary based upon worst case results.
 - 3. Provide a detailed written discussion and explanation of the tabulated outputs:
 - a. Include all scenarios.
 - 4. Provide alternative device settings to allow the Owner to select the desired functionality of the system:
 - a. Minimize the arc-flash energy by selective trip and time settings for equipment maintenance purposes.
 - b. Identify the arc-flash energy based upon the criteria of maintaining coordination and selectivity of the protective devices.

2.03 MANUFACTURERS

- A. Update the Owner's existing electrical system studies.
- B. Electrical system study software: One of the following or equal:
 - 1. Operation Technology, Inc., ETAP.
 - 2. SKM Systems Analysis, Powertools.

2.04 EXISTING PRODUCTS (NOT USED)

2.05 MATERIALS (NOT USED)

2.06 MANUFACTURED UNITS (NOT USED)

2.07 EQUIPMENT (NOT USED)

2.08 COMPONENTS

- A. Arc-flash hazard labels:
 - 1. Dimensions:
 - a. Minimum 5 inches by 3.5 inches.
 - 2. Materials:
 - a. Polyester with polyvinyl polymer over-laminate.
 - b. Self-adhesive.
 - c. Resistant to:
 - 1) UV.
 - 2) Chemicals and common cleaning solvents.
 - 3) Scuffing.
 - 4) Wide temperature changes.
 - 3. Contents:
 - a. Short-circuit bus identification.
 - b. Calculated incident energy (calories/square centimeter) range:
 - 1) Based on worst-case study results.
 - c. Site-specific personal protective equipment level number.
 - d. Arc-flash protection boundary.
 - e. Shock hazard boundary:
 - 1) Contractor may provide separate labels for indication of the shock hazard boundary.
 - f. Fed from:
 - 1) Identify the tag number of the upstream equipment providing power.
 - 4. Color scheme:
 - a. For locations above 40 calories/square centimeter:
 - 1) White label with red "DANGER" strip across the top.
 - 2) Black lettering.
 - b. For locations below 40 calories/square centimeter:
 - 1) White label with orange "WARNING" strip across the top.
 - 2) Black lettering.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. After review and acceptance of the arc-flash hazard study by the Engineer, install arc-flash hazard labels:
 - 1. At all locations required by NFPA, ANSI, or IEEE standards.
 - 2. At a minimum, in the following locations:
 - a. Front of each main or incoming service compartment.
 - b. Front of each low-voltage switchgear section.
 - c. Front of each medium-voltage circuit breaker door.
 - d. Front of each accessible auxiliary or conductor compartment.
 - e. Each accessible rear or side vertical section.
 - f. Each motor control center vertical section.

- g. Each panelboard covered by the study.
- h. Each control panel, individual starter or VFD, or other equipment covered by the scope of the study.

3.04 OWNER TRAINING

- A. Including, but not limited to:
 - 1. Introduction and basics of NFPA 70E: 2 hours 2 sessions.
 - 2. Detailed review of the electrical system study: 2 hours 1 session.

3.05 FIELD QUALITY CONTROL

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

3.06 ADJUSTING

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

END OF SECTION

SECTION 26_06_01A

CONDUIT SCHEDULE

PART 1 GENERAL

1.01 SUMMARY

- A. Conduit requirements:
 - 1. As defined in Section 26_05_00 and Section 26_05_33.
- B. Cable requirements and definitions:
 - 1. As defined in Section 26_05_00 and Section 26_05_18.
 - 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. */FO: Fiber optic (* indicates strand count).
 - 5. CAT6: Category 6 Ethernet cable.
 - 6. MFR: Manufacturer or vendor furnished cable.
 - 7. PULL: Pull Rope.
 - 8. 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									ENGINEER	BHT
DNWTP SOLIDS DEWATERING IMPROVEMENT PROJECT									REVISION	
SLUDGE PS, DAY TANKS, EXISTING THICKENERS & PUMP STATIONS									DATE	6/11/25
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-65-110	65E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: 65-FSL-931 TO: CONDUIT TEE 2 #14 >> 65-FSL-931 CONTROL	C-65-112
C-65-111	65E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: 65-SV-931 TO: CONDUIT TEE 2 #14 >> 65-SV-931 CONTROL	C-65-112
C-65-112	65E01	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: 65-LCP-931 2 #14 >> 65-FSL-931 CONTROL 2 #14 >> 65-SV-931 CONTROL	C-65-115 C-65-110 C-65-111
C-65-113	65E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: 65-PSH-931 TO: 65-LCP-931 2 #14 >> 65-PSH-931 CONTROL	C-65-115
C-65-114	65E01	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: 65-TSH-931 TO: 65-LCP-931 2 #14 >> 65-TSH-931 CONTROL 2 #14 >> 65-TE-931 CONTROL	C-65-115
C-65-115	65E01	1"	18	#14	XHHW-2	1	#14	XHHW-2	FR: 65-LCP-931 TO: J-BOX 2 #14 >> 65-FSL-931 CONTROL 2 #14 >> 65-SV-931 CONTROL 2 #14 >> 65-PSH-931 CONTROL 2 #14 >> 65-TSH-931 CONTROL 2 #14 >> 65-TE-931 CONTROL 8 #14 >> 65-LCP-931 CONTROL	C-65-146 C-65-112 C-65-112 C-65-113 C-65-114 C-65-114
C-65-120	65E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: 65-FSL-932 TO: CONDUIT TEE 2 #14 >> 65-FSL-932 CONTROL	C-65-122
C-65-121	65E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: 65-SV-932 TO: CONDUIT TEE 2 #14 >> 65-SV-932 CONTROL	C-65-122
C-65-122	65E01	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: 65-LCP-932 2 #14 >> 65-FSL-932 CONTROL 2 #14 >> 65-SV-932 CONTROL	C-65-125 C-65-120 C-65-121
C-65-123	65E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: 65-PSH-932 TO: 65-LCP-932 2 #14 >> 65-PSH-932 CONTROL	C-65-125
C-65-124	65E01	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: 65-TSH-932 TO: 65-LCP-932 2 #14 >> 65-TSH-932 CONTROL 2 #14 >> 65-TE-932 CONTROL	C-65-125
C-65-125	65E01	1"	18	#14	XHHW-2	1	#14	XHHW-2	FR: 65-LCP-932 TO: J-BOX 2 #14 >> 65-FSL-932 CONTROL 2 #14 >> 65-SV-932 CONTROL 2 #14 >> 65-PSH-932 CONTROL 2 #14 >> 65-TSH-932 CONTROL 2 #14 >> 65-TE-932 CONTROL 8 #14 >> 65-LCP-932 CONTROL	C-65-146 C-65-122 C-65-122 C-65-123 C-65-124 C-65-124
C-65-130	65E01	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: 65-FSL-941 TO: CONDUIT TEE 4 #14 >> 65-FSL-941 CONTROL	C-65-132
C-65-131	65E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: 65-SV-941 TO: CONDUIT TEE 2 #14 >> 65-SV-941 CONTROL	C-65-132
C-65-132	65E01	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: 65-LCP-941 4 #14 >> 65-FSL-941 CONTROL 2 #14 >> 65-SV-941 CONTROL	C-65-135 C-65-130 C-65-131
C-65-133	65E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: 65-PSH-941 TO: 65-LCP-941 2 #14 >> 65-PSH-941 CONTROL	C-65-135
C-65-134	65E01	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: 65-TSH-941 TO: 65-LCP-941 2 #14 >> 65-TSH-941 CONTROL 2 #14 >> 65-TE-941 CONTROL	C-65-135

CONDUIT SCHEDULE AREA									ENGINEER	BHT
DNWTP SOLIDS DEWATERING IMPROVEMENT PROJECT									REVISION	
SLUDGE PS, DAY TANKS, EXISTING THICKENERS & PUMP STATIONS									DATE	6/11/25
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-65-135	65E01	1.5"	20	#14	XHHW-2	1	#14	XHHW-2	FR: 65-LCP-941 TO: J-BOX 4 #14 >> 65-FSL-941 CONTROL 2 #14 >> 65-SV-941 CONTROL 2 #14 >> 65-PSH-941 CONTROL 2 #14 >> 65-TSH-941 CONTROL 2 #14 >> 65-TE-941 CONTROL 8 #14 >> 65-LCP-941 CONTROL	C-65-146 C-65-132 C-65-132 C-65-133 C-65-134 C-65-134
C-65-140	65E01	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: 65-FSL-942 TO: CONDUIT TEE 4 #14 >> 65-FSL-942 CONTROL	C-65-142
C-65-141	65E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: 65-SV-942 TO: CONDUIT TEE 2 #14 >> 65-SV-942 CONTROL	C-65-142
C-65-142	65E01	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: 65-LCP-942 4 #14 >> 65-FSL-942 CONTROL 2 #14 >> 65-SV-942 CONTROL	C-65-145 C-65-140 C-65-141
C-65-143	65E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: 65-PSH-942 TO: 65-LCP-942 2 #14 >> 65-PSH-942 CONTROL	C-65-145
C-65-144	65E01	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: 65-TSH-942 TO: 65-LCP-942 2 #14 >> 65-TSH-942 CONTROL 2 #14 >> 65-TE-942 CONTROL	C-65-145
C-65-145	65E01	1.5"	20	#14	XHHW-2	1	#14	XHHW-2	FR: 65-LCP-942 TO: J-BOX 4 #14 >> 65-FSL-942 CONTROL 2 #14 >> 65-SV-942 CONTROL 2 #14 >> 65-PSH-942 CONTROL 2 #14 >> 65-TSH-942 CONTROL 2 #14 >> 65-TE-942 CONTROL 8 #14 >> 65-LCP-942 CONTROL	C-65-146 C-65-142 C-65-142 C-65-143 C-65-144 C-65-144
C-65-146	65E01 65E02 65E03	2"	76	#14	XHHW-2	1	#14	XHHW-2	FR: J-BOX TO: MCC-65 2 #14 >> 65-FSL-931 CONTROL 2 #14 >> 65-SV-931 CONTROL 2 #14 >> 65-PSH-931 CONTROL 2 #14 >> 65-TSH-931 CONTROL 2 #14 >> 65-TE-931 CONTROL 8 #14 >> 65-LCP-931 CONTROL 2 #14 >> 65-FSL-932 CONTROL 2 #14 >> 65-SV-932 CONTROL 2 #14 >> 65-PSH-932 CONTROL 2 #14 >> 65-TSH-932 CONTROL 2 #14 >> 65-TE-932 CONTROL 8 #14 >> 65-LCP-932 CONTROL 4 #14 >> 65-FSL-941 CONTROL 2 #14 >> 65-SV-941 CONTROL 2 #14 >> 65-PSH-941 CONTROL 2 #14 >> 65-TSH-941 CONTROL 2 #14 >> 65-TE-941 CONTROL 8 #14 >> 65-LCP-941 CONTROL 4 #14 >> 65-FSL-942 CONTROL 2 #14 >> 65-SV-942 CONTROL 2 #14 >> 65-PSH-942 CONTROL 2 #14 >> 65-TSH-942 CONTROL 2 #14 >> 65-TE-942 CONTROL 8 #14 >> 65-LCP-942 CONTROL	C-65-115 C-65-115 C-65-115 C-65-115 C-65-115 C-65-115 C-65-115 C-65-125 C-65-125 C-65-125 C-65-125 C-65-125 C-65-125 C-65-125 C-65-125 C-65-125 C-65-135 C-65-135 C-65-135 C-65-135 C-65-135 C-65-135 C-65-135 C-65-145 C-65-145 C-65-145 C-65-145 C-65-145 C-65-145
C-65-150	65E01	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: 65-LSH/LS2/LS1/LSL-980 TO: J-BOX 8 #14 >> 65-LSH/LS2/LS1/LSL-980 CONTROL	C-65-151
C-65-151	65E01	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: J-BOX TO: 65-VCP-980 8 #14 >> 65-LSH/LS2/LS1/LSL-980 CONTROL	C-65-150
C-65-160	65E01	0.75"	10	#14	XHHW-2	1	#14	XHHW-2	FR: 65-FV-940A TO: J-BOX 10 #14 >> 65-FV-940A CONTROL	C-65-166
C-65-161	65E01	0.75"	10	#14	XHHW-2	1	#14	XHHW-2	FR: 65-FV-940B TO: J-BOX 10 #14 >> 65-FV-940B CONTROL	C-65-166

CONDUIT SCHEDULE AREA

DNWTP SOLIDS DEWATERING IMPROVEMENT PROJECT

SLUDGE PS, DAY TANKS, EXISTING THICKENERS & PUMP STATIONS

ENGINEER

BHT

REVISION

DATE

6/11/25

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-65-162	65E01	0.75"	10	#14	XHHW-2	1	#14	XHHW-2	FR: 65-FV-930A TO: J-BOX 10 #14 >> 65-FV-930A CONTROL	C-65-166
C-65-163	65E01	0.75"	10	#14	XHHW-2	1	#14	XHHW-2	FR: 65-FV-930B TO: J-BOX 10 #14 >> 65-FV-930B CONTROL	C-65-166
C-65-164	65E01	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: 65-VCP-930 TO: J-BOX 8 #14 >> 65-VCP-930 CONTROL	C-65-166
C-65-165	65E01	1"	12	#14	XHHW-2	1	#14	XHHW-2	FR: 65-VCP-980 TO: J-BOX 12 #14 >> 65-VCP-980 CONTROL	C-65-166
C-65-166	65E01 65E02 65E03	2"	60	#14	XHHW-2	1	#14	XHHW-2	FR: J-BOX TO: PCM-910 10 #14 >> 65-FV-940A CONTROL 10 #14 >> 65-FV-940B CONTROL 10 #14 >> 65-FV-930A CONTROL 10 #14 >> 65-FV-930B CONTROL 8 #14 >> 65-VCP-930 CONTROL 12 #14 >> 65-VCP-980 CONTROL	C-65-160 C-65-161 C-65-162 C-65-163 C-65-164 C-65-165
C-65-200	65E03	1.5"	30	#14	XHHW-2	1	#14	XHHW-2	FR: MCC-65 TO: CONDUIT TEE 14 #14 >> 65-PMP-931 CONTROL 8 #14 >> 65-MIX-981 CONTROL 8 #14 >> 65-MIX-982 CONTROL	C-65-202
C-65-201	65E03	1.5"	22	#14	XHHW-2	1	#14	XHHW-2	FR: MCC-65 TO: CONDUIT TEE 14 #14 >> 65-PMP-932 CONTROL 8 #14 >> 65-SF-9X1 CONTROL	C-65-202
C-65-202	65E03	2"	52	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 14 #14 >> 65-PMP-931 CONTROL 8 #14 >> 65-MIX-981 CONTROL 8 #14 >> 65-MIX-982 CONTROL 14 #14 >> 65-PMP-932 CONTROL 8 #14 >> 65-SF-9X1 CONTROL	C-65-204 C-65-200 C-65-200 C-65-200 C-65-201 C-65-201
C-65-203	65E03	1.5"	28	#14	XHHW-2	1	#14	XHHW-2	FR: MCC-65 TO: CONDUIT TEE 14 #14 >> 65-PMP-941 CONTROL 14 #14 >> 65-PMP-942 CONTROL	C-65-204
C-65-204	65E03	2"	80	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 14 #14 >> 65-PMP-931 CONTROL 8 #14 >> 65-MIX-981 CONTROL 8 #14 >> 65-MIX-982 CONTROL 14 #14 >> 65-PMP-932 CONTROL 8 #14 >> 65-SF-9X1 CONTROL 14 #14 >> 65-PMP-941 CONTROL 14 #14 >> 65-PMP-942 CONTROL	C-65-206 C-65-202 C-65-202 C-65-202 C-65-202 C-65-202 C-65-203 C-65-203
C-65-205	65E03	1.5"	20	#14	XHHW-2	1	#14	XHHW-2	FR: MCC-65 TO: CONDUIT TEE 10 #14 >> 65-RDP-991 CONTROL 10 #14 >> 65-RDP-992 CONTROL	C-65-206
C-65-206	65E03	2.5"	100	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 14 #14 >> 65-PMP-931 CONTROL 8 #14 >> 65-MIX-981 CONTROL 8 #14 >> 65-MIX-982 CONTROL 14 #14 >> 65-PMP-932 CONTROL 8 #14 >> 65-SF-9X1 CONTROL 14 #14 >> 65-PMP-941 CONTROL 14 #14 >> 65-PMP-942 CONTROL 10 #14 >> 65-RDP-991 CONTROL 10 #14 >> 65-RDP-992 CONTROL	C-65-208 C-65-204 C-65-204 C-65-204 C-65-204 C-65-204 C-65-204 C-65-204 C-65-205 C-65-205
C-65-207	65E03	1.5"	28	#14	XHHW-2	1	#14	XHHW-2	FR: MCC-65 TO: CONDUIT TEE 14 #14 >> 65-THU-921 CONTROL 14 #14 >> 65-THU-922 CONTROL	C-65-208

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NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-65-208		3"	128	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-910 14 #14 >> 65-PMP-931 CONTROL C-65-206 8 #14 >> 65-MIX-981 CONTROL C-65-206 8 #14 >> 65-MIX-982 CONTROL C-65-206 14 #14 >> 65-PMP-932 CONTROL C-65-206 8 #14 >> 65-SF-9X1 CONTROL C-65-206 14 #14 >> 65-PMP-941 CONTROL C-65-206 14 #14 >> 65-PMP-942 CONTROL C-65-206 10 #14 >> 65-RDP-991 CONTROL C-65-206 10 #14 >> 65-RDP-992 CONTROL C-65-206 14 #14 >> 65-THU-921 CONTROL C-65-207 14 #14 >> 65-THU-922 CONTROL C-65-207	
C-65-210	65E03	0.75"	2 4	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: 65-AHU-993 TO: 65-HP-993 2 #12 >> 65-AHU-993 POWER 4 #14 >> 65-AHU-993 CONTROL	
C-65-211	65E03	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: 65-TIT-993 TO: 65-AHU-993 2 #14 >> 65-TIT-993 CONTROL	
C-65-220	65E03	0.75"	2 4	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: 65-AHU-994 TO: 65-HP-994 2 #12 >> 65-AHU-994 POWER 4 #14 >> 65-AHU-994 CONTROL	
C-65-221	65E03	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: 65-TIT-994 TO: 65-AHU-994 2 #14 >> 65-TIT-994 CONTROL	
C-65-250	65E03 66E01	2"	4 24	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: EXISTING THICKENERS PULLBOX TO: PCM-910 6 #14 >> THU-921 CONTROL 2 #14 >> TSH-921 CONTROL 2 #14 >> XSHA-921 CONTROL 2 #14 >> XSHB-921 CONTROL 6 #14 >> THU-922 CONTROL 2 #14 >> TSH-922 CONTROL 2 #14 >> XSHA-922 CONTROL 2 #14 >> XSHB-922 CONTROL 2 #12 >> LIT-921 POWER 2 #12 >> LIT-922 POWER	
C-65-300	66E03	2"	8	#14	XHHW-2	1	#14	XHHW-2	FR: EXISTING VCP-971 TO: HH-01 2 #14 >> AUXAA-971 CONTROL C-65-330 2 #14 >> AUXAB-971 CONTROL 2 #14 >> LSL-971 CONTROL 2 #14 >> LSH-971 CONTROL	
C-65-310	66E02	2"	12	#14	XHHW-2	1	#14	XHHW-2	FR: EXISTING RECYLED DECANT PS HANDHOLE TO: HH-01 2 #14 >> TSH-992 CONTROL C-65-330 2 #14 >> LCP-992 CONTROL 2 #14 >> LSA-991 CONTROL 2 #14 >> LSHH-991 CONTROL 2 #14 >> LSB-991 CONTROL 2 #14 >> LSL-991 CONTROL	
C-65-330	01E01 65E03	2"	24	#14	XHHW-2	1	#14	XHHW-2	FR: HH-01 TO: 65-PB-01 2 #14 >> AUXAA-971 CONTROL C-65-330A 2 #14 >> AUXAB-971 CONTROL C-65-330 2 #14 >> LSL-971 CONTROL C-65-330 2 #14 >> LSH-971 CONTROL C-65-330 2 #14 >> TSH-992 CONTROL C-65-310 2 #14 >> LCP-992 CONTROL C-65-310 2 #14 >> LSA-991 CONTROL C-65-310 2 #14 >> LSHH-991 CONTROL C-65-310 2 #14 >> LSB-991 CONTROL C-65-310 2 #14 >> LSL-991 CONTROL C-65-310 2 #14 >> LSHB-1311 CONTROL C-65-320 2 #14 >> LSHB-1311 CONTROL C-65-320	

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C-65-330A	65E03	1.5"	24	#14	XHHW-2	1	#14	XHHW-2	FR: 65-PB-01 TO: PCM-910 2 #14 >> AUXAA-971 CONTROL 2 #14 >> AUXAB-971 CONTROL 2 #14 >> LSL-971 CONTROL 2 #14 >> LSH-971 CONTROL 2 #14 >> TSH-992 CONTROL 2 #14 >> LCP-992 CONTROL 2 #14 >> LSA-991 CONTROL 2 #14 >> LSHH-991 CONTROL 2 #14 >> LSB-991 CONTROL 2 #14 >> LSL-991 CONTROL 2 #14 >> LSHB-1311 CONTROL 2 #14 >> LSHB-1311 CONTROL	C-65-330 C-65-330 C-65-330 C-65-330 C-65-330 C-65-330 C-65-330 C-65-330 C-65-330 C-65-330 C-65-330 C-65-330
L-65-100	65E03	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: 65-ACP-910 TO: MCC-65(65-PNL-01) 2 #12 >> 65-ACP-910 POWER	
L-65-110	65E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: 65-FIT-934 TO: J-BOX 2 #12 >> 65-FIT-934 POWER	L-65-114
L-65-111	65E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: 65-FIT-930 TO: J-BOX 2 #12 >> 65-FIT-930 POWER	L-65-114
L-65-112	65E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: 65-FIT-922 TO: J-BOX 2 #12 >> 65-FIT-922 POWER	L-65-114
L-65-113	65E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: 65-FIT-921 TO: J-BOX 2 #12 >> 65-FIT-921 POWER	L-65-114
L-65-114	65E01 65E02 65E03	0.75"	8	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: PCM-910 2 #12 >> 65-FIT-934 POWER 2 #12 >> 65-FIT-930 POWER 2 #12 >> 65-FIT-922 POWER 2 #12 >> 65-FIT-921 POWER	L-65-110 L-65-111 L-65-112 L-65-113
L-65-120	65E03	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: 65-LVR-997 TO: MCC-65(65-PNL-01) 2 #12 >> 65-LVR-997 POWER	
L-65-200	65E03	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: PCM-910 TO: MCC-65(65-PNL-01) 2 #12 >> PCM-910 POWER CKT 1 2 #12 >> PCM-910 POWER CKT 2	
L-65-210	65E03	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: 65-HP-993 TO: MCC-65(65-PNL-01) 2 #12 >> 65-HP-993 POWER	
L-65-220	65E03	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: 65-HP-994 TO: MCC-65(65-PNL-01) 2 #12 >> 65-HP-994 POWER	
L-65-250	65E03 66E01	2"	4 4	#10 #12	XHHW-2 XHHW-2	1	#10	XHHW-2	FR: EXISTING THICKENERS PULLBOX TO: MCC-65(65-PNL-01) 2 #10 >> THICKENERS LIGHTS 2 #10 >> THICKENERS RECEPTACLES & RH-3 2 #12 >> HTU-921 POWER 2 #12 >> POLE LIGHT RUNNER	
L-65-300	65E03	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: HEAT TRACE EAST TO: MCC-65(65-PNL-01) 2 #12 >> HEAT TRACE EAST POWER	
L-65-301	65E03	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: HEAT TRACE NORTH TO: MCC-65(65-PNL-01) 2 #12 >> HEAT TRACE NORTH POWER	
L-65-302	65E03	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: HEAT TRACE WEST TO: MCC-65(65-PNL-01) 2 #12 >> HEAT TRACE WEST POWER	
L-65-303	65E03	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: HEAT TRACE SOUTH TO: MCC-65(65-PNL-01) 2 #12 >> HEAT TRACE SOUTH POWER	

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NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
L-65-322	66E04	2"	4	#12	XHHW-2	1	#12	XHHW-2	FR: UNDER DRAIN PUMP STATION OUTLETS TO: HH-01 2 #12 >> PORTABLE TRASH PUMPS POWER 2 #12 >> EXISTING LIGHT POLE POWER	L-65-322A
L-65-322A	66E04	2"	4	#12	XHHW-2	1	#12	XHHW-2	FR: HH-01 TO: 65-PB-01 2 #12 >> PORTABLE TRASH PUMPS POWER 2 #12 >> EXISTING LIGHT POLE POWER	L-65-322B L-65-322 L-65-322
L-65-322B	66E04	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: 65-PB-01 TO: MCC-65(65-PNL-01) 2 #12 >> PORTABLE TRASH PUMPS POWER 2 #12 >> EXISTING LIGHT POLE POWER	L-65-322A L-65-322A
N-65-001 XISTING D4079	70E01	2"	1		24/FO	1	#14	XHHW-2	FR: EXISTING VCP-900 TO: HH-01 1 24/FO >> PCM-910 NETWORK	N-65-001A
N-65-100	65E03	0.75"	1		CAT6	1	#14	XHHW-2	FR: 65-ACP-910 TO: PCM-910 1 CAT6 >> 65-ACP-910 NETWORK	
N-65-001A	01E01 65E03	2"	1		24/FO	1	#14	XHHW-2	FR: HH-01 TO: 65-PB-01 1 24/FO >> PCM-910 NETWORK	N-65-001B N-65-001
N-65-001B	65E03	2"	1		24/FO	1	#14	XHHW-2	FR: 65-PB-01 TO: PCM-910 1 24/FO >> PCM-910 NETWORK	N-65-001A
P-65-001 XISTING D1014	70E01	2"	3	#4/0	XHHW-2	1	#1	XHHW-2	FR: EXISTING MCC-22 TO: HH-01 3 #4/0 >> MCC-65 POWER	P-65-001A
P-65-002 XISTING D1056	70E01	2"	3	#4/0	XHHW-2	1	#1	XHHW-2	FR: EXISTING MCC-22 TO: HH-01 3 #4/0 >> MCC-65 POWER	P-65-002A
P-65-003 XISTING D4153	70E01	2"	3	#4/0	XHHW-2	1	#1	XHHW-2	FR: EXISTING MCC-22 TO: HH-01 3 #4/0 >> MCC-65 POWER	P-65-003A
P-65-110	65E01 65E02 65E03	1.5"	1	3/C-#12:VFD	VFD			INTEGRAL	FR: 65-PMP-931 TO: MCC-65 1 3/C-#12:VFD >> 65-PMP-931 POWER	
P-65-120	65E01 65E02 65E03	1.5"	1	3/C-#12:VFD	VFD			INTEGRAL	FR: 65-PMP-932 TO: MCC-65 1 3/C-#12:VFD >> 65-PMP-932 POWER	
P-65-130	65E01 65E02 65E03	1.5"	1	3/C-#12:VFD	VFD			INTEGRAL	FR: 65-PMP-941 TO: MCC-65 1 3/C-#12:VFD >> 65-PMP-941 POWER	
P-65-140	65E01 65E02 65E03	1.5"	1	3/C-#12:VFD	VFD			INTEGRAL	FR: 65-PMP-942 TO: MCC-65 1 3/C-#12:VFD >> 65-PMP-942 POWER	
P-65-150	65E01	0.75"	5 2	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: 65-PMP-981 TO: CONDUIT TEE 3 #12 >> 65-PMP-981 POWER 2 #12 >> 65-ME-981 CONTROL 2 #14 >> 65-TE-981 CONTROL	P-65-152
P-65-151	65E01	0.75"	5 2	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: 65-PMP-982 TO: CONDUIT TEE 3 #12 >> 65-PMP-982 POWER 2 #12 >> 65-ME-982 CONTROL 2 #14 >> 65-TE-982 CONTROL	P-65-152
P-65-152	65E01	1"	10 4	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: J-BOX 3 #12 >> 65-PMP-981 POWER 2 #12 >> 65-ME-981 CONTROL 2 #14 >> 65-TE-981 CONTROL 3 #12 >> 65-PMP-982 POWER 2 #12 >> 65-ME-982 CONTROL 2 #14 >> 65-TE-982 CONTROL	P-65-153 P-65-150 P-65-150 P-65-150 P-65-151 P-65-151 P-65-151

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NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-65-153	65E01	1"	10 4	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: 65-VCP-980 3 #12 >> 65-PMP-981 POWER 2 #12 >> 65-ME-981 CONTROL 2 #14 >> 65-TE-981 CONTROL 3 #12 >> 65-PMP-982 POWER 2 #12 >> 65-ME-982 CONTROL 2 #14 >> 65-TE-982 CONTROL	P-65-152 P-65-152 P-65-152 P-65-152 P-65-152 P-65-152
P-65-154	65E01 65E02 65E03	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: 65-VCP-980 TO: MCC-65 3 #10 >> 65-VCP-980 POWER	
P-65-160	65E01	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: 65-FV-930A TO: 65-DISC-930A 3 #12 >> 65-FV-930A POWER	
P-65-161	65E01	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: 65-DISC-930A TO: CONDUIT TEE 3 #12 >> 65-FV-930A POWER	P-65-164
P-65-162	65E01	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: 65-FV-930B TO: 65-DISC-930B 3 #12 >> 65-FV-930B POWER	
P-65-163	65E01	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: 65-DISC-930B TO: CONDUIT TEE 3 #12 >> 65-FV-930B POWER	P-65-164
P-65-164	65E01 65E02 65E03	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: MCC-65 3 #12 >> 65-FV-930A POWER 3 #12 >> 65-FV-930B POWER	P-65-161 P-65-163
P-65-170	65E01	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: 65-FV-940A TO: 65-DISC-940A 3 #12 >> 65-FV-940A POWER	
P-65-171	65E01	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: 65-DISC-940A TO: CONDUIT TEE 3 #12 >> 65-FV-940A POWER	P-65-174
P-65-172	65E01	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: 65-FV-940B TO: 65-DISC-940B 3 #12 >> 65-FV-940B POWER	
P-65-173	65E01	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: 65-DISC-940B TO: CONDUIT TEE 3 #12 >> 65-FV-940B POWER	P-65-174
P-65-174	65E01 65E02 65E03	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: MCC-65 3 #12 >> 65-FV-940A POWER 3 #12 >> 65-FV-940B POWER	P-65-171 P-65-173
P-65-180	65E01 65E02 65E03	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: 65-VCP-930 TO: MCC-65 3 #10 >> 65-VCP-930 POWER	
P-65-181	65E01	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: 65-GDR-930 TO: 65-VCP-930 3 #10 >> 65-GDR-930 POWER	
P-65-190	65E01	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: 65-EUH-995 TO: 65-DSIC-995 3 #12 >> 65-EUH-995 POWER	
P-65-191	65E01	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: 65-DISC-995 TO: CONDUIT TEE 3 #12 >> 65-EUH-995 POWER	P-65-194
P-65-192	65E01	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: 65-EUH-996 TO: 65-DSIC-996 3 #12 >> 65-EUH-996 POWER	
P-65-193	65E01	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: 65-DISC-996 TO: CONDUIT TEE 3 #12 >> 65-EUH-996 POWER	P-65-194
P-65-194	65E01 65E02	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: MCC-65 3 #12 >> 65-EUH-995 POWER 3 #12 >> 65-EUH-996 POWER	P-65-191 P-65-193

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NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-65-195	65E03	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: 65-SF-997 TO: 65-DSIC-997 3 #12 >> 65-SF-997 POWER	
P-65-196	65E03	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: 65-DISC-997 TO: MCC-65 3 #12 >> 65-SF-997 POWER	
P-65-250	65E03 66E01	2"	10	#12	XHHW-2	1	#12	XHHW-2	FR: EXISTING THICKENERS PULLBOX TO: MCC-65 3 #12 >> THU-921 POWER 2 #12 >> MWH-921 POWER 3 #12 >> THU-921 POWER 2 #12 >> MWH-921 POWER	
P-65-300	66E03	2"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EXISTING VCP-971 TO: HH-01 3 #10 >> EXISTING VCP-971 POWER	
P-65-310	66E02	2"	3 2	#12 #14	XHHW-2 XHHW-2	1	#10	XHHW-2	FR: EXISTING RECYLED DECANT PS HANDHOLE TO: HH-01 3 #12 >> RDP-922 POWER 2 #14 >> XSH-992 CONTROL	
P-65-001A	01E01 65E03	2"	3	#4/0	XHHW-2	1	#1	XHHW-2	FR: HH-01 TO: 65-PB-01 3 #4/0 >> MCC-65 POWER	P-65-001B P-65-001
P-65-001B	65E03	2"	3	#4/0	XHHW-2	1	#1	XHHW-2	FR: 65-PB-01 TO: MCC-65 3 #4/0 >> MCC-65 POWER	P-65-001A
P-65-002A	01E01 65E03	2"	3	#4/0	XHHW-2	1	#1	XHHW-2	FR: HH-01 TO: 65-PB-01 3 #4/0 >> MCC-65 POWER	P-65-002B P-65-002
P-65-002B	65E03	2"	3	#4/0	XHHW-2	1	#1	XHHW-2	FR: 65-PB-01 TO: MCC-65 3 #4/0 >> MCC-65 POWER	P-65-002A
P-65-003A	01E01 65E03	2"	3	#4/0	XHHW-2	1	#1	XHHW-2	FR: HH-01 TO: 65-PB-01 3 #4/0 >> MCC-65 POWER	P-65-003B P-65-003
P-65-003B	65E03	2"	3	#4/0	XHHW-2	1	#1	XHHW-2	FR: 65-PB-01 TO: MCC-65 3 #4/0 >> MCC-65 POWER	P-65-003A
P-65-300A	01E01 65E03	2"	3	#10	XHHW-2	1	#10	XHHW-2	FR: HH-01 TO: 65-PB-01 3 #10 >> EXISTING VCP-971 POWER	
P-65-300B	65E03	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: 65-PB-01 TO: MCC-65 3 #10 >> EXISTING VCP-971 POWER	
P-65-310A	01E01 65E03	2"	3 2	#12 #14	XHHW-2 XHHW-2	1	#10	XHHW-2	FR: HH-01 TO: 65-PB-01 3 #12 >> RDP-922 POWER 2 #14 >> XSH-992 CONTROL	
P-65-310B	65E03	0.75"	3 2	#12 #14	XHHW-2 XHHW-2	1	#10	XHHW-2	FR: 65-PB-01 TO: MCC-65 3 #12 >> RDP-922 POWER 2 #14 >> XSH-992 CONTROL	
S-65-101	65E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: 65-LCP-931 TO: J-BOX 1 2/CS-#16 >> 65-LCP-931 SIGNAL	S-65-105
S-65-102	65E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: 65-LCP-932 TO: J-BOX 1 2/CS-#16 >> 65-LCP-932 SIGNAL	S-65-105
S-65-103	65E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: 65-LCP-941 TO: J-BOX 1 2/CS-#16 >> 65-LCP-941 SIGNAL	S-65-105
S-65-104	65E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: 65-LCP-942 TO: J-BOX 1 2/CS-#16 >> 65-LCP-942 SIGNAL	S-65-105

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CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
S-65-105	65E01 65E02 65E03	1"	4	2/CS-#16		1	#14	XHHW-2	FR: J-BOX TO: MCC-65 1 2/CS-#16 >> 65-LCP-931 SIGNAL 1 2/CS-#16 >> 65-LCP-932 SIGNAL 1 2/CS-#16 >> 65-LCP-941 SIGNAL 1 2/CS-#16 >> 65-LCP-942 SIGNAL	S-65-101 S-65-102 S-65-103 S-65-104
S-65-110	65E02	0.75"	2	MFR	CABLE	1	#14	XHHW-2	FR: 65-FE-930 TO: CONDUIT TEE 2 MFR >> 65-FE-930 SIGNAL	S-65-112
S-65-111	65E02	0.75"	2	MFR	CABLE	1	#14	XHHW-2	FR: 65-FE-934 TO: CONDUIT TEE 2 MFR >> 65-FE-934 SIGNAL	S-65-112
S-65-112	65E02	1"	4	MFR	CABLE	1	#14	XHHW-2	FR: 65-FE-930 TO: CONDUIT TEE 2 MFR >> 65-FE-930 SIGNAL 2 MFR >> 65-FE-934 SIGNAL	S-65-114 S-65-110 S-65-111
S-65-113	65E02	0.75"	2	MFR	CABLE	1	#14	XHHW-2	FR: 65-FE-921 TO: CONDUIT TEE 2 MFR >> 65-FE-921 SIGNAL	S-65-114
S-65-114	65E02	1.5"	6	MFR	CABLE	1	#14	XHHW-2	FR: 65-FE-930 TO: CONDUIT TEE 2 MFR >> 65-FE-930 SIGNAL 2 MFR >> 65-FE-934 SIGNAL 2 MFR >> 65-FE-921 SIGNAL	S-65-116 S-65-112 S-65-113
S-65-115	65E02	0.75"	2	MFR	CABLE	1	#14	XHHW-2	FR: 65-FE-922 TO: CONDUIT TEE 2 MFR >> 65-FE-922 SIGNAL	S-65-116
S-65-116	65E01 65E02	1.5"	8	MFR	CABLE	1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 2 MFR >> 65-FE-930 SIGNAL 2 MFR >> 65-FE-934 SIGNAL 2 MFR >> 65-FE-921 SIGNAL 2 MFR >> 65-FE-922 SIGNAL	S-65-114 S-65-114 S-65-114 S-65-115
S-65-117	65E01	1"	2 2	MFR 2/CS-#16	CABLE	1	#14	XHHW-2	FR: 65-FIT-921 TO: J-BOX 2 2/CS-#16 >> 65-FIT-921 SIGNAL 2 MFR >> 65-FE-921 SIGNAL	S-65-121
S-65-118	65E01	1"	2 2	MFR 2/CS-#16	CABLE	1	#14	XHHW-2	FR: 65-FIT-922 TO: J-BOX 2 2/CS-#16 >> 65-FIT-922 SIGNAL 2 MFR >> 65-FE-922 SIGNAL	S-65-121
S-65-119	65E01	1"	2 2	MFR 2/CS-#16	CABLE	1	#14	XHHW-2	FR: 65-FIT-930 TO: J-BOX 2 2/CS-#16 >> 65-FIT-930 SIGNAL 2 MFR >> 65-FE-930 SIGNAL	S-65-121
S-65-120	65E01	1"	2 2	MFR 2/CS-#16	CABLE	1	#14	XHHW-2	FR: 65-FIT-934 TO: J-BOX 2 2/CS-#16 >> 65-FIT-934 SIGNAL 2 MFR >> 65-FE-934 SIGNAL	S-65-121
S-65-121	65E01	2"	10	2/CS-#16		1	#14	XHHW-2	FR: J-BOX TO: PCM-910 2 2/CS-#16 >> 65-FIT-921 SIGNAL 2 2/CS-#16 >> 65-FE-921 SIGNAL 2 2/CS-#16 >> 65-FIT-922 SIGNAL 2 2/CS-#16 >> 65-FIT-930 SIGNAL 2 2/CS-#16 >> 65-FIT-934 SIGNAL	S-65-117 S-65-117 S-65-118 S-65-119 S-65-120
S-65-200	65E03	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: MCC-65(65-VFD-931) TO: CONDUIT TEE 2 2/CS-#16 >> 65-VFD-931 SIGNAL	S-65-202
S-65-201	65E03	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: MCC-65(65-VFD-932) TO: CONDUIT TEE 2 2/CS-#16 >> 65-VFD-932 SIGNAL	S-65-202
S-65-202	65E03	1"	4	2/CS-#16		1	#14	XHHW-2	FR: MCC-65(65-VFD-931) TO: CONDUIT TEE 2 2/CS-#16 >> 65-VFD-931 SIGNAL 2 2/CS-#16 >> 65-VFD-932 SIGNAL	S-65-204 S-65-200 S-65-201

June 2025

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NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
S-65-203	65E03	1"	4	2/CS-#16		1	#14	XHHW-2	FR: MCC-65(65-VFD-941/942) TO: CONDUIT TEE 2 2/CS-#16 >> 65-VFD-941 SIGNAL 2 2/CS-#16 >> 65-VFD-942 SIGNAL	S-65-204
S-65-204	65E03	1.5"	8	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-910 2 2/CS-#16 >> 65-VFD-931 SIGNAL 2 2/CS-#16 >> 65-VFD-932 SIGNAL 2 2/CS-#16 >> 65-VFD-941 SIGNAL 2 2/CS-#16 >> 65-VFD-942 SIGNAL	S-65-202 S-65-202 S-65-203 S-65-203
S-65-250	65E03 66E01	2"	2	2/CS-#16		1	#14	XHHW-2	FR: EXISTING THICKENERS PULLBOX TO: PCM-910 1 2/CS-#16 >> THICKENER NO.1 LIT-921 SIGNAL 1 2/CS-#16 >> THICKENER NO.2 LIT-922 SIGNAL	
X-65-004	65E03	2"	1	PULL	ROPE				FR: HH-01 TO: 65-PB-01 1 PULL >> SPARE	
X-65-301	66E03	2"	1	PULL	ROPE				FR: STUB UP AT CENTRATE PS TO: HH-01 1 PULL >> SPARE	
X-65-302	66E03	2"	1	PULL	ROPE				FR: STUB UP AT CENTRATE PS TO: HH-01 1 PULL >> SPARE	
X-65-303	01E01 65E03	2"	1	PULL	ROPE				FR: HH-01 TO: 65-PB-01 1 PULL >> SPARE	
X-65-311	66E02	2"	1	PULL	ROPE		#10		FR: EXISTING RECYLED DECANT PS HANDHOLE TO: HH-01 1 PULL >> SPARE (RDP-991 CONTROL)	
X-65-312	66E02	2"	1	PULL	ROPE		#10		FR: EXISTING RECYLED DECANT PS HANDHOLE TO: HH-01 1 PULL >> SPARE (RDP-991 POWER)	
X-65-320	66E04	2"	1	PULL	ROPE		#12		FR: STUB UP AT UNDER DRAIN PUMP STATION TO: HH-01 1 PULL >> SPARE(UNDER DRAIN PUMPS POWER)	
X-65-321	66E04	2"	1	PULL	ROPE				FR: STUB UP AT UNDER DRAIN PUMP STATION TO: HH-01 1 PULL >> SPARE(UNDER DRAIN PUMPS POWER)	
X-65-323	66E04	2"	4	#14	XHHW-2	1	#2	XHHW-2	FR: UNDER DRAIN PUMP STATION FLOATS TO: HH-01 2 #14 >> LSHHB-1311 CONTROL 2 #14 >> LSHB-1311 CONTROL	
X-65-004A	65E03	2"	1	PULL	ROPE				FR: 65-PB-01 TO: STUB UP AT ELECTRICAL ROOM 1 PULL >> SPARE	
X-65-303A	01E01 65E03	0.75"	1	PULL	ROPE				FR: 65-PB-01 TO: STUB UP AT ELECTRICAL ROOM 1 PULL >> SPARE	
X-65-311A	01E01 65E03	2"	1	PULL	ROPE		#10		FR: HH-01 TO: 65-PB-01 1 PULL >> SPARE (RDP-991 CONTROL)	
X-65-311B	65E03	0.75"	1	PULL	ROPE		#10		FR: 65-PB-01 TO: MCC-65 1 PULL >> SPARE (RDP-991 CONTROL)	
X-65-312A	01E01 65E03	2"	1	PULL	ROPE		#10		FR: HH-01 TO: 65-PB-01 1 PULL >> SPARE (RDP-991 POWER)	
X-65-312B	65E03	0.75"	1	PULL	ROPE		#10		FR: 65-PB-01 TO: MCC-65 1 PULL >> SPARE (RDP-991 POWER)	
X-65-320A	01E01 65E03	2"	1	PULL	ROPE		#12		FR: HH-01 TO: 65-PB-01 1 PULL >> SPARE(UNDER DRAIN PUMPS POWER)	

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NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE		
X-65-320B	65E03	0.75"	1	PULL	ROPE		#12		FR: 65-PB-01 TO: MCC-65 1 PULL >> SPARE(UNDER DRAIN PUMPS POWER)	
X-65-321A	66E04	2"	1	PULL	ROPE				FR: HH-01 TO: MCC-65 1 PULL >> SPARE(UNDER DRAIN PUMPS POWER)	
X-65-321B	66E04	0.75"	1	PULL	ROPE				FR: 65-PB-01 TO: MCC-65 1 PULL >> SPARE(UNDER DRAIN PUMPS POWER)	
X-65-323A	66E04	2"	4	#14	XHHW-2	1	#2	XHHW-2	FR: HH-01 TO: 65-PB-01 2 #14 >> LSHHB-1311 CONTROL 2 #14 >> LSHB-1311 CONTROL	
X-65-323B	66E04	0.75"	4	#14	XHHW-2	1	#2	XHHW-2	FR: 65-PB-01 TO: PCM-910 2 #14 >> LSHHB-1311 CONTROL 2 #14 >> LSHB-1311 CONTROL	
C-67-001	67E01	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: 65-LCP-981 TO: CONDUIT TEE 6 #14 >> 65-LCP-981 CONTROL	C-67-003
C-67-002	67E01	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: 65-LCP-982 TO: CONDUIT TEE 6 #14 >> 65-LCP-982 CONTROL	C-67-003
C-67-003	65E03 67E01	2"	12	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: 65-PB-02 6 #14 >> 65-LCP-981 CONTROL 6 #14 >> 65-LCP-982 CONTROL	C-67-003A C-67-001 C-67-002
C-67-003A	65E03	1"	12	#14	XHHW-2	1	#14	XHHW-2	FR: 65-PB-02 TO: PCM-910 6 #14 >> 65-LCP-981 CONTROL 6 #14 >> 65-LCP-982 CONTROL	C-67-003 C-67-003
L-67-001	65E03 67E01	2"	2 2	#10 #12	XHHW-2 XHHW-2	1	#10	XHHW-2	FR: J-BOX TO: 65-PB-02 2 #12 >> HOMOGENIZATION TANK LIGHTS 2 #10 >> HOMOGENIZATION TANK RECEPTACLE	
L-67-001A	65E03	1"	2 2	#10 #12	XHHW-2 XHHW-2	1	#10	XHHW-2	FR: 65-PB-02 TO: MCC-65(65-PNL-01) 2 #12 >> HOMOGENIZATION TANK LIGHTS 2 #10 >> HOMOGENIZATION TANK RECEPTACLE	
P-67-001	67E01	0.75"	3 2 2	#10 #12 #14	XHHW-2 XHHW-2 XHHW-2	1	#10	XHHW-2	FR: 65-MIX-981 TO: 65-DISC-981 3 #10 >> 65-MIX-981 POWER 2 #12 >> 65-MVH-981 CONTROL 2 #14 >> 65-TSH-981 CONTROL	
P-67-002	67E01	0.75"	3 2 2	#10 #12 #14	XHHW-2 XHHW-2 XHHW-2	1	#10	XHHW-2	FR: 65-MIX-982 TO: 65-DISC-982 3 #10 >> 65-MIX-982 POWER 2 #12 >> 65-MVH-982 CONTROL 2 #14 >> 65-TSH-982 CONTROL	
P-67-001A	65E01 67E01	2"	3 2 2	#10 #12 #14	XHHW-2 XHHW-2 XHHW-2	1	#10	XHHW-2	FR: 65-DISC-981 TO: 65-PB-02 3 #10 >> 65-MIX-981 POWER 2 #12 >> 65-MVH-981 CONTROL 2 #14 >> 65-TSH-981 CONTROL	
P-67-001B	65E03	1"	3 2 2	#10 #12 #14	XHHW-2 XHHW-2 XHHW-2	1	#10	XHHW-2	FR: 65-PB-02 TO: MCC-65 3 #10 >> 65-MIX-981 POWER 2 #12 >> 65-MVH-981 CONTROL 2 #14 >> 65-TSH-981 CONTROL	
P-67-002A	65E03 67E01	2"	3 2 2	#10 #12 #14	XHHW-2 XHHW-2 XHHW-2	1	#10	XHHW-2	FR: 65-DISC-982 TO: 65-PB-02 3 #10 >> 65-MIX-982 POWER 2 #12 >> 65-MVH-982 CONTROL 2 #14 >> 65-TSH-982 CONTROL	

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CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-67-002B	65E03	0.75"	3 2 2	#10 #12 #14	XHHW-2 XHHW-2 XHHW-2	1	#10	XHHW-2	FR: 65-PB-02 TO: MCC-65 3 #10 >> 65-MIX-982 POWER 2 #12 >> 65-MWH-982 CONTROL 2 #14 >> 65-TSH-982 CONTROL	
S-67-001	67E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: 65-LE-981 TO: 65-LIT-981 1 2/CS-#16 >> 65-LE-981 SIGNAL	
S-67-002	67E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: 65-LE-982 TO: 65-LIT-981 1 2/CS-#16 >> 65-LE-982 SIGNAL	
S-67-003	67E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: 65-LIT-981 TO: CONDUIT TEE 1 2/CS-#16 >> 65-LIT-981 SIGNAL	S-67-005
S-67-004	67E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: 65-LIT-982 TO: CONDUIT TEE 1 2/CS-#16 >> 65-LIT-982 SIGNAL	S-67-005
S-67-005	65E03 67E01	2"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: 65-PB-02 1 2/CS-#16 >> 65-LIT-981 SIGNAL 1 2/CS-#16 >> 65-LIT-982 SIGNAL	S-67-005A S-67-003 S-67-004
S-67-005A	65E03	1"	2	2/CS-#16		1	#14	XHHW-2	FR: 65-PB-02 TO: PCM-910 1 2/CS-#16 >> 65-LIT-981 SIGNAL 1 2/CS-#16 >> 65-LIT-982 SIGNAL	S-67-005 S-67-005
X-67-006	65E03 67E01	2"	1	PULL	ROPE				FR: STUB UP AT HOMEGENIZATION TANK AREA TO: 65-PB-02 1 PULL >> SPARE	
X-67-007	65E03 67E01	2"	1	PULL	ROPE				FR: STUB UP AT HOMEGENIZATION TANK AREA TO: 65-PB-02 1 PULL >> SPARE	
X-67-008	65E03 67E01	2"	1	PULL	ROPE				FR: STUB UP AT HOMEGENIZATION TANK AREA TO: 65-PB-02 1 PULL >> SPARE	
X-67-009	65E03 67E01	2"	1	PULL	ROPE				FR: STUB UP AT HOMEGENIZATION TANK AREA TO: 65-PB-02 1 PULL >> SPARE	
X-67-006A	65E03	1"	1	PULL	ROPE				FR: 65-PB-02 TO: PCM-910 1 PULL >> SPARE	
X-67-007A	65E03	1"	1	PULL	ROPE				FR: 65-PB-02 TO: MCC-65 1 PULL >> SPARE	
X-67-008A	65E03	1"	1	PULL	ROPE				FR: 65-PB-02 TO: MCC-65 1 PULL >> SPARE	
X-67-009A	65E03	1"	1	PULL	ROPE				FR: 65-PB-02 TO: STUB UP AT ELECTRICAL ROOM 1 PULL >> SPARE	
D3005	01E01 70E01	2"	1	PULL	ROPE				FR: HH-01 TO: DEWATERING BUILDING (LP-221 & LP-222) 1 PULL >> SPARE	
D1045	01E01 70E01	0.75"	1	PULL	ROPE				FR: HH-01 TO: DEWATERING BUILDING (MCC-22) 1 PULL >> SPARE	
D1047	01E01 70E01	0.75"	1	PULL	ROPE				FR: HH-01 TO: DEWATERING BUILDING (MCC-22) 1 PULL >> SPARE	
D1049	01E01 70E01	1.5"	1	PULL	ROPE				FR: HH-01 TO: DEWATERING BUILDING (MCC-22) 1 PULL >> SPARE	
D4078	01E01 70E01	2"	1	PULL	ROPE				FR: HH-01 TO: DEWATERING BUILDING (VCP-900) 1 PULL >> SPARE	

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CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
D4152	01E01 70E01	2"	1	PULL	ROPE				FR: HH-01 TO: DEWATERING BUILDING (VCP-900) 1 PULL >> SPARE	
D4164	01E01 70E01	2"	1	PULL	ROPE				FR: HH-01 TO: DEWATERING BUILDING (VCP-900) 1 PULL >> SPARE	
D4165	01E01 70E01	2"	1	PULL	ROPE				FR: HH-01 TO: DEWATERING BUILDING 1 PULL >> SPARE	
D4166	01E01 70E01	1"	1	PULL	ROPE				FR: HH-01 TO: DEWATERING BUILDING (VCP-900) 1 PULL >> SPARE	

END OF CONDUIT SCHEDULE

END OF SECTION

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FIELD ELECTRICAL ACCEPTANCE TESTS

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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. Project references:
 - 1. Specification sections for the electrical equipment being tested.
 - 2. Electrical equipment Shop Drawings.
- B. Standards:
 - 1. American National Standards Institute (ANSI).
 - 2. ASTM International (ASTM):
 - a. D877 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
 - b. D923 - Standard Practices for Sampling Electrical Insulating Liquids.
 - c. D924 - Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
 - d. D971 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
 - e. D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
 - f. D1298 - Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
 - g. D1500 - Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
 - h. D1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field.
 - i. D1533 - Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
 - j. D1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
 - k. D3612 - Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.
 - 3. Institute of Electrical and Electronics Engineers (IEEE):
 - a. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
 - b. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
 - c. 95 - IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2,300 V and Above) With High Direct Voltage.

- d. 421.3 - IEEE Standard for High-Potential Test Requirement for Excitation Systems for Synchronous Machines.
- e. 450 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
- f. 1106 - IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.
- g. 1188 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.
- h. C57.13 - IEEE Standard Requirements for Instrument Transformers.
- i. C57.13.1 - IEEE Guide for Field Testing of Relaying Current Transformers.
- j. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
- k. C57.104 - IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.
- 4. Insulated Cable Engineer's Association (ICEA).
- 5. InterNational Electrical Testing Association (NETA).
 - a. ATS- Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- 6. International Electrotechnical Commission (IEC).
- 7. National Electrical Manufacturers Association (NEMA):
 - a. MG1 - Motors and Generators.
- 8. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
 - b. 110 - Standard for Emergency and Standby Power Systems.
- 9. National Institute of Standards and Technology (NIST).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Testing laboratory: Organization performing the acceptance tests.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Copper Ethernet test form:
 - 1. Cable test reports:
 - a. Submit 3 copies of test reports showing the results of all tests specified in this Section:
 - 1) Test type.
 - 2) Test location.
 - 3) Test date.
 - 4) Cable number.
 - 5) Cable length.
 - 6) Certification that the cable meets or exceeds the specified standard.
 - b. Furnish hard copy and electronic copy for all traces.

- C. Manufacturers' testing procedures:
 - 1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer prior to beginning testing.
- D. Test report:
 - 1. Include the following:
 - a. Summary of Project.
 - b. Description of equipment tested.
 - c. Description of tests performed.
 - d. Test results.
 - e. Conclusions and recommendations.
 - f. Completed test forms.
 - g. List of test equipment used and calibration dates.
 - h. LAN cable test reports.
- E. Test data records:
 - 1. Include the following:
 - a. Identification of the testing organization.
 - b. Equipment identification.
 - c. Nameplate data.
 - d. Humidity, temperature and or other conditions that may affect the results of the tests and or calibrations.
 - e. Dates of inspections, tests, maintenance and or calibrations.
 - f. Indication of the inspections, tests, maintenance, and or calibrations to be performed and recorded.
 - g. Expected results when calibrations are to be performed.
 - h. Indication of as-found and as-left results as applicable.
 - i. Indication of test results outside specified tolerances.
- F. Testing laboratory qualifications:
 - 1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
 - a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
 - 1) Corporate history and references.
 - 2) Resume of individual performing test.
 - 3) Equipment list and test calibration data.
- G. Division of responsibilities:
 - 1. Submit a list identifying who is responsible for performing each portion of the testing.

1.06 QUALITY ASSURANCE

- A. Testing laboratory qualifications:
 - 1. 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 HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. General requirements:
1. Testing of electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.
 2. Conduct tests in the presence of the Engineer or the Engineer's representative:
 - a. Engineer will witness visual, mechanical, and electrical tests, and inspections.
 3. Testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.
- B. Responsibilities:
1. Contractor responsibilities:
 - a. Ensure that resources are made available for testing and that 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 acceptance tests specified in this Section.
 - b. Provide required equipment, materials, labor, and technical support during acceptance tests.
- C. Sequencing:
1. Prior to testing:
 - 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 equipment to be tested.
 2. Perform testing in the following sequence:
 - a. Perform routine tests as the equipment is installed, including:
 - 1) Insulation-resistance tests.
 - 2) Continuity tests.

- 3) Rotational tests.
- b. Adjusting and preliminary calibration.
- c. Acceptance tests.
- d. Demonstration.
- e. Commissioning and plant start-up.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

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 applicable test instrumentation within rated accuracy.
 - a. Calibrating standard shall be of better accuracy than that of the equipment tested.
 - 2. 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 test equipment.
 - 5. Maintain an up-to-date instrument calibration record for each test instrument:
 - a. 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. Requirements prior to testing:
 - 1. Do not begin testing until the following conditions have been met:
 - a. Instruments required are available and in proper operating condition.
 - b. Required dispensable materials such as solvents, rags, and brushes are available.
 - c. Equipment handling devices such as cranes, vehicles, chain falls, and other lifting equipment are available or scheduled.
 - d. Instruction books, calibration curves, or other printed material to cover the electrical devices are available.
 - e. Datasheets to record test results are available.

3.03 INSTALLATION

- A. Test decal:
 - 1. Testing laboratory shall affix a test decal on the exterior of equipment or equipment enclosure of protective devices after performing electrical tests.
 - 2. Color coded to communicate the condition of maintenance of the protective. 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. Shall include the following information at a minimum:
 - a. Testing organization.
 - b. Project identifier.
 - c. Test date.
 - d. Technician identifier.

3.04 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning.
- B. Functional Testing:
 - 1. Also called Field Acceptance Testing.
- C. Panelboards:
 - 1. Cleaning:
 - a. Visually inspect panelboard for evidence of discoloration, abnormal dust accumulation, metal shards, or any other indication of overheating, wear, or other abnormal conditions prior to cleaning.
 - b. Clean cabinet with a brush, vacuum cleaner, or clean, dry, lint-free rags to remove any accumulation of dust, dirt, or other foreign matter. Do not use liquids, solvents or detergents when cleaning panelboards or components.
 - c. Avoid blowing dust into panelboards. Do not use a blower or compressed air.
 - d. Clean supports, terminals, and other major insulating surfaces with clean, dry, lint-free rags or soft bristled brushes.
 - e. Remove dust, soot, grease, moisture, and foreign material from surface of circuit breakers.
 - 2. General:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Check panelboard circuit schedule for accuracy.
 - c. Verify appropriate anchorage, required area clearances, and correct alignment.
 - d. Inspect overall general condition for physical damage.
 - 1) Check for broken studs and loose or damaged wires, connector, terminations, etc.
 - 2) Check bolts, nuts, washer, and pins for tightness.
 - 3) Tighten or use manufacturer's replacement parts as required.
 - e. Inspect cabinets for signs of rust, corrosion, or deteriorating paint. Inspect cabinets for evidence of localized heat damage to the paint. Investigate sources of heat. Repair painted surfaces.

- f. Check that covers are in place and fastened. Plug any open unused knockouts.
 - g. Inspect panelboard for moisture. Seal off any cracks or openings which have allowed moisture to enter the cabinet. Inspect component devices. Replace any components that show evidence of damage from moisture.
 - h. Look for any recent changes in sprinklers or other plumbing that might expose indoor panelboards to a source of liquids. Eliminate sources of water, moisture, or liquids, or provide adequate barriers to protect panelboards from sources of water, moisture, or liquids.
 - i. Inspect panelboards and internal components for evidence of overheating, arc spatter, sooty deposits, and tracking.
 - 1) Investigate and correct sources of arcing or overheating.
 - 2) Consult the panelboard manufacturer for recommendations.
 - j. Verify that fuse and/or circuit breaker sizes and types correspond to record drawings, if available, as well as to the circuit breakers' address for microprocessor communications packages, if equipped.
 - k. Set adjustable circuit breakers in accordance with engineering coordination study supplied by the Contractor.
3. Terminations, connections, and lugs:
- a. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - a) Compare bolted connection resistance values to values of similar connections:
 - (1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - b. Inspect terminations, connection, and lugs for alignment, physical damage, burns, corrosion, discoloration, flaking, heat damage, arcing, pitting, melting, deterioration, carbonization, cracks, chips, breaks, partial discharge, or moisture. Investigate and eliminate sources of any damage.
 - c. Follow manufacturer recommendations for cleaning, repairing, and replacing damaged parts.
 - d. Replace overheated connections. Tighten connections to proper torque levels as specified above.
4. Conductors and raceways:
- a. Inspect supply conductors and terminations for overheating, discoloration, and oxidation. Investigate and correct any deficiencies.
 - b. Ensure the conductors are protected within their ampacities.
 - c. Visually check panelboard, cables, and raceways for proper bonding and grounding. Correct improper bonding and grounding.
 - d. Inspect conductors for discoloration, arcing, pitting, melting, flaking of insulation and/or metal parts. Repair or replace damaged components in accordance with the manufacturer's recommendations.
 - e. Inspect for frayed or broken wires. Replace or repair damaged components in accordance with manufacturer recommendations.
 - f. Inspect for frayed or broken wires. Replace or repair conductors as necessary.

- g. Inspect conduits for moisture. Seal conduits which are a source of moisture and provide means to drain moisture away from the panelboard.
- 5. Circuit breakers:
 - a. Perform visual and mechanical inspection as specified in this Section.
 - b. Operate several times in order to exercise the mechanisms and the contacts, and to ensure smooth operation. Do not oil or grease parts of molded case circuit breakers.
 - c. Visually check for evidence of overheating and thermal damage. Investigate and eliminate sources of overheating.
 - d. Check for visual defects, chipping, cracks, breaks, burns, and deterioration. Replace damaged circuit breakers.
 - e. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.
 - f. Inspect interchangeable trip-unit circuit breakers for tightness of trip units.
 - g. Check terminals and connections for tightness as specified above.
 - h. Breakers rated 100 A and higher:
 - 1) Perform electrical tests as specified in this Section.
- D. Dry type transformers:
 - 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify that resilient mounts are free and that any shipping brackets have been removed.
 - e. Inspect equipment for cleanliness.
 - f. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - g. Verify that as-left tap connections are as specified.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
 - 1) Apply voltage in accordance with the manufacturer's published data.
 - a) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Calculate dielectric absorption ration or polarization index.
 - d. Perform turns ratio tests at all tap positions.
 - e. Verify correct secondary voltage, phase-to-phase and phase-to-neutral after energization and before loading.

3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Tap connections are left as found unless otherwise specified.
 - d. Minimum insulation-resistance values of transformer insulation shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate insulation values less than the allowable minimum.
 - e. Dielectric absorption ratio or polarization index shall not be less than 1.0.
 - f. Turns-ratio results should not deviate more than 1/2 percent from either the adjacent coils or calculated ratio.
 - g. Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.
- E. Low voltage cables, 600 volt maximum:
 1. Visual and mechanical inspection:
 - a. Compare cable data with the Drawings and Specifications.
 - b. Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.
 - c. Inspect bolted electrical connections for high resistance by one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - d. Inspect compression applied connectors for correct cable match and indentation.
 - e. Inspect for correct identification and arrangement.
 - f. Inspect cable jacket insulation and condition.
 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation resistance test on each conductor sized #8 AWG or larger with respect to ground and adjacent conductors:
 - 1) Applied potential shall be 500 volts DC for 300-volt rated cable and 1,000 volts DC for 600-volt rated cable.
 - 2) Test duration shall be 1 minute.
 - c. Perform continuity tests on power and control conductors to ensure correct cable connection.
 - d. Verify uniform resistance of parallel conductors.

3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Insulation-resistance values shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate values of insulation-resistance less than the allowable minimum.
 - c. Cable shall exhibit continuity.
 - d. Deviations in resistance between parallel conductors shall be investigated.
- F. Low voltage molded case and insulated case circuit breakers:
 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage and alignment.
 - d. Verify the unit is clean.
 - e. Operate the circuit breaker to ensure smooth operation.
 - f. Inspect bolted electrical connections for high resistance by one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - g. Perform adjustments for final protective device settings in accordance with the coordination study.
 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. For breakers 100 A and higher:
 - 1) 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 the manufacturer's published data.
 - b) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Perform a contact/pole-resistance test.
 - 3) Determine long-time pickup and delay by primary current injection.
 - 4) Determine short-time pickup and delay by primary current injection.
 - 5) Determine ground-fault pickup and delay by primary current injection.
 - 6) Determine instantaneous pickup value by primary current injection.
 - 7) Test functions of the trip unit by means of secondary injection.
 - 8) Perform minimum pickup voltage tests on shunt trip and close coils in accordance with the 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 trip logs and indicators.
 - 10) Verify operation of charging mechanism.
 - 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Insulation-resistance values shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate values of insulation-resistance less than the allowable minimum.
 - d. Microhm or DC millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
 - 1) If the manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
 - e. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed the manufacturer's published time-current characteristic tolerance band, including adjustment factors:
 - 1) If the manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
 - f. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed the manufacturer's published time-current tolerance band.
 - g. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed the manufacturer's published time-current tolerance band.
 - h. Instantaneous pickup values shall be as specified and within the manufacturer's published tolerances:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - i. Pickup values and trip characteristics shall be within the manufacturer's published tolerances.
 - j. Determine energy reducing maintenance switch pickup value by primary current injection.
 - k. Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.
 - l. Charging mechanism shall operate in accordance with the manufacturer's published data.

G. Instrument transformers - current transformers:

- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.

- c. Verify correct connection of transformers with system requirements.
 - d. Verify that adequate clearances exist between primary and secondary circuit wiring.
 - e. Verify the unit is clean.
 - f. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - g. Verify that required grounding and shorting connections provide contact.
 - h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
2. Electrical tests:
- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1,000 VDC for 1 minute:
 - 1) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
 - c. Perform a polarity test of each current transformer in accordance with IEEE C57.13.1.
 - d. Perform a ratio verification test using the voltage or current method in accordance with IEEE C57.13.1.
 - e. Perform an excitation test on current transformers used for relaying applications in with accordance with IEEE C57.13.1.
 - f. Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1.
 - g. When applicable, perform insulation-resistance tests on the primary winding with the secondary grounded:
 - 1) Test voltages shall be in accordance with NETA ATS tables.
 - h. When applicable, perform dielectric withstand tests on the primary winding with the secondary grounded:
 - 1) Test voltages shall be in accordance with NETA ATS tables.
 - i. Perform power-factor or dissipation-factor tests in accordance with the test equipment manufacturer's published data.
 - j. Verify that current transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
 - 1) That grounding point should be located as specified by the Engineer in the Contract Documents.
3. Test values:
- a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.

- c. Insulation-resistance values of instrument transformers shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
- d. Polarity results shall agree with transformer markings.
- e. Ratio errors shall be in accordance with IEEE C57.13.
- f. Excitation results for current transformers shall match the curve supplied by the manufacturer or be in accordance with IEEE C57.13.1.
- g. Measured burdens shall be compared to instrument transformer ratings.
- h. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
- i. Power-factor or dissipation-factor values shall be compared to the manufacturer's published data:
 - 1) In the absence of the manufacturer's published data, use the test equipment manufacturer's published data.
- j. Test results shall indicate that the circuits have only 1 grounding point.

H. Instrument transformers - voltage transformers:

- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Verify correct connection of transformers with system requirements.
 - d. Verify that adequate clearances exist between primary and secondary circuit wiring.
 - e. Verify the unit is clean.
 - f. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - g. Verify that required grounding and connections provide contact.
 - h. Verify correct primary and secondary fuse sizes for voltage transformers.
 - i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - j. Perform as-left tests.
- 2. Electrical tests - voltage transformers:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests winding-to-winding and winding-to-ground:
 - 1) Test voltage shall be applied for 1 minute in accordance with NETA ATS requirements.
 - 2) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
 - c. Perform a polarity test on each voltage transformer to verify the polarity marks on H₁- X₁ relationship as applicable.
 - d. Perform a turns ratio test on all tap positions.
 - e. Measure voltage circuit burdens at transformer terminals.

- f. Perform a dielectric withstand test on the primary windings with the secondary windings grounded:
 - 1) Dielectric voltage shall be in accordance with NETA ATS tables.
 - 2) Apply the test voltage for 1 minute.
 - g. Perform power-factor or dissipation-factor tests in accordance with the test equipment manufacturer's published data.
 - h. Verify that voltage transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
 - 1) That grounding point should be located as specified by the Engineer in the Contract Documents.
 - 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Insulation-resistance values of instrument transformers shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - d. Polarity results shall agree with transformer markings.
 - e. Ratio errors shall be in accordance with IEEE C57.13.
 - f. Measured burdens shall be compared to instrument transformer ratings.
 - g. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
 - h. Power-factor or dissipation-factor values shall be compared to the manufacturer's published data:
 - 1) In the absence of the manufacturer's published data, use the test equipment manufacturer's published data.
 - i. Test results shall indicate that the circuits have only 1 grounding point.
- I. Metering devices, microprocessor based:
 - 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect meters and cases for physical damage.
 - c. Clean front panel.
 - d. Verify tightness of electrical connections.
 - e. Record the following:
 - 1) Model number.
 - 2) Serial number.
 - 3) Firmware revision.
 - 4) Software revision.
 - 5) Rated control voltage.
 - f. Verify operation of display and indicating devices.
 - g. Record passwords.
 - h. Verify the unit is grounded in accordance with the manufacturer's instructions.

- i. Set required parameters, including instrument transformer ratios, system type, frequency, power demand methods/intervals, and communications requirements.
 - 2. Electrical tests:
 - a. Apply voltage or current as appropriate to each analog input and verify correct measurement and indication.
 - b. Confirm correct operation and setting of each auxiliary input/output feature, including mechanical relay, digital and analog.
 - c. After initial system energization, confirm measurements and indications are consistent with loads present.
 - 3. Test values:
 - a. Nameplate data shall match the Contract Documents.
 - b. Tightness of electrical connections shall ensure a low resistance connection.
 - c. Display and indicating devices shall operate in accordance with the manufacturer's published data.
 - d. Measurement and indication of applied voltages and currents shall be within the manufacturer's published tolerances for accuracy.
 - e. Auxiliary input/output features shall operate in accordance with the settings and the manufacturer's published data.
 - f. Measure and indications shall be consistent with energized system loads.
- J. Grounding systems:
 - 1. Visual and mechanical inspection:
 - a. Inspect ground system for compliance with the Contract Documents and the NEC.
 - b. Inspect physical and mechanical condition.
 - c. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - d. Inspect anchorage.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.
 - c. Perform point-to-point tests to determine the resistance between the main grounding system and major electrical equipment frames, the system neutral and any derived neutral points.
 - 3. Test values:
 - a. Grounding system electrical and mechanical connections shall be free of corrosion.
 - b. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

- c. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - d. Resistance between the main grounding electrode and ground shall be as specified in Section 26_05_26 - Grounding and Bonding.
 - e. Investigate point-to-point resistance values that exceed 0.5 ohm.
- K. Rotating machinery, AC induction motors and generators:
- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate information with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging.
 - e. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - f. Perform special tests such as airgap spacing and machine alignment.
 - g. Manually rotate the rotor and check for problems with the bearings or shaft.
 - h. Rotate the shaft and measure and record the shaft extension runout.
 - i. Rotating equipment:
 - 1) Operate at rated design load conditions.
 - 2) Confirm that equipment is properly assembled.
 - 3) Confirm the equipment moves or rotates in the proper direction.
 - 4) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
 - 5) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
 - j. Verify correct application of appropriate lubrication and lubrication systems.
 - k. Verify that resistance temperature detector (RTD) circuits conform to that indicated on the Drawings.
 - 2. Electrical tests - AC induction:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance test in accordance with IEEE 43:
 - 1) On motors 200 horsepower and smaller, test duration shall be 1 minute. Calculate dielectric absorption ratio for 60/30-second periods.
 - 2) On motors larger than 200 horsepower, test duration shall be 10 minutes. Calculate polarization index.
 - c. On machines rated at 2,300 volts and greater, perform dielectric withstand voltage tests in accordance with:
 - 1) IEEE 95 for DC dielectric withstand voltage tests.
 - 2) NEMA MG1 for AC dielectric withstand voltage tests.
 - d. Perform phase-to-phase stator resistance test on machines rated at 2,300 volts and greater.

- e. Perform insulation power-factor or dissipation-factor tests.
 - f. Perform power-factor tip-up tests.
 - g. Perform surge comparison tests.
 - h. Perform insulation-resistance test on insulated bearings in accordance with the manufacturer's published data.
 - i. Test surge protection devices as specified in this Section.
 - j. Test motor starter as specified in this Section.
 - k. Perform resistance tests on resistance temperature detector (RTD) circuits.
 - l. Verify operation of motor space heater, if applicable.
 - m. Perform vibration test while machine is running under load.
3. Test values:
- a. Inspection:
 - 1) Air baffles shall be clean and installed in accordance with the manufacturer's published data.
 - 2) Filter media shall be clean and installed in accordance with the manufacturer's published data.
 - 3) Cooling fans shall operate.
 - 4) Slip ring alignment shall be within the manufacturer's published tolerances.
 - 5) Brush alignment shall be within the manufacturer's published tolerances.
 - 6) Brush rigging shall be within the manufacturer's published tolerances.
 - b. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - c. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - d. Airgap spacing and machine alignment shall be in accordance with the manufacturer's published data.
 - e. Recommended minimum insulation-resistance ($IR_{1 \min}$) test results in megohms shall be in accordance with NETA ATS tables.
 - 1) Polarization index value shall not be less than 2.0.
 - 2) Dielectric absorption ratio shall not be less than 1.4.
 - f. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
 - g. Investigate phase-to-phase stator resistance values that deviate by more than 5 percent.
 - h. Power factor or dissipation factor values shall be compared to the manufacturer's published data:
 - 1) In the absence of the manufacturer's published data, compare values of similar machines.
 - i. Tip-up values shall indicate no significant increase in power factor.
 - j. If no evidence of distress, insulation failure, or waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, the test specimen is considered to have passed the test.

- k. Bearing insulation-resistance measurements shall be within manufacturer's published tolerances:
 - 1) In the absence of the manufacturer's published data, compare values of similar machines.
 - l. Test results of surge protection devices shall be as specified in this Section.
 - m. Test results of motor starter equipment shall be as specified in this Section.
 - n. RTD circuits shall conform to the design intent and machine protection device manufacturer's published data.
 - o. Heaters shall be operational.
 - p. Vibration amplitudes of the uncoupled and unloaded machine shall be in accordance with the manufacturer's published data:
 - 1) In the absence of the manufacturer's published data, vibration amplitudes shall not exceed values in NETA ATS tables.
 - 2) If values exceed those in the NETA ATS tables, perform a complete vibration analysis.
- L. Motor starters, low voltage:
- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate information with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify the unit is clean.
 - e. Inspect contactors:
 - 1) Verify mechanical operation.
 - 2) Verify contact gap, wipe, alignment, and pressure is in accordance with the manufacturer's published data.
 - f. Motor-running protection:
 - 1) Verify overload element rating/motor protection settings are correct for its application.
 - 2) If motor running protection is provided by fuses, verify correct fuse rating.
 - g. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - h. Lubrication requirements:
 - 1) Verify appropriate lubrication on moving current-carrying parts.
 - 2) Verify appropriate lubrication on moving and sliding surfaces.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the starter closed, and across each open pole for 1 minute:
 - 1) Test voltage shall be in accordance with the manufacturer's published data.
 - 2) Refer to NETA ATS tables in the absence of the manufacturer's published data.

- c. Test motor protection devices in accordance with the manufacturer's published data.
- d. Test circuit breakers as specified in this Section.
- e. Perform operational tests by initiating control devices.
- 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Insulation-resistance values shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate values of insulation-resistance less than the allowable minimum.
 - d. Motor protection parameters shall be in accordance with the manufacturer's published data.
 - e. Circuit breaker test results shall as be specified in this Section.
 - f. Control devices shall perform in accordance with system design requirements.
- M. Motor control centers, low voltage:
 - 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding and required clearances.
 - d. Verify the unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
 - e. Verify that circuit breaker/fuse sizes and types correspond to the approved Submittals and the coordination study.
 - f. Verify that current and voltage transformer ratios correspond to those indicated on the Drawings.
 - g. Verify that wiring connections are tight and that wiring is secure to prevent damage during routine operation of moving parts.
 - h. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - i. Verify operation and sequencing of interlocking systems:
 - 1) Attempt closure on locked-open devices.
 - 2) Attempt to open locked-closed devices.
 - 3) Make/attempt key-exchanges in all positions.
 - j. Lubrication requirements:
 - 1) Verify appropriate lubrication on moving current-carrying parts.

- 2) Verify appropriate lubrication on moving and sliding surfaces.
- k. Inspect insulators for evidence of physical damage or contaminated surfaces.
- l. Verify correct barrier and shutter installation and operation.
- m. Exercise active components.
- n. Inspect indicating devices for correct operation.
- o. Verify that filters are in place and/or vents are clear.
- p. Perform visual and mechanical inspection of instrument transformers as specified in this Section.
- q. Perform visual and mechanical inspection of surge arresters as specified in this Section.
- r. Inspect control power transformers:
 - 1) Inspect for physical damage, cracked insulation, broken leads, and tightness of connections, defective wiring, and overall general condition.
 - 2) Verify that primary and secondary fuse/circuit breaker ratings match the Submittal Drawings.
 - 3) Verify correction functioning of grounding contacts.
- s. Perform visual and mechanical inspection of motor control center components as specified in this Section.
- 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute:
 - 1) Perform test in accordance with NETA ATS tables.
 - c. Perform a dielectric withstand test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with the manufacturer's published data or NETA ATS tables. Apply the test voltage for 1 minute.
 - d. Perform ground-resistance tests:
 - 1) Perform point-to-point tests to determine the resistance between the main grounding system and major electrical equipment frames, system neutral and derived neutral points.
 - e. Control power transformers:
 - 1) Perform insulation-resistance tests, winding-to-winding and winding-to-ground:
 - a) Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.
 - 2) Perform secondary wiring integrity test:
 - a) Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:
 - (1) Verify correct potential at all devices.
 - 3) Verify correct secondary voltage by energizing primary winding with system voltage:
 - a) Measure secondary voltage with the secondary wiring disconnected.
 - f. Verify operation of space heaters.
 - g. Perform electrical tests of motor control center components as specified in this Section.

3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Insulation-resistance values for bus and control power transformers shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate insulation values less than the allowable minimum.
 - 3) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
 - d. Bus insulation shall withstand the over potential test voltage applied.
 - e. Instrument transformer test values shall be as specified in this Section.
 - f. Investigate grounding system point-to-point resistance values that exceed 0.5 ohm.
 - g. Meter accuracy shall be in accordance with the manufacturer's published data.
 - h. Control power transformers:
 - 1) Insulation-resistance values of control power transformers shall be in accordance with the manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - b) Investigate insulation values less than the allowable minimum.
 - c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
 - 2) Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.
 - 3) Secondary voltage shall be as indicated on the Drawings.
 - i. Heaters shall be operational.
 - j. Test values for motor control center components shall be as specified in this Section.

N. Variable frequency drive systems:

1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify the unit is clean.
 - e. Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
 - f. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
 - g. Motor running protection:
 - 1) Verify drive overcurrent setpoints are correct for their application.
 - 2) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.

- 3) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.
 - h. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - i. Verify correct fuse sizing in accordance with the manufacturer's published data.
 - j. Perform visual and mechanical inspection of input circuit breaker as specified in this Section.
2. Electrical tests:
- a. Perform resistance measurements through bolted connections with low resistance ohmmeter.
 - b. Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
 - c. Test for the following parameters in accordance with relay calibration procedures specified in NETA ATS, or as recommended by the manufacturer:
 - 1) Input phase loss protection.
 - 2) Input overvoltage protection.
 - 3) Output phase rotation.
 - 4) Overtemperature protection.
 - 5) Direct current overvoltage protection.
 - 6) Overfrequency protection.
 - 7) Drive overload protection.
 - 8) Fault alarm outputs.
 - d. Harmonic distortion measurements for both voltage and current is within the specification limits at the installed site.
 - e. Peak voltage at the motor terminations is less than 90 percent of the motor insulation dielectric withstand level.
 - f. Perform continuity tests on bonding conductors as specified in accordance with NETA ATS.
 - g. Perform start-up of drive in accordance with the manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.
 - h. Perform operational tests by initiating control devices:
 - 1) Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
 - 2) Verify operation of drive from remote start/stop and speed control signals.
 - i. Perform electrical tests of input circuit breaker as specified in this Section.
 - j. Measure fuse resistance.
3. Test values:
- a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

- b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Overload test trip times at 300 percent of overload element rating shall be in accordance with the manufacturer's published time-current curve.
 - d. Test values for input circuit breaker shall be as specified in this Section.
 - e. Relay calibration results shall be as specified in this Section.
 - f. Continuity of bonding conductors shall be in accordance with NETA ATS.
 - g. Control devices shall perform in accordance with system requirements.
 - h. Operational tests shall conform to system design requirements.
 - i. Investigate fuse resistance values that deviate from each other by more than 15 percent.
- O. Surge arresters, low-voltage:
 - 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding, and clearances.
 - d. Verify the arresters are clean.
 - e. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - f. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
 - g. Verify that stroke counter is correctly mounted and electrically connected, if applicable.
 - h. Record stroke counter reading.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform an insulation-resistance test on each arrester, phase terminal-to-ground:
 - 1) Apply voltage in accordance with manufacturer's published data.
 - 2) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - c. Test grounding connection as specified in this Section.
 - 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.

- c. Insulation-resistance values shall be in accordance with the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
 - 2) Investigate insulation values less than the allowable minimum.
 - d. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.
 - P. Fiber-optic cables:
 - 1. Visual and mechanical inspection:
 - a. Compare cable, connector, and splice data with the Contract Documents.
 - b. Inspect cable and connections for physical and mechanical damage.
 - c. Verify that connectors and splices are correctly installed.
 - 2. Optical tests:
 - a. Perform cable length measurement, fiber fracture inspection, and construction defect inspection using an optical time domain reflectometer (OTDR):
 - 1) OTDR test performed on fiber cables less than 100 meters shall be performed with the aid of a launch cable.
 - 2) Adjust OTDR pulse width settings to a maximum setting of 1/1,000th of the cable length or 10 nanoseconds.
 - b. Perform connector and splice integrity test using an optical time domain reflectometer.
 - c. Perform cable attenuation loss measurement with an optical power loss test set:
 - 1) Perform attenuation tests with an optical loss test set capable and calibrated to show anomalies of 0.1 dB as a minimum.
 - 2) Test multimode fibers at 850 nanometer and 1,300 nanometer.
 - 3) Test single mode fibers at 1,310 nanometer and 1,550 nanometer.
 - d. Perform connector and splice attenuation loss measurement from both ends of the optical cable with an optical power loss test set:
 - 1) At the conclusion of all outdoor splices at 1 location, and before they are enclosed and sealed, splices shall be tested with OTDR at the optimal wavelengths (850 and 1,300 for multimode, 1,310 and 1,550 for single mode), in both directions. Splices shall be tested for integrity as well as attenuation.
 - e. Perform fiber links integrity and attenuation tests using each link shall be an OTDR and an optical loss test set:
 - 1) OTDR traces shall be from both directions on each fiber at the 2 optimal wavelengths, 850 nanometer, and 1,300 nanometer for multimode fibers.
 - 2) Optical loss testing shall be done with handheld test sets in 1 direction at the 2 optimal wavelengths for the appropriate fiber type. Test equipment shall equal or exceed the accuracy and resolution of Agilent/HP 8147 high performance OTDR.
 - 3. Test values:
 - a. Cable and connections shall not have been subjected to physical or mechanical damage.
 - b. Connectors and splices shall be installed in accordance with industry standards.

- c. Optical time domain reflectometer signal should be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.
- d. Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer's recommendations when no local site specifications are available.
- e. Individual fusion splice losses shall not exceed 0.1 dB. Measurement results shall be recorded, validated by trace, and filed with the records of the respective cable runs.

Q. Copper Ethernet cable installation testing:

- 1. Pre-installation:
 - a. Immediately prior to installation, verify that cable to be installed matches that which was submitted.
 - b. Verify that no damage has been done to the cable during shipping or handling.
 - c. Inspect cable for physical and mechanical damage.
 - d. Engineer shall be notified if a cable fails to meet inspection and the cable shall not be installed unless otherwise directed by the Engineer.
- 2. Post-installation:
 - a. Prior to copper Ethernet cable termination, perform cable end-to-end continuity validation testing on installed cables, conductor pairs and cable shields using toner and probe kit. Any cable that fails testing shall be removed and replaced.
 - b. Inspect equipment outlet connectors for damage and ensure connectors hold tightly in field device ports.
- 3. Test equipment:
 - a. Certification equipment used for the testing shall be capable of verifying twisted pair cable installation with end-to-end continuity testing.
 - b. Use only test cords and adapters that are qualified by the test equipment manufacturer for channel or link test configuration.
 - c. Manufacturers: The following or equal:
 - 1) Fluke Networks, IntelliTone Pro 200 Toner and Probe Kit, MT-8200-60-KIT.
 - d. Permanent link testing requirements: As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.05 FIELD QUALITY CONTROL (NOT USED)

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

- A. Dispose of testing expendables.
- B. Vacuum cabinets.
- C. Sweep clean surrounding areas.

END OF SECTION

SECTION 26_09_13

ELECTRICAL POWER MONITORING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Power meters and accessories.

1.02 REFERENCES

- A. American National Standard Institute (ANSI):
 - 1. C12.20 - Electricity Meters - 0.2 and 0.5 Accuracy Classes.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C57.13.6 - Standard for High Accuracy Instrument Transformers.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. FS - Full scale.
 - 2. SSM - Solid state multifunction power meter.
 - 3. THD - Total harmonic distortion.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Power meter data, including, but not limited to:
 - a. Power requirements.
 - b. Communications protocols.
 - c. Input/outputs.
 - d. Dimensions.
 - e. Measurement functions.
 - f. Front panel controls.
 - g. Display characteristics.
 - 2. Accessory data:
 - a. Test switch dimensions and wiring diagrams.
- C. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.
- D. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.

2. Descriptive and technical bulletins and sales aids edited to reflect only the equipment to be provided and covering each of the components in the system.
 3. A maintenance section including instruction leaflets and technical data necessary to setup, change setup and maintain the power meters.
 4. Original licensed copies of software and software manuals.
- E. Configuration files and reports:
1. Settings, including, but not limited to:
 - a. Device tag name.
 - b. IP addresses.
 - c. Alarm settings.
 - d. Time synchronization settings.
 - e. Security settings.
 2. Configuration files are to be provided in the selected manufacturer's native format.
 3. Configuration reports are to be submitted in .PDF format, listing each configured parameter setting and description of each parameter.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS

- A. One of the following or equal:
1. ABB.
 2. Allen-Bradley.
 3. Eaton.
 4. Electro Industries/GaugeTech Power Meters.
 5. GE Multilin.
 6. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. Power meters:

1. Power meter type 1 (SSM1) device shall be used in MCCs and shall include at a minimum:
 - a. Individual phase currents, within 0.5 percent FS.
 - b. Phase-to-phase and phase-to-neutral voltages, within 0.5 percent FS.
 - c. Watts, VARs, VA, within 1 percent FS.
 - d. Watt-hours, VAR-hours, VA-hours, within 1 percent FS.
 - e. PF (apparent and displacement), within 2 percent FS.
 - f. Frequency, within 1 percent hertz.
 - g. Demand:
 - 1) Ampere, within 0.5 percent FS.
 - 2) Watt, VAR, VA, within 1 percent FS.
 - h. Minimum and maximum values:
 - 1) Volts (L-L), volts (L-N), current, watts, VARS, VA.
 - 2) Power factor:
 - a) Apparent.
 - b) Displacement.
 - c) Frequency.
 - i. Synch-input kilowatts utility.
 - j. LCD with LED backlight.
 - k. Communications:
 - 1) EtherNet/IP.

2.08 ACCESSORIES

A. Current transformers:

1. Ring type:
 - a. Suitable for service within low or medium voltage equipment as indicated on the Drawings.
 - b. Designed to have a mechanical and thermal rating to withstand short-circuit current, stresses, and heating effects equal to the rating of the equipment of the application.
2. Current ratio: As indicated on the Drawings.
3. Rated in accordance with IEEE C57.13.6 with accuracy of the current transformers suitable for relay accuracy class and rated for 200 percent burden for the required connected devices.
4. Identify polarity with standard marking or symbols.
5. Capable of carrying rated primary current continuously without damage.
6. Install secondary wiring from current transformers in a suitable wiring trough, or conduit to proper short-circuiting type terminal blocks for connection to relays, instruments, and other devices.
7. Three CTs for 3-wire systems. 4CTs for 4-wire systems.

B. Voltage transformers:

1. Indoor dry type, single-phase, 60 hertz, with a minimum thermal capacity of not less than 400 volt-amperes at 55 degrees Celsius rise above 40 degrees Celsius ambient.

2. Accuracy classification determined in accordance with IEEE C57.13.6, suitable for relay accuracy class, and 200 percent burden, for the required connected devices, with the secondary voltage 120 volts.
 3. Insulation levels as required for the equipment system voltage but not less than:
 - a. 600 VAC, 10 kV BIL for 480 VAC systems.
 - b. 5.6 kV, 60 kV BIL for 2300 and 4160 VAC systems.
 - c. 15.5 kV, 110 kV BIL for 12.47 kV and 13.2 kV systems.
 4. Identify polarity with standard markings or symbols.
 5. Connect transformer secondary to voltage buses as required.
 6. Provide primary and secondary current-limiting fuses.
- C. Test switches:
1. Ten-pole:
 - a. 3 voltage poles, for phase voltage:
 - 1) 600 V rated.
 - b. Four 30 A, non-shorting current poles, for neutral current and let-thru phase currents.
 - c. Three 30 A, shorting current poles, for shorting phase currents.
 2. Base to be made of electrical grade plastic.
 3. Barriers between poles for pole isolation and separation.
 4. Clear cover encapsulating the test switch to enable visual verification of each switch position.
 5. Knife-blade type switches, accepting a horizontal gang interlocking bar.
 6. Screw type terminals on each switch.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install power meters in accordance with the manufacturer's instructions in the electrical equipment as indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING (NOT USED)

END OF SECTION

SECTION 26_22_14
DRY-TYPE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 389 - IEEE Recommended Practice for Testing Electronics Transformers and Inductors.
 - 2. C57.96 - IEEE Guide for Loading Dry-Type Distribution and Power Transformers.
- B. Underwriters Laboratory (UL):
 - 1. 1561 - Standard for Dry-Type General Purpose and Power Transformers.
- C. United States Department of Energy (DOE):
 - 1. 10 CFR Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Catalog cutsheets.
 - 2. Nameplate data.
 - 3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - 4. Inrush current.
 - 5. Insulation system and temperature constraints.
 - 6. Number and rating of taps.
 - 7. Sound levels.

8. Connection diagrams:
 - a. Primary.
 - b. Secondary.
 9. BIL rating.
 10. Required clearances.
 11. Percent impedance.
 12. Efficiency.
 13. Certification of full capacity capability at the Project elevation and ambient conditions.
 14. For equipment installed in structures designated as seismic design category C, D, E, or F, submit the following as specified in Section 01_81_50 - Design Criteria:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Delegated Design Submittals:
1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
- D. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 2. Provide manufacturer's installation instructions.
- E. Quality Control Submittals:
1. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide equipment and components that are fully rated for the site elevation and operating environment where the equipment will be installed as specified in Section 01_81_50 - Design Criteria and as indicated on the Drawings.
- B. Provide 3-phase or 1-phase, 60 hertz dry-type with voltage ratings, kilovolt-ampere capacities, and connections as indicated on the Drawings:
 - 1. Transformers shall provide full capacity at the Project elevation and environmental conditions as specified in Section 01_81_50 - Design Criteria after all derating factors have been applied.
 - 2. Suitable for continuous operation at full rating with normal life expectancy in accordance with IEEE C57.96.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. ABB.
 - 2. Eaton.
 - 3. Jefferson.
 - 4. Schneider Electric.

2.04 MATERIALS

- A. Cores:
 - 1. Non-aging, grain-oriented silicon steel.
 - 2. Magnetic flux densities below the saturation point.
- B. Windings:
 - 1. High-grade magnet wire.
 - 2. Impregnated assembly with non-hydroscopic, thermo-setting varnish:
 - a. Cured to reduce hot-spots and seal out moisture.
 - 3. Material electrical grade:
 - a. Copper.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

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

Kilovolt-Amperes Range	Audible Sound Level (dB)
1-9	40
10-50	45

Kilovolt-Amperes Range	Audible Sound Level (dB)
51-150	50
151-300	55
301-500	60
501-700	62
701-1,000	64

3. Taps:
 - a. 15 kilovolt-amperes and less:
 - 1) Two 5 percent full capacity primary taps below rated voltage.
 - b. 25 kilovolt-amperes and larger:
 - 1) Four 2.5 percent full capacity primary taps below rated voltage.
 - 2) Two 2.5 percent full capacity primary taps above rated voltage.
 - c. Operated by a tap changer handle or tap jumpers accessible through a panel.
 4. Terminals:
 - a. UL listed for either copper or aluminum conductors.
 - b. Rated for 75 degrees Celsius.
 5. Daily overload capacities, at rated voltage and without reduction in life, in accordance with IEEE C57.96.
- B. Transformers less than 15 kilovolt-amperes:
1. Insulation class: 185 degrees Celsius.
 2. Temperature rise: 115 degrees Celsius.
- C. Energy efficient transformers 15 kilovolt-amperes and larger:
1. Insulation class: 220 degrees Celsius.
 2. Temperature rise: 80 degrees Celsius, except as noted below:
 - a. 150 degree Celsius rise for dry-type transformers located in motor control centers.
 3. Efficiency:
 - a. In accordance with DOE 10 CFR Part 431.
- D. Enclosures:
1. Heavy gauge steel:
 - a. Outdoor: Moisture and water resistant with rodent screens over openings and in a weather-protected enclosure, NEMA Type 3R.
 - b. Indoor: NEMA Type 2.
 2. Louvers to limit coil temperature rise to the value stated above, and case temperature rise to 50 degrees Celsius.
 3. Built-in vibration dampeners to isolate the core and coils from the enclosure:
 - a. Neoprene vibration pads and sleeves.

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Nameplates:

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

2.09 FABRICATION (NOT USED)

2.10 FINISHES

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

2.11 SOURCE QUALITY CONTROL

A. Factory tests:

1. Applied voltage test to each winding and from each winding to the core:
 - a. 600-volt class winding 4.5 kilovolt.
2. Induced voltage test at 2 times normal voltage and 400 hertz for 1,080 cycles.
3. Voltage ratio and polarity.
4. Sound level, performed in a test room with ambient sound level not exceeding 24 dB.
5. Perform tests in accordance with UL 1561.
6. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Anchoring and bracing to structures:

1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
2. Install anchors of type and material indicated on approved anchoring designs.

3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

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

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING

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

END OF SECTION

SECTION 26_24_16

PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- B. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- C. Underwriters Laboratories, Inc. (UL):
 - 1. 67 - Standard for Panelboards.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer of panelboard.
 - 2. Bill of material.
 - 3. Assembly ratings including:
 - a. Voltage.
 - b. Phase.
 - c. Continuous current.
 - d. Short circuit interrupting rating.
 - 4. NEMA enclosure type.
 - 5. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.
 - 6. Furnish circuit breaker Submittals as specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
 - 7. For equipment installed in structures designated as seismic design category C, D, E, or F, submit the following as specified in Section 01_81_50 - Design Criteria:
 - 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. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
 - a. Height.
 - b. Length.
 - c. Width.
 - 2. Weight.
 - 3. Anchoring locations.
 - 4. Breaker layout drawing with dimensions:
 - a. Location of the main, branches, solid neutral, and ground.
 - 5. Conduit entry/exit locations:
 - a. Identify conduit entry/exit locations and restrictions.
 - 6. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for every panelboard.
- D. Calculations:
 - 1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic requirements at the Project Site.
- E. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
 - c. For wall mounted equipment weighing 125 pounds or more.
- F. Installation instructions:
 - 1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 - 2. Provide manufacturer's installation instructions.
- G. Quality Control Submittals:
 - 1. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 2. Test reports.
- H. Operations and maintenance manual:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:
 - a. Including, but not limited to:
 - 1) Instruction narratives and bulletins.
 - 2) Renewal parts lists.
 - 3) Time-current curves for all devices.

1.05 QUALITY ASSURANCE

- A. Where indicated as service entrance equipment, panelboards shall be UL listed and labeled "Suitable for Service Entrance."

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

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

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide equipment and components that are fully rated for the site elevation and operating environment where the equipment will be installed as specified in Section 01_81_50 - Design Criteria and as indicated on the Drawings.
- B. Non-conditioned spaces:
 - 1. Provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.
- C. Outdoor installations:
 - 1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer's specified operating ranges.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. ABB.
 - 2. Eaton.
 - 3. Schneider Electric.
- B. Circuit breakers:
 - 1. Same manufacturer as the panelboard.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. Provide panelboards with:
 - 1. Molded-case circuit breakers with trip ratings as shown on the panel schedules.
 - 2. Spares and spaces for future circuit breakers in panels as shown on the panel schedules.
 - a. Space for future devices as specified in Section 26_05_00 - Common Work Requirements for Electrical.
- B. Short circuit rating:
 - 1. Provide as indicated on the Drawings.
 - 2. Testing method in accordance with UL 67.
 - 3. Mark each panelboard with its maximum short circuit rating at the supply voltage.
 - 4. Panelboards shall be fully rated.

2.07 COMPONENTS

- A. Enclosure:
 - 1. NEMA enclosure type as indicated on the Drawings:
 - a. Where not indicated on the Drawings, as specified in Section 26_05_00 - Common Work Results for Electrical for the installed location.
 - 2. Minimum width: 20 inches.
 - 3. Gutter space in accordance with the NEC:
 - a. Minimum of 4 inches.
 - 4. Dead-front, no live parts when the panelboard is in service.
 - 5. Enclose entire panelboard bus assembly in a corrosion resistant galvanized steel cabinet.
 - 6. 4-piece front to provide ease of wiring access.
 - 7. Lockable, hinged door over the protective devices with a flush, cylinder tumbler-type lock with catch and door pull:
 - a. Minimum 2 keys per panelboard.
 - b. Key all panelboard locks alike:
 - 1) Match locks on existing panelboards to the extent possible.
 - 8. Circuit directory frame and card on the inside of the door.
 - 9. Interior design such that replacement of circuit breakers does not require disturbing adjacent units or removal of the main bus connectors.
 - 10. Outdoor locations: Provide NEMA Type 4X enclosures with a NEMA Type 4X stainless steel outer enclosure (with a hinged door) and a NEMA Type 1 interior panelboard, unless otherwise indicated.
- B. Bus:
 - 1. General:
 - a. Tin-plated copper.
 - 2. Phase bus:
 - a. Full size and height without reduction.

- b. Dimensions and temperature rise in accordance with UL 67:
 - 1) Limit current density to less than 1,000 amps per square inch.
 - c. Insulate current carrying parts from ground and phase-to-phase with a high dielectric strength insulator.
 - 3. Ground bus:
 - a. Copper, solidly bonded.
 - 4. Neutral bus:
 - a. Provide where indicated on the Drawings.
 - b. 100 percent rated.
 - c. Provide lugs for each outgoing feeder requiring a neutral connection.
 - 5. Provide insulation barriers over the vertical bus behind the dead front shield to provide increased safety during field service.
- C. Lugs:
 - 1. UL listed for copper and aluminum wire:
 - a. Rated for 75-degree Celsius terminations.
 - b. Provide bolted or compression main lug terminations as required for the incoming cable size.
- D. Circuit breakers: As specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers and as indicated on the Drawings:
 - 1. Provide with bolt-on connections:
 - a. Plug-in circuit breakers are not allowed.

2.08 ACCESSORIES

- A. Surge protective devices:
 - 1. Furnish panelboards with surge protective devices as indicated on the Drawings.
 - 2. As specified in Section 26_43_14 - Surge Protective Devices.
- B. Nameplates:
 - 1. As specified in Section 26_05_53 - Identification for Electrical Systems.
 - 2. Install on outside of door.
 - 3. Indicating:
 - a. Panel designation.
 - b. Voltage.
 - c. Number of phases and configuration.
- C. Circuit identification labels:
 - 1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.
 - 2. Type all information on the cards using designations in the panel schedules.
 - 3. Laminated on both sides.
- D. Pad locking mechanism:
 - 1. Provide a pad locking attachment to allow circuit breakers to be locked in the off position.
 - 2. At a minimum, provide 1 mechanism per panelboard:
 - a. Provide multiple mechanisms if required to accommodate all circuit breaker frame sizes in the panelboard.

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- A. Finish stand-alone panelboards with a primer, rust-resistant phosphate undercoat, and 2 coats of oven-baked enamel with manufacturer's standard gray.
- B. Finish panelboards mounted in motor control centers to match the motor control center finish and color.

2.11 SOURCE QUALITY CONTROL

- A. Source Testing:
 - 1. Perform standard factory tests on the panelboards.
 - 2. Test in accordance with NEMA and UL standards.
 - 3. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. General:
 - 1. Mounted as indicated on the Drawings.
 - 2. Mount rigidly to structural members with exposed surfaces plumb and level to within 1/32 inch.
 - 3. Perform Work in accordance with the manufacturer's instructions and Shop Drawings.
 - 4. Provide brackets, hangers, supports, and hardware for mounting as required.
 - 5. In NEMA Type 4 and NEMA Type 4X locations, mount panelboards on 7/8-inch deep stainless steel preformed channel, with channel running vertically from top to bottom of panelboard:
 - a. Use only stainless steel mounting hardware.
 - 6. Mount panelboard so that top operating handle is not more than 6 feet-7 inches above the operating floor.
- C. Provide typewritten schedule in each panelboard.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

END OF SECTION

SECTION 26_24_20

LOW VOLTAGE MOTOR CONTROL CENTERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Low voltage motor control centers.

1.02 REFERENCES

- A. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 2. ICS 18-2001 - Motor Control Centers.
- B. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- C. Underwriters Laboratories (UL):
 - 1. 845 - Motor Control Centers.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. SELV: Safety extra-low voltage.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Manufacturer of motor control center.
 - 2. Manufacturer of motor control center parts.
 - 3. Nameplate schedule.
 - 4. Bill of material.
 - 5. Enclosure:
 - a. NEMA rating.
 - b. Finish color.
 - 6. Ratings:
 - a. Voltage.
 - b. Phase.

- c. Current:
 - 1) Horizontal bus ampacity.
 - 2) Vertical bus ampacity.
 - 3) Ground bus ampacity.
 - d. Short circuit withstand rating.
 - e. Protective device interrupting rating.
 - 7. List of recommended spare parts.
 - 8. Catalog cutsheets:
 - a. Submit complete manufacturer's catalog information:
 - 1) Clearly indicate the features of the equipment, including any options necessary to meet the required functionality.
 - 9. Furnish component Submittals as specified in the appropriate Section.
 - 10. For equipment installed in structures designated as seismic design category C, D, E, or F, submit the following as specified in Section 01_81_50 - Design Criteria:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop Drawings:
 - 1. Layout drawings:
 - a. Provide fully dimensioned and to scale layout drawings which include:
 - 1) Dimensions:
 - a) Overall length.
 - b) Overall width.
 - c) Overall height.
 - d) Overall weight and weight of individual shipping splits.
 - 2. Interfaces to other equipment.
 - 3. Shipping splits.
 - 4. Allowable top and bottom conduit windows.
 - 5. Complete component and unit layout drawings, including control, networking, and metering components.
 - 6. Indicate lug sizes, type, and manufacturer based on the cable size specified in the Contract Documents and as indicated on the Drawings.
 - 7. Elementary schematics:
 - a. Provide 1 custom schematic diagram for each compartment:
 - 1) Include remote devices.
 - 2) Show wire numbers on the schematics:
 - a) Provide wire numbering as specified in Section 26_05_53 - Identification for Electrical Systems.
 - 8. External connection diagram showing the wiring to the external controls and devices associated with the motor control center.
 - 9. One-line diagrams:
 - a. Provide complete one-line diagrams for each motor control center, including, but not limited to: Protective devices, starters, drives, metering, and other equipment.
 - b. Indicate electrical ratings of the equipment shown on the one-line diagrams.

- D. Calculations:
 - 1. Detailed calculations or details of the actual physical testing performed on the motor control center to prove the motor control center is suitable for the seismic requirements at the Project Site.
- E. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
- F. Installation instructions:
 - 1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 - 2. Provide manufacturer's installation instructions.
- G. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
- H. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.
- I. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Provide complete operating and maintenance instructions presenting full details for care and maintenance of all types of equipment furnished and/or installed under this Section. Include the following:
 - a. Electrical ratings:
 - 1) Phase.
 - 2) Wire.
 - 3) Voltage.
 - 4) Ampacity.
 - 5) Bus bracing and protective device interrupting ratings.
 - b. Manufacturer's operating and maintenance instructions for the motor control center and component parts, including:
 - 1) Starters.
 - 2) Overload relays and heater elements.
 - 3) Variable frequency drives.
 - 4) Protective devices, including, but not limited to, fuses, circuit breakers and protective relays.
 - 5) Pilot devices.
 - c. Complete renewal parts list.

- J. Test forms and reports:
 - 1. Submit complete factory acceptance test procedures and forms used during the test.
- K. Record documents:
 - 1. Elementary schematics:
 - a. Furnish as-built elementary schematics indicating final:
 - 1) Wire numbers.
 - 2) Interfaces with other equipment.
 - b. Provide 1 custom schematic diagram for each compartment:
 - 1) Include remote devices.
 - 2) Show wire numbers on the schematics.
 - c. Layout drawings: Provide complete dimensioned component and unit layout drawings.
 - 2. Record documents shall reflect modifications made during the submittal review process and during construction.

1.06 QUALITY ASSURANCE

- A. All portions of the motor control center, vertical bays, and components shall be UL listed and labeled.
 - 1. Where indicated as service entrance equipment, the motor control center shall be UL labeled and listed "Suitable for Service Entrance".

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Ship the motor control center and associated equipment to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize on-site off-loading equipment.
- B. Furnish temporary equipment heaters within the motor control center to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Meetings: After the fault current study is completed and submitted and before the equipment shop drawings are submitted, the Supplier shall conduct at least one remote programming and data exchange coordination meeting with the Owner using Team™ or Zoom™.
- B. Sequencing:
 - 1. Conduct the initial fault current study as specified in Section 26_05_74 - Electrical System Studies and submit results for the Engineer's review.
 - 2. After successful review of the initial fault current study, as specified in Section 26_05_74 - Electrical System Studies, submit complete equipment submittal.
 - 3. Conduct factory acceptance test.

4. Submit manufacturer's test results.
5. Ship equipment to the Project Site after successful completion of factory acceptance test.
6. Assemble equipment in the field.
7. Conduct field acceptance test and submit results for the Engineer's review.
8. Submit manufacturer's certification that the equipment has been properly installed and is fully functional for the Engineer's review.
9. Conduct Owner's Training sessions.
10. Commissioning and process start-up as specified in Section 01_75_17 - Commissioning.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Factory assembled, factory wired and factory tested motor control centers:
 1. Motor control centers and major components to be products of a single manufacturer.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in Section 01_81_50 - Design Criteria and as indicated on the Drawings.
- B. Outdoor installations:
 1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer's specified operating ranges.
- C. Existing motor control centers:
 1. Provide complete motor control center vertical sections or individual motor control center units to be added to existing motor control centers as specified in this Section and as indicated on the Drawings.
 2. Provide additions that are of the same manufacturer, type, and electrical ratings as the existing motor control centers:
 - a. Provide hardware necessary to connect the buses of the new and existing motor control centers.
 3. Provide enclosures to match the NEMA ratings and colors of the existing motor control centers.
- D. Doors:
 1. Provide snake-skin cable management sleeve or spiral wire-wrap wires where they pass from the interior of the cabinet past the door hinge to door-mounted devices.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. ABB/GE.
 - 2. Allen-Bradley.
 - 3. Eaton.
 - 4. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. General:
 - 1. Furnish motor control centers as specified in the Contract Documents and indicated on the Drawings.
 - 2. Arrange the equipped sections to form continuous motor control center lineups as indicated on the Drawings:
 - a. Identify any deviations from the Drawings in writing and submit for approval.
 - 3. Provide wire markers at each end of every wire as specified in Section 26_05_53 - Identification for Electrical Systems.
 - 4. Provide complete and functional motor control centers.
 - 5. Provide devices or accessories not specified in this Section but necessary for the proper installation and operation of the equipment.
- B. Design and construct motor control center to operate at the voltage level and configuration indicated on the Drawings.
- C. Bus system:
 - 1. Material:
 - a. Tin-plated copper.
 - b. Short-circuit rating:
 - 1) As indicated on the Drawings.
 - c. Bus bar supports:
 - 1) High impact strength, non-tracking glass-polyester material that is impervious to moisture and gases.
 - 2. Horizontal power bus:
 - a. Current-carrying capacity as indicated on the Drawings.
 - b. Mounting:
 - 1) Mount horizontal bus bars edgewise, one above the other, and fully isolated from wireways and units.
 - c. Temperature rise:
 - 1) In accordance with UL 845.
 - 2) De-rate the temperature rating of the bus for the specified conditions of ambient temperature and altitude as specified in Section 01_81_50 - Design Criteria.
 - 3. Vertical power bus:
 - a. Current-carrying capacity of not less than 600 amps.

- b. Mounting:
 - 1) Enclose the vertical bus in a polyester-glass cover with small openings to permit unit stabs to mate with the bus:
 - a) Provide a shutter mechanism to cover the stab openings when plug-in units are removed.
 - 2) Provide top and bottom bus covers for insulation and isolation of the ends of the bus.
 - c. Isolated from the unit compartments by a full height barrier.
 - 4. Ground bus:
 - a. Horizontal ground bus:
 - 1) Current-carrying capacity:
 - a) 300 amps when the horizontal bus is 2,000 amps or less.
 - b) 600 amps when the horizontal bus is greater than 2,000 amps.
 - 2) Mounting:
 - a) Full width, firmly secured to each vertical section structure:
 - (1) Located in the top or bottom wireway.
 - b) Pre-drilled and furnished with lugs for connection to equipment ground wires:
 - (1) Furnish a minimum of 10 lugs per vertical section of MCC.
 - b. Vertical ground bus:
 - 1) Mounting:
 - a) Furnish in each vertical section.
 - b) Bolted to the horizontal ground bus.
 - c) Install parallel to the vertical power bus.
 - d) Mount vertical ground bus such that plug-in units engage the ground bus before any connection to the power bus is made. Upon removal of plug-in units, ground stabs are disconnected from the ground bus after the power stabs have been disconnected.
 - 5. Bus splice bars:
 - a. Provided to join the bus at the splits.
 - b. Connected to each horizontal bus bar with a minimum of 2 bolts.
 - c. Employ conical or spring washers at connections, designed to maintain constant pressure against the splice joint.
 - d. Same ampacity rating as the horizontal bus.
 - 6. Provide bus system configured for back-to-back MCCs, where required.
- D. Enclosures:
 - 1. Each motor control center shall consist of one or more vertical sections bolted together:
 - a. Freestanding.
 - b. Totally enclosed.
 - c. Dead-front assembly.
 - d. Designed for modification and/or addition of future vertical sections.
 - e. Form each vertical section of heavy gauge steel.
 - f. Designed for back-to-back arrangement installation, where required and/or as indicated on the Drawings.
 - 2. Enclosure rating:
 - a. Indoor:
 - 1) NEMA Type 1 gasketed.

3. Standard section dimensions:
 - a. Nominal height: 90 inches.
 - b. Nominal depth: 20 inches.
 - c. Vertical section width as indicated on the Drawings.
4. Wireways:
 - a. Provide each vertical section with a horizontal wireway at the top and bottom of the section:
 - 1) Arranged to provide a full-width metal enclosed wiring trough across the entire motor control center assembly.
 - b. Provide each vertical section with a full-height vertical wireway.
 - c. Completely isolated from the vertical and horizontal bus bars.
 - d. Provide a removable, hinged door.
5. Shipping splits:
 - a. No more than 3 vertical sections and not more than 60 inches in width.
 - b. Solid busing between vertical sections in a shipping split is not acceptable.
6. Lifting angles:
 - a. Furnish each vertical section and/or shipping split with a removable lifting angle mounted to the top of the enclosure:
 - 1) Extending the entire width of the shipping split.
7. Mounting channels:
 - a. Mount each vertical section and/or shipping split on an external 1.5-inch by 3-inch mounting channel.

E. Units:

1. A plug-in unit consists of:
 - a. Assembly.
 - b. Support pan.
 - c. Door assembly.
2. Completely enclosed and isolated from adjacent units, buses, and wireways, except for conductor entries into the unit, by a metal enclosure.
3. Supported and guided by a removable unit support pan:
 - a. Re-arrangement of units and the removal of a unit so that a new and possibly larger unit can be added without the removal of an in-service unit to gain access to the unit support pan.
4. Held in place by screws or other positive locking means after insertion.
5. Provide a test position with the unit supported in the structure but disengaged from the bus.
6. Integral plug-in ground stab.
7. Stabs:
 - a. Free floating.
 - b. Self-aligning.
 - c. Backed by spring steel clips to ensure high pressure contacts.
 - d. Electrolytically tin-plated copper.
8. Handle:
 - a. Provide a flange mounted handle mechanism to operate each disconnect switch or circuit breaker.
 - b. Door mounted operators or operator handles are not acceptable.
 - c. Engaged with the disconnect device at all times as an integral part of the unit independent of the door position.
 - d. Lockable in the "OFF" position with up to 3 padlocks.

- e. Mechanically interlocked so that the door cannot be opened with the handle in the "ON" position:
 - 1) Provide a means for qualified personnel to defeat this interlock.
 - f. Interlocked so the unit cannot be inserted or withdrawn with the handle in the "ON" position.
 - g. Lockable in the "ON" position:
 - 1) This shall not prevent the circuit breaker from operating and opening the contacts in the event of a fault condition.
 - h. Color-coded to indicate position.
 - i. Located so the center of the grip when it is in its highest position is not more than 6 feet-7 inches above the finished floor, including the height of the housekeeping pad and mounting channels.
9. Space for future devices:
- a. Provide spaces as indicated on the Drawings.
 - b. As specified in Section 26_05_00 - Common Work Requirements for Electrical.

2.07 COMPONENTS

- A. Provide components contained within the motor control center as specified in:
- 1. Section 26_05_53 - Identification for Electrical Systems.
 - 2. Section 26_05_18 - 600-Volt or Less Wires and Cables.
 - 3. Section 26_05_21 - Low Voltage Wire Connections.
 - 4. Section 26_09_13 - Electrical Power Monitoring.
 - 5. Section 26_29_24 - Variable Frequency Drives 0.50 - 50 Horsepower.
 - 6. Section 26_22_14 - Dry-Type Transformers.
 - 7. Section 26_43_14 - Surge Protective Devices.
 - 8. Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
 - 9. Section 26_29_05 - Motor Starters.
 - 10. Section 26_24_16 - Panelboards.
 - 11. Section 26_28_14 - Low Voltage Fuses.
 - 12. Section 40_67_01 - Control Systems: Panels, Enclosures, and Panel Components.

2.08 ACCESSORIES

- A. Wiring:
- 1. Wire the motor control center in accordance with the following NEMA class and type as defined by NEMA ICS 18-2001:
 - a. NEMA Class II-S:
 - 1) Furnish wiring diagrams for individual units consisting of drawings that identify electrical devices, electrical connections, and indicate terminal numbering designations.
 - 2) Furnish individual unit diagrams with each unit and include inter-wiring between units, i.e., electrical interlocking, etc., as specifically specified in the Contract Documents.
 - 3) Provide custom drawings with unique terminal numbering designations in lieu of standard manufacturer drawings.
 - b. NEMA Type B wiring:
 - 1) Control wiring:
 - a) Type B-T pull-apart terminal blocks.

- 2) Power wiring:
 - a) Type B-T for Size 1 starters.
 - b) Type B-T or B-D for Size 2 and 3 starters.
 - c) Type B for Size 4 and larger starters and feeder units.
- B. Lugs and terminals:
 - 1. For external connections of No. 6 AWG wire or larger:
 - a. UL listed for copper or aluminum conductors.
 - 2. Compression type, requiring a hydraulic press and die for installation.
 - 3. Provide additional terminal blocks as needed for control conductors passing through the MCC.
 - 4. Provide 30 percent spare control block terminals.
- C. Nameplates:
 - 1. Provide nameplates as specified in Section 26_05_53 - Identification for Electrical Systems:
 - a. Identifying the motor control center designation as indicated on the Drawings.
 - 2. Furnish individual nameplates for each unit indicated on the Drawings:
 - a. 1 nameplate to identify the unit designation.
 - b. 1 nameplate to identify the load served.
 - c. Furnish space units with blank nameplates.
 - 3. Manufacturer's labels:
 - a. Furnish each vertical section with a label identifying:
 - 1) Serial number.
 - 2) Bus rating.
 - 3) Vertical section reference number.
 - 4) Date of manufacture.
 - 5) Catalog number of section.

2.09 FINISHES

- A. Finish metal surfaces and structural parts with phosphatizing, or equal, treatment before painting.
- B. Finish interior surfaces, including bus support angles, control unit back plates, and top and bottom barrier plates with baked white enamel.
- C. Finish exterior of enclosure with the manufacturer's standard gray.
 - 1. Finish NEMA Type 3R exterior cabinets with ultraviolet resistant enamel paint that is UL recognized for outdoor use.

2.10 SOURCE QUALITY CONTROL

- A. Source Testing (Factory Acceptance Tests):
 - 1. Witnessed, in-person:
 - a. Number of Owner and Engineer representatives in person: 2.
 - 2. Test the complete motor control center at the manufacturer's establishment. Completely assemble, wire and test the motor control center:
 - a. Detailed inspections before and after assembly to ensure correctness of design and workmanship.

3. Prove out Overload control logic as well as interaction with the Owner's control and maintenance systems.
4. ICSC/programmer shall attend the witnessed Source Testing.
5. Provide groups of wires leaving the shipping-assembled equipment with terminal blocks with suitable numbering strips.
6. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 PREPARATION

- A. Anchoring and bracing to structures:
 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 2. Install anchors of type and material indicated on approved anchoring designs.
 3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. General:
 1. Furnish cables, conduit, lugs, bolts, and other accessories necessary to completely install the motor control center for the line, load, and control connections.
 2. Assemble and install the motor control center in the locations and with the layouts as indicated on the Drawings.
 3. Make bus splice connections.
 4. Perform Work in accordance with the manufacturer's instruction and Shop Drawings.
 5. Furnish components and equipment necessary to complete the installation.
 6. Replace hardware, lost or damaged during installation or handling, in order to provide a complete installation.
 7. Install the MCC on a raised concrete housekeeping pad:
 - a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units:
 - 1) Remove the manufacturer's supplied mounting channels as required by the manufacturer's installation instructions.
 - b. Weld and/or bolt the motor control center frame to leveling channels.
- C. Provide openings in the top or bottom of the motor control center for conduit only:
 1. No additional openings will be accepted:
 - a. Miscut holes will require that the entire vertical section or removable panel be replaced.
 - b. No hole closers or patches will be accepted.
- D. Bundle circuits together and terminate in each unit:
 1. Tie with nylon wire ties as specified in Section 26_05_18 - 600-Volt or Less Wires and Cables.

2. Label wires at each end with wire markers as specified in Section 26_05_53 - Identification for Electrical Systems as shown on the approved elementary schematics.

E. Furnish Manufacturer's Certificate of Installation Verification.

3.03 FIELD QUALITY CONTROL

A. Functional Testing:

1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

B. Manufacturer's services:

1. Provide the services of a manufacturer's representative to:
 - a. Inspect, verify, and certify that the motor control center installation meets the manufacturer's requirements.

3.04 OWNER TRAINING

A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

1. Number of sessions:
 - a. Operations: 2.
 - b. Maintenance: 2.

3.05 ADJUSTING

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

END OF SECTION

SECTION 26_27_26

WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Switches.
 - 2. Receptacles.
 - 3. Device cover wall plates.

1.02 REFERENCES

- A. Federal Specifications (FS):
 - 1. W-C-596 - Connector, Electrical, Power, General Specification for.
 - 2. W-S-896/2 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
- B. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
- C. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- D. Telecommunications Industry Association (TIA):
 - 1. T568A - Eight-position jack pin/pair assignment.
 - 2. T568B - Optional eight-position jack pin/pair assignment.
- E. Underwriters Laboratories, Inc. (UL):
 - 1. 20 - General Use Snap Switches.
 - 2. 498 - Standard for Attachment Plugs and Receptacles.
 - 3. 943 - Ground-Fault Circuit-Interruptioners.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. GFCI: Ground fault circuit interrupter.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Catalog cutsheets.

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

1.06 QUALITY ASSURANCE

- A. Wiring devices shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

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

2.03 MANUFACTURERS

- A. Switches:
 - 1. One of the following or equal:
 - a. Cooper Wiring Devices.
 - b. Hubbell.
 - c. Leviton.
 - 2. Occupancy sensor switches:
 - a. One of the following or equal:
 - 1) Cooper Wiring Devices.
 - 2) WattStopper.
 - 3. Dimmer switches:
 - a. One of the following or equal:
 - 1) Cooper Wiring Devices.
 - 2) Lutron.
- B. Receptacles:
 - 1. General purpose:
 - a. One of the following or equal:
 - 1) Cooper Wiring Devices.
 - 2) Hubbell.
 - 3) Leviton.

- C. Device cover wall plates:
 - 1. General location:
 - a. One of the following or equal:
 - 1) Cooper Wiring Devices.
 - 2) Legrand.
 - 2. Wet or corrosive areas:
 - a. One of the following or equal:
 - 1) ABB.
 - 2) Cooper Wiring Devices.
 - 3) Hubbell.
 - 4) Pass and Seymour.
 - 3. In-use covers:
 - a. One of the following or equal:
 - 1) ABB.
 - 2) Cooper Wiring Devices.
 - 3) Pass and Seymour.
 - 4) TayMac.
- D. Data and communications jacks:
 - 1. Network jacks:
 - a. One of the following or equal:
 - 1) Belden, REVConnect Connectivity System.
 - 2) Hubbell.
 - 3) Leviton, Quickport series.
 - 4) Panduit.
 - 2. Wall plates:
 - a. One of the following or equal:
 - 1) Belden, REVConnect Connectivity System.
 - 2) Leviton, Quickport series.
 - 3) Optical Cable Corporation (OCC).
 - 4) Panduit.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

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

2. General purpose switches:
 - a. Toggle type.
 3. Toggle switches used for programmable panelboards shall be as recommended by the panelboard manufacturer.
 4. Switches for office areas:
 - a. Rocker type.
 - b. Rectangular.
 5. Switches for use with photocell:
 - a. Maintained contact.
 - b. 2 circuit.
 - c. 3 position:
 - 1) Center off.
 6. Occupancy sensor switches:
 - a. Wall switch with dual-technology passive infrared and ultrasonic sensor.
 - 1) Configured such that lights turn on only when both infrared and ultrasonic sensors detect activity, but do not turn off as long as either sensor detects activity.
 - b. Selectable "automatic-on" mode activated by sensors or "manual-on" mode activated by pushbutton.
 - c. Adjustable 5- to 30-minute time delay.
 - d. Selectable audible alert as a warning before lights turn off.
 - e. Rated for fluorescent lighting loads of up to 800 W.
 - f. True multi-way switching allowing identical controls at any location for multi-way switching applications.
 7. Dimmer switches:
 - a. Shall be rectangular design with LED light level indicators.
 - b. Suitable for use with type of lamp switched.
- B. Receptacles:
1. General purpose receptacles:
 - a. Single or duplex as indicated on the Drawings.
 - b. 125 VAC.
 - c. 20 amp or as indicated on the Drawings.
 - d. NEMA Type 5-20R configuration for 20 amp receptacles.
 - e. Other NEMA configurations as indicated on the Drawings.
 - f. Listed in accordance with UL 498.
 - g. Designed and constructed in accordance with FS W-C-596.
 - h. Back and side wired.
 - i. 1-piece, rivet-less mounting strap.
 - j. Color:
 - 1) Ivory in finished areas.
 - 2) Brown in all other areas.
 - 3) Orange when powered by a UPS.
 2. Ground fault interrupter receptacles (GFCI):
 - a. 125 VAC.
 - b. 20 amp.
 - c. Trip level 4 to 6 mA.
 - d. Individual and feed through protection.
 - e. UL 943 and UL 498 listed.
 - f. NEMA Type 5-20R configuration.

- g. For damp or wet locations:
 - 1) Weather resistant, in accordance with UL 498.
- C. Device cover wall plates:
 - 1. General location:
 - a. Type 302 or 304 stainless steel.
 - b. Brushed satin finish.
 - c. Minimum thickness: 0.032 inches.
 - d. Rectangular or square shape.
 - e. Engraving:
 - 1) Engrave each switch device cover wall plate with the following:
 - a) Area served.
 - b) Panelboard and Circuit.
 - 2) Engrave each receptacle device cover wall plate with the following:
 - a) Panelboard and Circuit.
 - 3) Treat engraving to improve visibility.
 - 4) Characters shall be block letter pantograph engraved with a minimum character height of 1/8-inch.
 - f. Coordinate the number of gangs, number, and type of openings with the specific location.
 - 2. Outdoor and wet areas requiring NEMA Type 4 or NEMA Type 4X enclosures:
 - a. General:
 - 1) UL listed for wet locations.
 - 2) Gasketed.
 - 3) Die cast metal:
 - a) Match material to box material.
 - b. Switches:
 - 1) Lever operated:
 - a) Provide toggle switch.
 - c. Receptacles:
 - 1) Weatherproof in-use cover:
 - a) Die cast metal construction with electrostatic powder coating for corrosion resistance.
 - b) Gasketed.
 - c) Lockable.
 - d) UL listed and in accordance with the NEC.
 - 3. Corrosive areas:
 - a. Neoprene.
 - b. Gasketed.
 - c. Weatherproof.
- D. Data and communications jacks:
 - 1. Process network jacks - conduit body mounted:
 - a. Network jacks located in process areas shall have a NEMA Type 4 rating (with closure cap).
 - b. Mounting of network jacks in conduit bodies adapter (with minifast connector) shall be accomplished using conduit body insert and environmental enclosure caps.
 - c. PC board connections are not to be allowed.
 - d. Furnish 10 RJ-45 to minifast connector patch cable 3 feet in length.

- e. Manufacturers: The following or equal:
 - 1) InterlinkBT.
- 2. Network/phone jacks:
 - a. Meets or exceeds TIA standards for the category of Ethernet cable connected.
 - b. Accommodates TIA T568A and TIA T568B wiring schemes.
 - c. UL listed or rated.
 - d. Provide different colors for each network unless otherwise indicated on the Drawings.
 - e. Power over Ethernet up to 100 watts.
 - f. Interchangeable icons to identify function.
 - g. In accordance with NEC requirements.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Mounting heights:
 - 1. Process and production areas:
 - a. Switches and receptacles: 48 inches from finished floor to top of device cover wall plate.
 - 2. Offices and finished areas:
 - a. Switches: 48 inches from finished floor to top of device cover wall plate.
 - b. Receptacles: 18 inches from finished floor to center of device cover wall plate.
- B. Switches:
 - 1. Over 300 volts:
 - a. Where switches used in systems of more than 300 volts between conductors, are to be ganged in outlet boxes, provide switches having no exposed live parts or use barriers between the individual switches.
- C. Receptacles:
 - 1. Provide GFCI receptacles as indicated on the Drawings.
 - a. Provide weather resistant GFCI receptacles in wet or damp areas.
 - 2. Mount receptacles vertically:
 - a. Ground slot down.
 - 3. 3-phase receptacles shall be consistent with respect to phase connection at the receptacle terminals. Correct errors in phasing at the source and not the receptacle.
- D. Ensure device cover wall plates make a firm seal with wall for recessed mounted devices:
 - 1. Outside edges of device cover wall plates parallel with building lines.

END OF SECTION

SECTION 26_28_01

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- B. Underwriters Laboratories (UL):
 - 1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Catalog cutsheets.
 - 2. Manufacturer's time-current curves for molded case circuit breakers furnished.
- C. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
 - c. For wall mounted equipment weighing 125 pounds or more.
- D. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

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

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. ABB.
 - 2. Eaton.
 - 3. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

- A. General:
 - 1. In accordance with UL 489.
 - 2. Operating mechanism:
 - a. Quick-make, quick-break, non-welding silver alloy contacts.
 - b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
 - c. Mechanically trip free from the handle.
 - d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
 - e. Lockable in the "OFF" position.
 - 3. Arc extinction:
 - a. In arc chutes.
 - 4. Voltage and current ratings:
 - a. Minimum ratings as indicated on the Drawings.
 - b. Minimum frame size 100A.
 - 5. Interrupting ratings:
 - a. Minimum ratings as indicated on the Drawings.

- b. Modify as required to meet requirements of the short circuit fault analysis as specified in Section 26_05_74 - Electrical System Studies.
 - c. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.).
- B. Motor circuit protectors:
 - 1. Instantaneous only circuit breaker as part of a listed combination motor controller.
 - 2. Each pole continuously adjustable in a linear scale with "LO" and "HI" settings factory calibrated.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

- A. Terminals:
 - 1. Line and load terminals suitable for the conductor type, size, and number of conductors indicated on the Drawings and in accordance with UL 489.
- B. Case:
 - 1. Molded polyester glass reinforced.
 - 2. Ratings clearly marked.
- C. Trip units:
 - 1. Provide thermal magnetic or solid-state trip units as indicated on the Drawings.
 - 2. Thermal magnetic:
 - a. Instantaneous short circuit protection.
 - b. Inverse time delay overload.
 - c. Ambient or enclosure compensated by means of a bimetallic element.
 - 3. Solid state:
 - a. With the following settings as indicated on the Drawings:
 - 1) Adjustable long time current setting.
 - 2) Adjustable long time delay.
 - 3) Adjustable short time pickup.
 - 4) Adjustable short time delay.
 - 5) Adjustable instantaneous pickup.
 - 6) Adjustable ground fault pickup as indicated on the Drawings.
 - 7) Adjustable ground fault delay as indicated on the Drawings.
 - 8)
 - b. Energy reducing maintenance switch on breakers 1,200 amps and above and on additional breakers as indicated on the Drawings.
 - 1) Indication on the breaker.
- D. Provide ground fault trip devices as indicated on the Drawings.
- E. Molded case circuit breakers for use in panelboards:
 - 1. Bolt-on type:
 - a. Plug-in type breakers are not acceptable.
 - 2. Ground fault trip devices as indicated on the Drawings.

2.08 ACCESSORIES

- A. Lockable handle:
 - 1. Provide assembly to lock operating handle in "OPEN" position.
 - 2. Where a molded case circuit breaker is located in a dedicated enclosure, provide a lockable handle. Reference the Electrical Specifications for additional locking requirements associated with other mounting installations.

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

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install breakers to correspond to the accepted Shop Drawings.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.
 - 1. Number of sessions:
 - a. Operations 1.
 - b. Maintenance 1.

3.06 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.

END OF SECTION

SECTION 26_28_14
LOW VOLTAGE FUSES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Fuses: 600-volt class and lower.

1.02 REFERENCES

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Catalog cutsheets.
 - 2. Complete fuse schedule.
 - 3. Manufacturer original 11-inch by 17-inch, time current curves for all fuses furnished.
- C. Shop Drawings:
 - 1. Include drawings of spare fuse cabinets.

1.05 QUALITY ASSURANCE

- A. Low voltage fuses shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.10 MAINTENANCE

- A. Spare parts:
 - 1. Provide 3 spare fuses for each size and type used or supplied under any Section of the Contract Documents.
 - 2. Provide spare fuse cabinet(s):
 - a. Metal cabinet with hinged door and shelves or fuse holders.
 - b. Gray enamel finish.
 - c. Mount near equipment and label "Spare Fuses" on face of cabinet.
 - d. Suitable pocket inside door of each cabinet with typewritten spare fuse inventory in clear plastic protective insert.
 - e. Provide as many cabinets as required to hold entire spare fuse inventory.

PART 2 PRODUCTS

2.01 GENERAL

- A. Fuses for overcurrent protection and/or current limiting applications as indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. Bussmann.
 - 2. Ferraz Shawmut.
 - 3. Littelfuse.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

- A. General:
 - 1. Provide durable, readily visible label inside each fuse enclosure, clearly indicating the correct type, size, and ratings of replacement fuse:
 - a. Label shall not cover or interfere with the equipment manufacturer's instructions.
 - 2. Affix a label indicating recommended torque for fuse mounting bolts or studs to the inside of fuse access doors.
 - 3. To ensure selective coordination of protective devices:
 - a. Provide fuses for new facilities by the same manufacturer.
 - b. Provide fuses for renovations of the same manufacturer as existing fuses.
 - 4. Provide fuses rated for the voltage and available short circuit current at which they are applied.

- B. Fuses for services, switchboard mains, feeders, and branch circuits:
 - 1. 600 amps and less:
 - a. Provide UL listed RK1 dual-element, time-delay fuses with amp ratings as indicated on the Drawings, except as may be modified by the Contract Documents.
 - 2. 601 to 6,000 amps:
 - a. Provide UL listed Class L fuses.
- C. Fuses for motor branch circuits:
 - 1. Amp ratings shall not exceed the motor controller manufacturer's recommended values:
 - a. If the manufacturer does not have such standards, provide fuses as specified in this Section.
 - 2. Provide Class RK1 fuses or fuses as indicated on the Drawings and as specified in the Contract Documents, rated in accordance with the fuse manufacturer's recommendations for backup running protection of motor circuits containing overload relays.
 - 3. Determine fuse ratings for overload protection of motor branch circuits by actual full-load currents of motors provided.
 - 4. Fuses in motor control centers may be time-delay Class J or Class CC fuses, if MCC manufacturer's standard designs use these fuse types:
 - a. Time-delay Class J fuse ratings shall not exceed 150 percent of motor full load current, except as permitted.
 - b. Follow the fuse manufacturer's recommendations for Class CC fuses.
 - c. A motor having starting duty or other special characteristics requiring larger fuses than specified above may have branch circuit fuse ratings increased as necessary to meet the motor's requirements, but no larger than maximum permitted by the NEC.
 - 1) Increased requirements for an individual motor shall not be cause for increasing size of all fuses.
 - 5. Provide Class L fuses for motor branch circuits requiring fuses over 600 amps, sized at 150 percent of motor full load current, except as permitted below:
 - a. A motor having starting duty or other special characteristics requiring larger fuses than specified above, may have branch circuit fuse ratings increased as necessary to meet the motor's requirements, but no larger than maximum permitted by the NEC.
 - 1) Increased requirements for an individual motor shall not be cause for increasing size of all fuses.
- D. Fusing of control circuits:
 - 1. Provide:
 - a. RK1 fuses installed in UL listed Class CC fuse blocks as specified in the Contract Documents.
 - 2. Provide minimum protection for control circuits in accordance with the latest revision of UL 508 for Industrial Control.
 - 3. Fuse both the primary and secondary circuit of control power transformers:
 - a. Fuse ratings shall be in accordance with NEC requirements.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. General:
 - 1. Properly aligned, electrically and mechanically secure.
 - 2. Evenly torque mounting bolts and nuts to ASTM recommendations for type and diameter of mounting bolts or studs provided.
 - 3. Paralleling of fuses is not permitted.
 - 4. Install fuses so that the fuse nameplate and rating are easily readable in the equipment.
- B. Replace fuses, on all phases, for any fuses that opened during start-up and testing.
- C. After completion of testing, deliver spare fuses in quantities specified:
 - 1. New, in manufacturer's original packaging, and stored in a clean, dry location.
- D. Install spare fuse cabinets where instructed by the Owner.

END OF SECTION

SECTION 26_28_17
DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Knife blade fusible and non-fusible disconnect switches.
 - 2. Switch-rated plugs and receptacles.

1.02 REFERENCES

- A. National Electric Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 2. KS 1-2001 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
- B. Underwriters Laboratories Inc. (UL):
 - 1. 98 - Enclosed and Dead-Front Switches.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Safety switches and disconnect switches are to be considered synonymous.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- 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.

8. Cross-referenced to the disconnect schedule indicated on the Drawings.
- C. Shop Drawings:
 1. Manufacturer's installation instructions:
 - a. Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance, Regulatory Requirements below.
 - b. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
 2. For each switch, indicate nameplate inscription, including voltage, circuit, fuse size (if applicable), and equipment served.
- D. Installation instructions:
 1. Provide manufacturer's installation instructions.

1.06 QUALITY ASSURANCE

- A. Regulatory requirements:
 1. NEMA Type KS 1- Enclosed and Miscellaneous Distribution Switches (600 V Maximum).
 2. UL 98 - Enclosed and Dead-Front Switches.
- B. Disconnect switches shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 1. Conduct the initial fault current study as specified in Section 26_05_74 - Electrical System Studies and submit results for the Engineer's review.
 2. After successful review of the initial fault current study, submit complete equipment Submittal.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide knife blade disconnect switches and switch-rated plugs and receptacles as indicated on the Drawings and specified in the Contract Documents.
- B. Provide equipment with the number of poles, voltage, current, short circuit, and horsepower ratings as required by the load and the power system.

2.03 MANUFACTURERS

- A. Knife-blade disconnect switches:
 - 1. One of the following or equal:
 - a. ABB.
 - b. Appleton.
 - c. Crouse-Hinds.
 - d. Eaton.
 - e. Schneider Electric.
 - f. Siemens.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. Knife-blade style switch disconnects:
 - 1. Switch mechanism:
 - a. Quick-make, quick-break heavy-duty operating mechanisms:
 - 1) Provisions for padlocking the switch in the Off position.
 - 2) A minimum of 90-degree handle travel position between Off and On positions:
 - a) Provide handle position indicators to identify the handle position.
 - 3) 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:
 - a) With an externally operated override.
 - 2. Switch interior:
 - a. Switch blades visible when the switch is Off and the cover is open.
 - b. Lugs:
 - 1) Front accessible.
 - 2) Removable.
 - 3) UL listed for 60/75-degree Celsius copper conductors.
 - c. Current carrying parts completely plated to resist corrosion.
 - d. Removable arc suppressors to facilitate easy access to line side lugs.
 - e. Furnish equipment ground kits for every switch.

3. Fused switches:
 - a. Furnish with fuses as indicated on the Drawings:
 - 1) Provide fuses as specified in Section 26_28_14 - Low Voltage Fuses.
 - b. UL approved for field conversion from standard Class H fuse spacing to Class J fuse spacing:
 - 1) Ratings 100 amps through 600 amps at 240 volts.
 - 2) Ratings 30 amps through 600 amps at 600 volts.
 - 3) Provide spring reinforced and plated fuse clips.
 4. Ratings:
 - a. UL horsepower rated for AC or DC with the rating not less than the load served.
 - b. Current:
 - 1) 30 to 1,200 amps.
 - c. Voltage:
 - 1) 250 volts AC, DC.
 - 2) 600 volts (30 A to 200 A, 600 volts DC).
 - d. Poles:
 - 1) 2, 3, 4, and 6 poles.
 - e. UL listed short circuit ratings:
 - 1) 10,000 RMS symmetrical amps when used with or protected by Class H or K fuses (30 to 600 amps).
 - 2) 200,000 RMS symmetrical amps when used with or protected by Class R or J fuses (30 to 600 amps employing appropriate fuse rejection).
 - 3) 200,000 RMS symmetrical amps when used with or protected by Class L fuses (800 to 1,200 amps).
- B. Where not indicated on the Drawings, provide switches with the NEMA ratings specified in Section 26_05_00 - Common Work Results for Electrical for the installed location.
- C. Size, fusing and number poles as indicated on the Drawings or as required:
1. Provide solid neutral where indicated on the Drawings.

2.07 COMPONENTS (NOT USED)

2.08 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.
- C. NEMA Type 7 and Type 9 enclosures furnished with drain and breather kit when used in outdoor applications.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. General:
 - 1. Use Myers hubs or bolt-on hubs for conduit penetrations on NEMA Type 12, Type 4, and Type 4X enclosures.
 - 2. Provide mounting brackets, stands, supports and hardware as required:
 - a. Match finish and materials for 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. As specified in Section 26_05_53 - Identification for Electrical Systems.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

END OF SECTION

SECTION 26_29_05

MOTOR STARTERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Motor starters and contactors.

1.02 REFERENCES

- A. Abbreviations:
 - 1. FVNR: Full voltage non-reversing.
- B. Standards:
 - 1. Institute of Electrical and Electronics Engineers (IEEE).
 - 2. International Electrotechnical Commission (IEC):
 - a. 801-1 - Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment - Part 1: General Information.
 - b. 947-4 - Low-Voltage Switchgear and Control Gear.
 - 3. National Electrical Manufacturer's Association (NEMA):
 - a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - b. ICS 2-230 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 V.
 - 4. Underwriters Laboratories, Inc. (UL):
 - a. 508 - Standard for Industrial Control Equipment.
 - b. 508A - Standard for Industrial Control Panels.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. 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 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing for individually enclosed starters.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures:
 - 1. Submit motor starter data with equipment Submittal.

- B. Product data:
 - 1. Manufacturer.
 - 2. Catalog cutsheets.
 - 3. Technical information.
 - 4. Complete nameplate schedule.
 - 5. Complete bill of material.
 - 6. List of recommended spare parts.
 - 7. Confirmation that the overload relay class for each starter meets the requirements of the equipment and motor supplier.
 - 8. Electrical ratings:
 - a. Phase.
 - b. Wire.
 - c. Voltage.
 - d. Ampacity.
 - e. Horsepower.
 - 9. Furnish circuit breaker submittals as specified in Section 26_28_01 - 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 control wires on the diagrams:
 - 1) Wire numbering as specified in Section 26_05_53 - Identification for Electrical Systems.
 - c. Indicate interfaces with other equipment on the Drawings.
- D. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
 - c. For wall mounted equipment weighing 125 pounds or more.
- A. Installation instructions:
 - 1. Detail the complete installation of the individually enclosed starters, including rigging, moving, and setting into place.
 - 2. Provide manufacturer's installation instructions.
- B. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
 - 4. Test reports.
- C. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.

- D. Operation and maintenance manuals:
1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 2. 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. Recommended spare 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.

1.06 QUALITY ASSURANCE

- A. Regulatory requirements:
1. 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 (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing, all starters:
1. Conduct the initial fault current study as specified in Section 26_05_74 - Electrical System Studies and submit results for the Engineer's review.
 2. After successful review of the initial fault current study, as specified in Section 26_05_74 - Electrical System Studies, submit complete equipment Submittal.
 3. Conduct factory acceptance test.
 4. Ship equipment to the Project Site after successful completion of factory acceptance test.

5. Assemble equipment in the field.
6. Submit Manufacturer's Certificate of Installation Verification.
7. Conduct field acceptance test and submit results for the Engineer's review.
8. Conduct Owner Training sessions.
9. Commissioning and process start-up as specified in Section 01_75_17 - Commissioning.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.11 MAINTENANCE

- A. Provide the following spare parts, suitably packaged and labeled with the corresponding equipment number:
 1. One spare fuse of each size and type per starter.

PART 2 PRODUCTS

2.01 GENERAL

- A. Starters for motor control centers, individual enclosed starters, or control panels.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in Section 01_81_50 - Design Criteria and as indicated on the Drawings.
- B. Non-conditioned spaces:
 1. For equipment located in non-conditioned spaces, provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.
- C. Outdoor installations:
 1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer's specified operating ranges.

2.03 MANUFACTURERS

- A. One of the following or equal:
 1. NEMA starters and contactors:
 - a. ABB.
 - b. Allen-Bradley.
 - c. Eaton.
 - d. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

- A. General:
 - 1. Provide combination type starters with motor circuit protector or thermal-magnetic circuit breaker and control power transformer with ratings as indicated on the Drawings.
 - 2. NEMA size, design, and rated:
 - a. NEMA Size 1 minimum.
 - 3. Coordinate motor circuit protector, thermal magnetic circuit breaker, or fusible disconnect, and overload trip ratings with nameplate horsepower and current ratings of the installed motor.
 - a. If motors provided are different in horsepower rating than those specified or indicated on the Drawings, provide starters coordinated to the actual motors furnished.
 - 4. Mount extended overload reset buttons to be accessible for operation without opening starter enclosure door.
- B. Full voltage starters (FVNR):
 - 1. Across-the-line full voltage magnetic starters.
 - 2. Rated for 600 volts.
 - 3. Electrical characteristics as indicated on the Drawings.
 - 4. Provide positive, quick-make, quick-break mechanisms, padlockable enclosure doors.
 - 5. Furnish starter with solid state electronic overload relays.
 - 6. Double-break silver alloy contacts.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

- A. Molded case circuit breakers:
 - 1. Circuit breaker type and ratings as indicated on the Drawings.
 - 2. Provide as specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
- B. Contactors:
 - 1. NEMA size as indicated on the Drawings.
 - 2. Electrically held:
 - a. For lighting loads designed to withstand the initial inrush currents of ballast and lamp loads.
 - 3. Factory adjusted and chatter free.
 - 4. Auxiliary contacts:
 - a. Contact ratings in accordance with NEMA A600 rating:
 - 1) Auxiliary contacts rated 10 amps at 600 volts.
 - b. Provide contacts indicated on the Drawings and any additional contacts required for proper operation.
 - c. Provide at least 1 normally open and 1 normally closed spare auxiliary contact.
 - 5. Constructed in accordance with the following standards:
 - a. UL 508.

- b. IEC 947-4:
 - 1) Type 1 coordination when protected by a circuit breaker.
 - 2) Type 2 coordination when protected by a suitable UL listed fuse.
 - c. IEC 801-1 parts 2 through 6.
- C. Overloads:
 - 1. Solid state electronic:
 - a. Selectable Class 10, 20, 30 protection.
 - b. Ambient insensitive:
 - 1) Operating temperature: -20 to 70 degrees Celsius.
 - c. Thermal memory.
 - d. Protective functions:
 - 1) Motor overcurrent.
 - 2) Phase unbalance (adjustable).
 - 3) Phase loss.
 - 4) Ground fault protection.
 - e. Self-powered.
 - f. Visible trip indicator.
 - g. Push-to-trip test.
 - h. Isolated normally open alarm contact.
 - i. Normally closed trip contact.
 - j. Manual reset.
- D. Control power transformer:
 - 1. Furnish integral control power transformer capacity to power:
 - a. Motor controls: Motor and starter accessories indicated on the Drawings or specified.
 - 2. Primary and secondary fusing as indicated on the Drawings:
 - a. Fusing sized by the manufacturer for the rating of the transformer furnished.
 - 3. Control power transformer secondary voltage:
 - a. As indicated on the Drawings.

2.08 ACCESSORIES

- A. Lugs and terminals:
 - 1. For external connections of No. 6 AWG and larger.
 - 2. UL listed for either copper or aluminum conductors.
- B. Surge protective devices:
 - 1. Furnish surge protection devices across the coil of each starter, contactor, and relay.
- C. Pilot devices:
 - 1. Provide pilot lights, switches, elapsed time meters, and other devices as specified or as indicated on the Drawings.
 - 2. As specified in Section 40_67_01 - Control Systems: Panels, Enclosures, and Panel Components.
- D. Nameplates and wire markers:
 - 1. As specified in Section 26_05_53 - 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 H₂S and chlorine.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Source Testing:
 - 1. Witnessed, in-person:
 - a. Number of Owner and Engineer representatives in person: 2.
 - 2. Prove out overload control logic as well as interaction with Owner's control and maintenance systems at the Supplier's facility:
 - a. PCIS programmer shall attend witnessed testing.
 - 3. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. Starters in motor control centers:
 - 1. As specified in Section 26_24_20 - Low Voltage Motor Control Centers.
- C. Starters in control panels:
 - 1. As specified in Section 40_67_01 - Control Systems: Panels, Enclosures, and Panel Components.

3.04 FIELD QUALITY CONTROL

- A. Field electrical acceptance testing:
 - 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.
 - 1. Number of sessions:
 - a. Operations: 2.
 - b. Maintenance: 2.

3.06 ADJUSTING

- A. Provide the services of a qualified manufacturer's representative for start-up assistance:
 - 1. Inspection and field adjustment:
 - a. Supervise equipment installation and confirm controls have been properly installed, aligned, adjusted, and readied for operation.
 - 2. Starter parameter and protection settings:
 - a. Program protection settings coordinated with the driven equipment supplier.
 - 3. Provide documentation of starter settings, including, but not limited to:
 - a. Ramp time.
 - b. Starting voltage.
 - c. Motor nameplate information.
 - d. All protection settings.
- B. Make adjustments as necessary and as recommended by the manufacturer, Engineer, or testing firm.
- C. Set overloads and motor circuit protectors based on the nameplate values of the installed motor.

END OF SECTION

SECTION 26_29_24

VARIABLE FREQUENCY DRIVES 0.50 - 50 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Variable frequency drives (VFD) 0.5 to 50 horsepower for control of NEMA Design B squirrel cage induction motors.

1.02 REFERENCES

- A. International Organization for Standardization (ISO):
 - 1. 9001 - Quality Management Systems - Requirements.
- B. National Electrical Manufacturers Association (NEMA).
- C. Underwriters Laboratories (UL):
 - 1. 508A - Standard for Safety for Industrial Control Panels.
 - 2. 845 - Standard for Motor Control Centers.
 - 3. 61800-5-1 - Standard for Adjustable Speed Electrical Power Drive Systems.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Point of common coupling: The point of common coupling for all harmonic calculation and field measurements for both voltage and current distortions is defined as the closest directly connected bus supplying power to the VFD.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures:
 - 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.
 - d. Weight.
 - 4. Nameplate schedule.
 - 5. Bill of material.
 - 6. Ratings:
 - a. Voltage.
 - b. Phase.
 - c. Input current.
 - d. Output current.
 - e. Interrupting rating.
 - f. Momentary current rating.
 - 7. List of recommended spare parts.
 - 8. Catalog cutsheets for major components.
 - 9. Design data:
 - a. Efficiency and power factor values.
 - b. Certification that the drive is sized for the full nameplate motor horsepower and current of the driven load at the installed altitude and ambient temperature.
 - 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 electronic circuits and printed circuit boards are conformally coated.
 - 10. For equipment installed in structures designated as seismic design category C, D, E, or F, submit the following as specified in Section 01_81_50 - Design Criteria:
 - 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. Dimensions.
 - b. Panel, sub-panel, and component layout indexed to the bill of material.
 - c. Conduit connections.
 - 2. Block diagram showing the basic control and protection systems specifying 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. Include terminal number and wire numbers.
 - 4. Complete single-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. Delegated Design Submittals:
1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
 - c. For wall mounted equipment weighing 125 pounds or more.
- E. Installation instructions:
1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 2. Provide manufacturer's installation instructions.
- F. Quality Control Submittals:
1. Manufacturer's representative qualifications.
 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 3. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
 4. Test reports.
 5. Report listing the setting of VFD adjustable parameters and their values after start-up.
- G. Owner Training Submittals:
1. As specified in Section 01_75_17 - Commissioning.
- H. Operation and maintenance manuals:
1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 2. Spare parts list with supplier names and part numbers.
 3. Startup and commissioning instructions and data.
 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. Written descriptions detailing the operational functions of controls on the front panel.
 6. Maintenance manual:
 - a. Furnish maintenance manuals with instructions covering details pertaining to care and maintenance of 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 which outline the purpose and operation of every control device used in normal operation.
 - 3) Schematic wiring and external diagrams:
 - a) Furnish Drawings in a reduced 11-inch by 17-inch format that are fully legible at that size.

- I. Test forms and reports:
 - 1. Submit complete factory acceptance test procedures and forms used during the test.

1.06 QUALITY ASSURANCE

- A. 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 61800-5-1 listed and labeled:
 - a. UL 61800-5-1 for individual units.
 - b. UL 508A for VFD systems in control panels.
 - c. UL 845 for VFD systems in motor control centers.
 - 3. VFDs shall be manufactured by the VFD manufacturer at its own facility which shall have a quality assurance program certified in accordance with ISO 9001.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Ship the VFDs and associated equipment to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize on-site off-loading equipment:
 - 1. VFDs shall be delivered to the Site preassembled and wired.
- B. Furnish temporary equipment heaters within the VFD to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Conduct factory acceptance test and submit certified test results for the Engineer's review.
 - 2. Ship equipment to Project Site after successful completion of factory acceptance test.
 - 3. Assemble equipment in the field.
 - 4. Conduct field acceptance test and submit results for the Engineer's review.
 - 5. Conduct Owner Training sessions.
 - 6. Commissioning and process start-up as specified in Section 01_75_17 - Commissioning.
- B. VFD manufacturer shall coordinate with the manufacturer of the driven equipment to develop the proper equipment protection and settings.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.11 SYSTEM START-UP

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

1.12 MAINTENANCE

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

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in Section 01_81_50 - Design Criteria and as indicated on the Drawings.
- B. Non-conditioned spaces:
 - 1. Provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.
- C. Outdoor installations:
 - 1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer's specified operating ranges.
- D. Design requirements:
 - 1. Each VFD system consists of components required to meet the performance, protection, safety, testing, and certification criteria of this Section.
 - 2. VFD system:
 - a. Is a fully integrated package.
 - b. Includes material necessary to interconnect VFD system elements, even if shipped separately.
 - 3. Coordinate bearing protection methods with the supplier of the driven equipment.
- E. Any modifications to a standard product necessary to meet this Section shall be made only by the VFD manufacturer:
 - 1. Each VFD shall be completely factory pre-wired, assembled, and then tested as a complete system by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.

2. 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 based upon the installed conditions:
 - a. Provide equipment necessary to mitigate potential damage to motor insulation.
 - b. Motors as specified in Section 26_05_09 - Low Voltage Motors up to 500 hp.

F. 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) VFD shall be capable of producing a variable alternating voltage/frequency output to provide continuous operation over the 40 to 200 percent (25 to 120 hertz) speed range.
 - b. Current requirements:
 - 1) Full rated current output 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. Minimum VFD system efficiency:
 - a. 96 percent when operating at the rated kW output.
 - b. VFD system efficiency shall be calculated as follows:

$$\text{Efficiency (\%)} = \frac{\text{Power (Load)}}{\text{Power (Supply)}} \times 100$$
 - 1) Power (Load) is the total power measured at the output terminals of the drive system, including VFD, output filters, or transformers.
 - 2) Power (Supply) is the total power measured at the input terminals of the VFD, including input filters, line reactors, isolation transformers, harmonic distortion attenuation equipment and auxiliary equipment (e.g., controls, fans) for complete system operation.
3. Total power factor:
 - a. Minimum of 0.96 lagging across the entire speed range.
 - b. At no speed shall the VFD have a leading power factor.
4. Frequency accuracy:
 - a. Minimum of within 0.01 percent.
5. Speed regulation:
 - a. Minimum of within 0.5 percent across the entire speed range.

2.03 MANUFACTURERS

- A. One of the following or equal:
1. ABB.
 2. Allen-Bradley.
 3. Danfoss VLT/Vacon.
 4. Schneider Electric.

5. Toshiba.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

A. General:

1. Sinusoidal pulse width modulated (PWM) type drive.
 - a. 6-pulse insulated gate bipolar transistor (IGBT) power section.
 - b. Microprocessor based controls.
 - c. Line reactor and output device as specified in this Section.

B. Ratings:

1. Voltage:
 - a. Input voltage as indicated on the Drawings.

C. Operational features:

1. Protective features:
 - a. Provide the following minimum 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.
2. Control mode:
 - a. Operation in either a constant volts/hertz or sensorless vector mode:
 - 1) Control 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:
 - 1) Each rate adjustable from 0.01 to 1,800 seconds.
5. Spinning load:
 - a. VFD shall be 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 speed reference, the VFD shall be programmable to either:
 - 1) Stop.
 - 2) Maintain current speed.
 - 3) Default to pre-selected speed.
7. Power interrupt ride-through:
 - a. VFD shall be capable of continuous operation in the event of a power loss of 5 cycles or less.

8. Inputs/outputs:
 - a. Manufacturer's standard number the following:
 - 1) Analog inputs:
 - a) Configurable as either 0 to 10 V or 4 to 20 mA.
 - 2) Analog outputs:
 - a) Programmable 4 to 20 mA 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/outputs as required to meet the control functions indicated on the Drawings.
9. Communications:
 - a. Provide each VFD with an EtherNet i/P communications interface module.
 - b. Use of gateways is not acceptable.
 - c. Protocols shall be certified by the governing authority.
10. Diagnostics:
 - a. Store a minimum of 4 fault conditions in non-volatile memory on a first in-first out basis.
 - b. Operational parameters stored at the time of the fault:
 - 1) Operating frequency.
 - 2) Drive status.
 - 3) Power mode.
 - c. Fault memory accessible via RS-232, RS-422, or RS-485.
11. Automatic restart:
 - a. User selectable automatic restart feature allowing the VFD to restart following a momentary power failure or other VFD fault:
 - 1) Programmable for up to 9 restart attempts.
 - 2) Adjustable time delay between restart attempts.

2.07 COMPONENTS

- A. Enclosure:
 1. NEMA Type 12 or motor control center as indicated on the Drawings.
 2. Provide cooling devices required to maintain the VFD within the manufacturer's specified temperature limits for the Project conditions:
 - a. Provide cooling device failure alarm.
- B. Power disconnect:
 1. Flange-mounted thermal magnetic circuit breaker.
 2. Lockable in the OFF position.
- C. Input reactor:
 1. Three percent input line reactor.
- D. Output device:
 1. Three percent output load reactor.

- E. Keypad:
1. Provide each VFD with a keypad for programming and control.
 2. Keypad requirements:
 - a. Password security to protect drive parameters.
 - b. Mounted on the door of the VFD enclosure.
 - c. Back-lit LCD:
 - 1) Minimum of 2 lines with a minimum of 16 characters per line.
 - d. Programming and display features language: English.
 - e. Capable of displaying the following parameters:
 - 1) Speed (percent).
 - 2) Output current (amperes).
 - 3) Output frequency (hertz).
 - 4) Input voltage.
 - 5) Output voltage.
 - 6) Total 3-phase kilowatt.
 - 7) Kilowatt-hour meter.
 - 8) Elapsed run time meter.
 - 9) Revolutions per minute.
 - 10) Direct current bus voltage.
 3. In addition to keys required for programming, provide the following controls on the keypad:
 - a. Auto/manual selector.
 - b. Start pushbutton.
 - c. Stop pushbutton.
 - d. Jog pushbutton.
 - e. Speed increment.
 - f. Speed decrement.
 - g. Forward/reverse selector.
 - h. Run LED indicator.
 - i. Program LED indicator.
 - j. Fault LED indicator.
 4. Provide the VFD with the hardwired controls as indicated on the Drawings.
- F. Control power transformer:
1. Furnish a control power transformer mounted and wired inside the VFD enclosure.
 2. With primary and secondary fusing.
 3. Sized to power VFD controls and options as well as any external devices indicated on the Drawings, including the motor winding heater.

2.08 ACCESSORIES

- A. Metal oxide varistors:
1. Provide protection for the VFD against:
 - a. Line transients: 5,000-volt peak minimum.
 - b. Line to ground transients: 7,000-volt peak minimum.
- B. Conformal coating:
1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as a protection against moisture, dust, temperature extremes, and chemicals such as H₂S and chlorine.

2.09 FABRICATION (NOT USED)

2.10 FINISHES

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

2.11 SOURCE QUALITY CONTROL

- A. Source Testing (Factory Acceptance Tests):
 - 1. Witnessed, in-person:
 - a. Number of Owner and Engineer representatives in person: 2.
 - 2. General:
 - a. Incoming inspection of components and raw materials based on strategic supplier base and experience.
 - b. VFDs furnished under this Section shall be tested and inspected as specified below. Testing of VFDs based on sampling plans is not allowed.
 - c. Testing procedures specified are the minimum acceptable requirements. Manufacturer may perform additional tests at its discretion.
 - 3. Failure of any component during testing requires repair of the faulted component and complete retest.
 - 4. Perform manufacturer's standard factory acceptance tests.
 - 5. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. General:
 - 1. Furnish cables, conduit, lugs, bolts, and other accessories needed to complete the 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 a raised concrete housekeeping pad:
 - a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
 - b. Weld and/or bolt the VFD frame to the leveling channels.
7. Provide openings in top or bottom of the VFD (free-standing 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.
 - b. Label wires at each end with wire numbers shown on the approved control drawings.
 - c. Connections to and from the VFD (free-standing or within motor control center) enclosure must be made via terminal blocks.

C. Furnish Manufacturer's Certificate of Installation Verification.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Field electrical acceptance testing:
 1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.
- C. Provide the services of a VFD manufacturer representative for startup assistance:
 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. Startup 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.

3.05 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.
 1. Number of sessions:
 - a. Operations: 2.
 - b. Maintenance: 2.

3.06 ADJUSTING

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

- B. Provide the services of a qualified manufacturer's representative for start-up assistance:
1. Inspection and field adjustment:
 - a. Supervise equipment installation and confirm controls have been properly installed, aligned, adjusted, and readied for operation.
 2. Drive parameter and protection settings:
 - a. Program protection settings provided by the VFD manufacturer and coordinated with the driven equipment supplier.
 3. Provide documentation of VFD settings, including, 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.
 - h. Motor nameplate information.
 - i. All protection settings.

END OF SECTION

SECTION 26_43_14
SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
1. High-energy surge protective devices.

1.02 REFERENCES

- A. Institute of Electrical and Electronics Engineers (IEEE):
1. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1,000 V and less) AC Power Circuits.
 2. C62.41.2 - Recommended Practice on Characterization of Surges in Low-Voltage (1,000 V and Less) AC Power Circuits.
 3. C62.45 - Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1,000 V and Less) AC Power Circuits.
 4. C62.62- Standard Test Specifications for Surge Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1,000 V and less) AC Power Circuits.
- B. International Electrotechnical Commission (IEC).
- C. National Electrical Manufacturers Association (NEMA).
- D. National Fire Protection Agency (NFPA):
1. 20 - Standard for the Installation of Stationary Pumps for Fire Protection.
 2. 70 - National Electrical Code (NEC).
 3. 75 - Standard for the Fire Protection of Information Technology Equipment.
 4. 780 - Standard for the Installation of Lightning Protection Systems.
- E. Underwriters Laboratory (UL):
1. 96A - Standard for Installation Requirements for Lightning Protection Systems.
 2. 1283 - Standard for Electromagnetic Interference Filters.
 3. 1449 - Standard for Surge Protective Devices.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. I_n : Nominal discharge current.
 2. MCOV: Maximum continuous operating voltage.
 3. MOV: Metal oxide varistor.
 4. SAD: Silicon avalanche diode.
 5. SCCR: Short circuit current rating.
 6. SPD: Surge protective device.

7. VPR: Voltage protection rating.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Furnish complete product data confirming detailed compliance or exception statements to all provisions of this Section.
 - 2. Manufacturer's catalog cutsheets indicating:
 - a. Manufacturer and model numbers.
 - b. Ratings of each SPD, including, but not limited to:
 - 1) Short circuit current rating.
 - 2) Nominal discharge current.
 - 3) Maximum continuous operating voltage.
 - 4) Voltage protection rating.
 - 5) System voltage.
 - 6) System frequency.
 - 7) Surge current capacity.
 - 3. Submit independent test data from a nationally recognized testing laboratory verifying the following:
 - a. Overcurrent protection.
 - b. UL 1449.
- C. Shop Drawings:
 - 1. Provide electrical and mechanical drawings by the manufacturer that detail:
 - a. Unit dimensions.
 - b. Weights.
 - c. Components.
 - d. Field connection locations.
 - e. Mounting provisions.
 - f. Connection details.
 - g. Wiring diagram.
- D. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
- E. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.
- F. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Provide the manufacturer's manual with installation, start-up, and operating instructions for the specified system.

1.06 QUALITY ASSURANCE

- A. Provide SPD units that are designed, manufactured, tested and installed in compliance with the following codes and standards:
 - 1. IEEE C62.41.1, C62.41.2, C62.45, C62.62.
 - 2. Federal Information Processing Standards Publication 94 (FIPS PUB 94).
 - 3. NEMA.
 - 4. NFPA 20, 70, 75, and 780.
 - 5. UL 1449 current edition and UL 1283.
- B. IEC 801.
- C. Provide surge protective devices that are suitable for application in IEEE C62.41.1, C62.41.2 Category A, B, and C3 environments, as tested to IEEE C62.45.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing:
 - 1. Coordinate with and provide SPD equipment to the electrical equipment manufacturer before final assembly and factory testing.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.
- B. Extended warranty:
 - 1. Furnish a manufacturer's standard parts and labor warranty from date of shipment against any part failure when installed in compliance with the manufacturer's written instructions, UL listing requirements, and any applicable national, state, or local electrical codes.
 - 2. Warranty shall include:
 - a. Direct, factory trained employees must be available within 48 hours for assessment of the problem.
 - b. A 24-hour toll-free 800-number for warranty support.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide surge protection as indicated on the Drawings.

2.03 MANUFACTURERS

- A. One of the following or equal:
1. ABB.
 2. Eaton.
 3. Southern Tier Technologies.
 4. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. Provide Type 1 or Type 2 SPD units as required for the locations indicated on the Drawings.
- B. Electrical requirements:
1. SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
 2. MCOV:
 - a. For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): Greater than 115 percent of the nominal system operating voltage.
 3. Operating frequency:
 - a. 47 to 63 hertz.
 4. SCCR:
 - a. 65 kAIC minimum, but not less than the equipment it is connected to as indicated on the Drawings.
 - b. Marked on the SPD in accordance with UL 1449 and the NEC.
 5. Nominal discharge current I_n :
 - a. 20 kA.
 6. Maximum VPR:

Modes	240/120 3W	208Y/120	480Y/277	480 V
L-N, L-G, N-G	700	700	1,200	1,800
L-L	1,200	1,200	2,000	1,800

7. Peak surge current:
 - a. Service entrance locations:
 - 1) 240 kA per phase minimum.
 - 2) 120 kA per mode minimum.

- b. Branch locations:
 - 1) 120 kA per phase, minimum.
 - 2) 60 kA per mode minimum.
- C. Protection modes:
 - 1. Provide SPD protection modes as follows:
 - a. Line to Neutral (L-N) where applicable.
 - b. Line to Ground (L-G).
 - c. Neutral to Ground (N-G), where applicable.
- D. Environmental requirements:
 - 1. Storage temperature:
 - a. -40 to 122 degrees Fahrenheit.
 - 2. Operating temperature:
 - a. 32 to 140 degrees Fahrenheit.
 - 3. Relative humidity:
 - a. 5 to 95 percent.
 - 4. Audible noise:
 - a. Less than 45 dBa at 5 feet (1.5 m).
 - 5. Operating altitude:
 - a. Zero to 12,000 feet above sea level.

2.07 COMPONENTS

- A. Enclosure:
 - 1. Located in electrical equipment as indicated on the Drawings.
- B. Internal connections:
 - 1. Provide low impedance copper plates for intra-unit connections:
 - a. Attach surge modules using bolted connections to the plates for low impedance connections.
 - 2. Size connections, conductors, and terminals for the specified surge current capacity.
- C. Surge diversion modules:
 - 1. MOV:
 - a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer's defects.
- D. Overcurrent protection:
 - 1. Individually fuse components, including suppression, filtering, and monitoring components:
 - a. Rated to allow maximum specified nominal discharge current capacity.
 - b. Overcurrent protection that limits specified surge currents is not acceptable.
- E. Connections:
 - 1. Provide terminals to accommodate wire sizes up to #2 AWG.

2.08 ACCESSORIES

- A. Unit status indicators:
 - 1. Provide red and green solid-state indicators, with printed labels, on the front cover to redundantly indicate on-line unit status:
 - a. The absence of the green light and the presence of the red light indicate that surge protection is reduced and service is needed to restore full operation.
 - b. Indicates the status of protection on each mode or phase.
- B. Dry contacts for remote monitoring:
 - 1. Electrically isolated Form C dry contacts (1 A/125 VAC, or 2 A/24 VDC) for remote monitoring of system integrity, and indication of under voltage, phase and/or power loss.
- C. Provide an audible alarm which activates under any fault condition:
 - 1. Alarm On/Off switch to silence the alarm.
 - 2. A visible LED will confirm whether alarm is On or Disabled.
 - 3. Locate both switches and the audible alarm on the unit's front cover.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Source Testing:
 - 1. Perform manufacturer's standard factory test:
 - a. Perform testing in accordance with UL 1449.
 - 2. Furnish test reports and Manufacturer's Certificate of Source Testing.
- B. Permanently affix surge rating to the SPD.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Follow the manufacturer's recommended installation practices and comply with all applicable codes.
- B. Special techniques:
 - 1. Install SPDs internal to equipment with as short and straight conductors, including ground conductor as practically possible:
 - a. Twist the input conductors together to reduce input conductor inductance.
 - 2. Do not subject SPD to insulation resistance testing.

3.04 FIELD QUALITY CONTROL

A. Field electrical acceptance testing:

1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING (NOT USED)

END OF SECTION

SECTION 26_50_10

LIGHTING: LED LUMINAIRES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. LED luminaires, drivers, poles, and accessories.

1.02 REFERENCES

- A. Illuminating Engineering Society (IES):
 - 1. LM-79 - Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products.
 - 2. LM-80 - Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules.
 - 3. RP-7 - Recommended Practice for Lighting Industrial Facilities.
 - 4. TM-21 - Projecting Long Term Lumen, Photon, and Radiant Flux Maintenance of LED Light Sources.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. 410 - Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts.
- D. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
- E. Underwriters Laboratories (UL):
 - 1. 1598 - Luminaires.
 - 2. 8750 - Light Emitting Diode (LED) Equipment for Use In Lighting Products.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. CCT (correlated color temperature) - Scientific scale to describe how “warm” or how “cool” the light source is, measured in Kelvin. The lower the Kelvin temperature, the warmer the light feels, or appears.
 - 2. CRI (color rendering index) - A quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source.
 - 3. Driver - Device that manages power and controls the current flow from AC to DC for an LED lighting product.

4. Efficacy - Lumen output of a light source per unit of power supplied to that source (lumens per watt).
5. EMI (electromagnetic interference) - Electrical interference (noise) generated by electrical and electronic devices.
6. FC (foot candles) - Measure of light level on a surface being illuminated.
7. L70 - Extrapolated life in hours of the luminaire when the luminous output depreciates 30 percent from initial values.
8. LED (light emitting diode) - A solid-state semiconductor device that produces light when electrical current flows through it.
9. LED light source - See LED luminaire.
10. LED luminaire - A complete lighting unit consisting of LED-based light emitting elements and a matched driver together with parts to distribute light, to position and protect the light emitting elements, and to connect the unit to a branch circuit.
11. Lumen - International (SI) unit of luminous flux or quantity of light. The amount of light that is spread over a square foot of surface by 1 candle power when all parts of the surface are exactly 1 foot from the light source.
12. Lumen ambient temperature multiplier - LED light source relative lumen output when compared to a standard ambient temperature.
13. Lumen maintenance factor - How well an LED light source is able to retain its intensity when compared to new.
14. Luminaire - Lighting unit.
15. THD (total harmonic distortion) - Combined effect of harmonic Distortion on the AC waveform produced by a driver or other device.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing for light poles.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 1. LED luminaires:
 - a. Catalog literature for each luminaire specified, cross-referenced to the luminaire type on the Luminaire Schedule, in the Drawings.
 - b. Provide for each luminaire type:
 - 1) Materials.
 - 2) Type of diffuser.
 - 3) Hardware.
 - 4) Gasketing.
 - 5) Reflector.
 - 6) Chassis.
 - 7) Finish and color.
 - 8) Driver type and protection.
 - 9) LED luminaire:
 - a) Initial lumen output at 40 degrees Celsius ambient.
 - b) Correlated color temperature.

- c) Lumen maintenance factors.
 - d) Lumen ambient temperature multipliers.
 - e) Drive current.
 - f) Efficacy.
- 10) Picture of luminaire.
- 11) IES optical distributions.
- 12) Dimensioned drawings:
 - a) Effective projected area rating for pole mounted luminaires.
- 13) Weight.
- 14) Photometric data:
 - a) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
 - b) Luminaire dirt depreciation factor.
 - c) Candlepower distribution curves.
 - d) Average luminaire brightness.
 - e) Lumen output charts.
- 15) Furnish support method for interior luminaires weighing more than 30 pounds and all wall-mounted luminaires:
 - a) Support methods shall be based on seismic requirements at the Project Site as specified in Section 01_81_50 - Design Criteria.
- c. Luminaire substitutions:
 - 1) Provide complete literature for each luminaire substitution:
 - 2) Submittals for substituted luminaires shall be sufficient for competent comparison of the proposed luminaire to the originally specified luminaire:
 - a) Photometric data:
 - (1) IES file in standard IES format.
 - (2) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
 - (3) Candlepower distribution curves.
 - (4) Average luminaire brightness.
 - (5) Lumen output charts.
 - (6) Power requirements in watts and volt-amperes.
 - b) Calculations:
 - (1) Provide software generated calculations showing illuminance levels in footcandles and power usage in watts per square foot for each of the areas in which substitutions are proposed:
 - (a) Use surface reflectance values in accordance with IES RP-7.
 - (b) Use manufacturer projected lumen maintenance factor for minimum of 60,000 hours to perform all calculations.
 - c) Specification sheets:
 - (1) If lacking sufficient detail to indicate compliance with Contract Documents, standard specification sheets will not be accepted. This includes, but is not limited to, luminaire type designation, manufacturer's complete catalog number, voltage, LED type, CCT, CRI, specific driver information, system efficacy, L70 life rating, and any modifications necessary to meet the requirements of the Contract Documents.

- 3) Substitutions for specified luminaires will be evaluated upon quality of construction, light distribution, energy use, appearance, and maintenance.
 - 4) Substitutions shall comply with all applicable building and energy codes.
 2. Driver: Provide for each driver type:
 - a. Catalog number.
 - b. Type of driver.
 - c. Output wattage.
 - d. Input voltage.
 - e. Operating voltage range.
 - f. Maximum input power.
 - g. Efficiency.
 - h. Operating line current.
 - i. Power factor.
 - j. Operating temperature range.
 - k. Current output range in ambient temperatures of 30 to 55 degrees Celsius.
 - l. Surge suppression data.
 3. Photocell:
 - a. Provide for each photocell type:
 - 1) Switching capacity.
 - 2) Life expectancy when used on LED sources.
 - 3) Means of adjusting the lighting pickup level.
 - 4) Enclosure type.
 - 5) Mounting method.
 4. Luminaire poles:
 - a. Submit complete data for each pole type including, but not limited to:
 - 1) Material.
 - 2) Finish and color.
 - 3) Handholes.
 - 4) Anchoring.
 - 5) Luminaire attachment methods and fittings.
 - 6) Pole height.
 - 7) Pole dimensions.
 - 8) Bolt hole circle layout and hardware.
 - 9) Accessories.
 - 10) Provide the EPA wind load rating.
 - 11) Installation instructions for rigging, moving and setting into place.
- C. Delegated Design Submittals:
 1. Project-specific calculations with anchoring and bracing details based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
- D. Record documents:
 1. Update the Luminaire Schedule in the Drawings to reflect the acceptable substitutions, after the substitution has been reviewed and accepted by the Engineer.

1.06 QUALITY ASSURANCE

- A. Luminaires shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Scheduling:
 - 1. Exterior and outdoor lighting system operation shall be demonstrated during the hours of darkness.
 - 2. Lighting demonstration shall occur within 2 weeks before substantial completion.

1.10 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.
- B. LED luminaire:
 - 1. 5-year warranty from the date of installation including material, workmanship, photometrics, driver, and LED modules.

1.11 MAINTENANCE

- A. Furnish 1 complete spare LED luminaire, with driver, of each type used.

PART 2 PRODUCTS

2.01 GENERAL

- A. Individual luminaire types are indicated on the Drawings and on the Luminaire Schedule.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide luminaires and accessories for all lighting systems, complete and operable, in accordance with the requirements of the Contract Documents.

2.03 MANUFACTURERS

- A. Luminaires:
 - 1. The following or equal:
 - a. As noted on the Luminaire Schedule.
- B. Drivers:
 - 1. One of the following or equal:
 - a. eldoLED.
 - b. Philips Advance.

- c. Thomas Research.
- C. Photo-electric cells:
 - 1. One of the following or equal:
 - a. Cooper.
 - b. Hubbell-Killark.
 - c. Intermatic.
 - d. Tork.
- D. Substitutions:
 - 1. Lighting design and luminaire selection has been based upon the photometric data of the identified luminaire. It is the Contractor's responsibility to ensure and prove to the Engineer at time of Submittal the substitutions meet the quality and photometric requirements of the original design.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

- A. LED luminaires:
 - 1. General:
 - a. Pre-wired with leads of 18-AWG, minimum, for connection to building circuits.
 - b. Provide the luminaires furnished as indicated on the Luminaire Schedule in the Drawings:
 - 1) Specifications noted in this Section are an addition or supplement to the Luminaire Schedule.
 - c. Individual LEDs connected such that a catastrophic loss or the failure of 1 LED will not result in the loss of the entire luminaire.
 - 2. Minimum ambient temperature range of 0 degrees Celsius to 40 degrees Celsius.
 - 3. Minimum rated life:
 - a. Office areas: 70,000 hours when operated at 25 degrees Celsius.
 - b. Process areas: 100,000 hours when operated at 40 degrees Celsius.
 - c. Hazardous areas: 100,000 hours when operated at 40 degrees Celsius.
 - 4. Minimum efficacy of 70 lumens/watt.
 - a. Hazardous areas: Minimum 60 lumens/watt.
 - 5. Minimum Color Rendering Index of 70.
 - 6. Tested according to IES LM-79 and LM-80.
 - 7. Lumen maintenance projection in accordance with IES TM-21.
 - 8. RoHS compliant.
 - 9. Integral driver.
 - 10. Suitable for dry, damp, or wet locations as indicated on the Drawings or on the Luminaire Schedule.
 - a. Wet or damp locations: UL 1598 listed.
 - 11. Designed as a complete LED assembly. Retrofit LED lamps in luminaires not designed specifically for LED light sources shall not be used.

12. Exterior/outdoor luminaires:
 - a. Luminaires in combination with their mounting pole and bracket shall be capable of withstanding:
 - 1) Wind levels at the Project Site without damage.
 - 2) Seismic levels at the Project Site.
 - b. Corrosion-resistant hardware and hinged doors or lens retainer.
 - c. Luminaires furnished with integral photoelectrical control shall be of the luminaire manufacturer's standard design.
- B. Photo-electric cells:
 1. Weatherproof
 2. In Class I Division 2 locations:
 - a. Rated for used in Class I Division 2, Groups A, B, C, D locations.
 - b. Factory sealed
 3. Photoelectric cells for control of multiple luminaires:
 - a. Self-contained.
 - b. Provided with time-delay features.
 - c. Sized to meet switching capacity of the circuit:
 - 1) Based on luminaire VA as indicated on the Drawings.
 4. Photoelectric cell for control of a single luminaire:
 - a. Integral to the luminaire.
- C. Luminaire control:
 1. Lighting control relays or contactors as specified in Section 26_29_05 - Motor Starters.
- D. Drivers:
 1. Dimmable, with dimming signal protocol of 0-10 VDC or DALI.
 2. Input power source:
 - a. As indicated on the Drawings.
 3. Drive current:
 - a. As indicated in the Luminaire Schedule.
 4. Power factor: Greater than 0.90.
 5. Efficiency: Greater than 80 percent.
 6. Total harmonic distortion (THD) of the input current less than 20 percent.
 7. Rated life of 60,000 hours in an LED luminaire operated at an ambient temperature of 40 degrees Celsius.
 8. Minimum operating temperature of -40 degrees Celsius.
 9. Sound rating: Class A+ or quieter.
 10. UL listed Class 2 Outdoor in accordance with UL 8750.
 11. In accordance with IEEE C62.41 Category A for transient protection.
 12. Driver must limit inrush current:
 - a. Meet or exceed NEMA 410 driver inrush standard:
 - 1) 230 amps per 10 amp load with a maximum of 106 amps squared-seconds at 120 V.
 - 2) 430 amps per 10 amp load with a maximum of 370 amps squared-seconds at 277 V.

2.07 COMPONENTS

- A. Luminaire poles:
 - 1. As indicated on the Luminaire Schedule.
 - 2. Anchor bolts:
 - a. Use anchor bolts, bolts, or welded studs for anchors for resisting seismic and wind forces.
 - 1) Standard hex bolt head.
 - 2) Do not use anchor bolts fabricated from rod stock with an L- or J-shape.
 - b. Complete with leveling shims.
 - 3. Anchor base:
 - a. Fabricated from the same type of material as the pole shaft.
 - b. Base plate to telescope the pole shaft.
 - c. Welded top and bottom along the entire perimeter.
 - d. With slotted bolt holes on the bolt circles as submitted.
 - 4. Pole shaft:
 - a. As indicated on the Luminaire Schedule.
 - 5. Handhole:
 - a. Reinforced handhole located approximately 18 inches above the base.
 - b. Complete with cover fabricated from the same material as the pole shaft and stainless steel attachment screws.
 - c. With an integral ground connection nut, 1/2 inch by 13 inch UNC welded to the pole for connection to the grounding system.
 - 6. Shroud:
 - a. Fabricated from the same type of material as the pole shaft.
 - b. 1-piece formed channel section that shall conform to the pole shaft taper.
 - c. Secured by a locking device with provisions for a padlock to prevent accidental lowering.
 - 7. Hinged poles:
 - a. Stainless steel hinge and pin.
 - b. Flexible wiring guide passing through the hinge area for wiring protection.
 - c. Furnish 1 pole mounted lowering winch, for raising and lowering of the hinged portion of the pole.
 - 8. Fastening hardware:
 - a. Stainless steel.
 - 9. Finish:
 - a. As indicated on the Luminaire Schedule.

2.08 ACCESSORIES

- A. Pole mounted convenience outlet:
 - 1. Where indicated, furnish a 120 volt, GFCI protected receptacle:
 - a. Integrally mounted in the pole shaft at 24 inches above the base.
 - 2. Complete with corrosion resistant and weatherproof cover.
- B. Pole mounted toggle switch:
 - 1. Where indicated, furnish a 120 volt 1-pole toggle switch:
 - a. Integrally mounted in the pole shaft at 48 inches above the base.
 - b. Complete with corrosion resistant and weatherproof cover.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. Special techniques:
 - 1. Support luminaires from structural elements capable of carrying the total weight.
 - 2. Install luminaires plumb and square with building and wall intersections:
 - a. Suspend pendant-mounted luminaires that are mounted from sloping ceilings with ball hangers, unless otherwise indicated on the Drawings.
 - b. Install luminaires in machinery rooms after machines have been installed, so as to ensure no conflict with machinery, piping, or ductwork.
 - 3. In all cases, coordinate luminaire locations with work of other trades to prevent obstruction of light from the fixtures:
 - a. Locate bottom of luminaire approximately at the bottom of ductwork, unless otherwise specified or indicated on the Drawings.
 - 4. Support luminaires weighing more than 25 pounds independently of the outlet box and the conduit.
 - 5. Provide ceiling or pendent mounted luminaires with a safety chain connecting the lens, driver, and other components to the building structure.
 - 6. Provide recessed luminaires with auxiliary safety supports attached directly to the building structure:
 - a. Safety supports shall consist of number 12 AWG soft drawn galvanized wires.
 - 7. Install luminaires in accordance with the architectural reflected ceiling drawings:
 - a. Center luminaires on ceiling tiles unless otherwise indicated.
 - 8. Support luminaires installed in suspended grid ceilings, independently of the grid:
 - a. Provide seismic restraint clips for luminaires installed in suspended grid ceilings.
 - 9. Provide luminaires equipped with battery backup with an additional unswitched conductor from the power source circuit designated on the Drawing. Wall switches shall be wired to switch luminaires on and off, while maintaining power to the backup batteries.
- C. Luminaire poles:
 - 1. Set poles on anchor bolts and secured with double nuts on each bolt.

2. Dry-pack the pole base, after the luminaire and pole has been leveled and plumbed.
3. Bond metal poles to the plant grounding system, utilizing a ground lug connection within the pole:
 - a. Route ground conductor through pier and pole base sleeve using Schedule 40 PVC conduit.

3.04 FIELD QUALITY CONTROL (NOT USED)

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING

- A. Aim and verify exterior and outdoor luminaires alignment, during dark evening hours, as directed by the Owner or the Engineer.

3.07 CLEANING

- A. Clean lenses, diffusers, and reflectors.
- B. Refinish luminaires' trim, poles, and support brackets, where finish has been damaged.
- C. Clean LED luminaires (new and old), used during construction for construction lighting, before substantial completion.
- D. Clean and re-lamp existing fluorescent and HID luminaires used during construction for construction lighting, before substantial completion.

3.08 SCHEDULES

- A. Refer to the Luminaire Schedule in the Drawings.

END OF SECTION

SECTION 31_00_00

EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Loosening, excavating, filling, grading, borrow, hauling, preparing subgrade, compacting in final location, wetting and drying, and operations pertaining to Site grading for buildings, basins, reservoirs, boxes, roads, and other facilities.
 - 2. Backfilling and compacting under and around structures.

1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. Standard Specifications for Highway Bridges.
- B. ASTM International (ASTM):
 - 1. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³).
 - 2. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Backfill adjacent to structure: Backfill within volume bounded by the exterior surfaces of structure, the surface of undisturbed soil in the excavation around structure, and finish grade around structure.
 - 2. Embankments: Dikes, levees, berms, and similar facilities.
 - 3. Excavation: Consists of loosening, removing, loading, transporting, depositing, and compacting in final location, wet and dry materials, necessary to be removed for purposes of construction of structures, ditches, grading, roads, and such other purposes as are indicated on the Drawings.

1.04 SUBMITTALS

- A. Copy of Property Owner's Agreement allowing placement of surplus soil material on their property.
- B. Provide one combined submittal that addresses requirements of related work, including requirements of Section 31_23_19 – Dewatering, Section 31_50_00 – Excavation Support and Protection, and Section 31_09_13 – Geotechnical Instrumentation and Monitoring.

- C. Excavation plan:
 - 1. Prepare and submit an excavation plan as required by Section 01_57_29 – Integrated Excavation Plan.
- D. Test reports:
 - 1. Submit certified test reports of tests specified to be performed by the Contractor.
 - 2. Sign and seal test reports by a registered Civil Engineer who practices geotechnical engineering registered in the state of Utah.

1.05 QUALITY ASSURANCE

- A. Initial compaction demonstration:
 - 1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
 - a. 50 cubic yards of backfill adjacent to structures.
 - b. 100 cubic yards of embankment work.
 - c. 100 cubic yards of fill.
 - d. 50 cubic yards of roadway base material.
 - e. 100 cubic yards of road fill.
 - 2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
 - 3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under the Field Quality Control article.
- B. Perform Work related to this Section in accordance with the approved Stormwater Pollution Prevention Plan (SWPPP).

1.06 SEQUENCING AND SCHEDULING

- A. Schedule earthwork operations to meet requirements specified in this Section for excavation and uses of excavated material.
- B. If necessary, stockpile excavated material in order to use it at specified locations.
- C. Excavation, backfilling, and filling: Perform excavation, backfilling, and filling during construction in manner and sequence that provides drainage at all times.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Performance requirements:
 - 1. Where mud or other soft or unstable material is encountered, remove such material and refill space with stabilization material. Wrap stabilization material with stabilization fabric.

2. Obtain acceptable import material from other sources if surplus obtained within the Project Site does not conform to specified requirements or are not sufficient in quantity.
3. No extra compensation will be made for hauling of fill materials nor for water required for compaction.

2.02 MATERIALS

- A. Water for compacting: Use water from source acceptable to the Engineer.
- B. Soil and rock materials:
 1. General:
 - a. Provide aggregate base course, Class 2 permeable, controlled low-strength material, drain rock, gravel, native material, sand, select material, and stabilization material where specified or indicated on the Drawings.
 - b. If suitable surplus materials are available, obtain native material and select material from cut sections or excavations or imported materials.
 2. Aggregate base course materials: As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
 3. Drain rock: As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
 4. Gravel: As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
 5. Structural Fill: As specified in Section 31_05_15 – Soils and Aggregates for Earthwork.
 6. Native material: As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
 7. Sand: As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
 8. Pea Gravel: As specified in Section 31_05_15 – Soils and Aggregates for Earthwork.
 9. Stabilization material: As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
- C. Controlled low-strength material: As specified in Section 31_23_24 - Controlled Low Strength Materials (CLSM).
- D. Geotextile fabrics:
 1. Filter: As specified in Section 31_32_18.02 - Filter Fabric.
 2. Stabilization: As specified in Section 31_32_18.04 - Stabilization Fabric.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions:
 1. Character and quantity of material:
 - a. Verify character and quantity of rock, gravel, sand, silt, water, and other inorganic or organic materials to be encountered in Work to be performed.

- b. Determine gradation, shrinkage, and swelling of soil, and suitability of material for use intended in Work to be performed.
- c. Determine quantity of material, and cost thereof, required for construction of backfills, cuts, embankments, excavations, fills, and roadway fills, whether from on-site excavations or imported materials. Include in cost of Work to be performed.
- d. Include wasting of excess material, if required, in the cost of Work to be performed.

3.02 PREPARATION

A. Backfills:

1. After clearing and excavation are completed, scarify entire areas that underlie backfills or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
2. Recompect scarified areas to density specified before placing backfill material or concrete.
3. If foundation areas have soft soils, do not scarify the top 6 inches prior to compaction.
 - a. Remove loose material using hand equipment or with a flat-edged backhoe bucket.
 - b. Do not remold and weaken the remaining soil by operating heavy equipment on final bottom elevation of excavation.
4. If foundation areas have cemented rock, cobbles, or boulders, do not scarify the top 6 inches prior to compaction. Moisten the native soil and compact the coarse fill as specified in this Section.
5. If soft clays and/or saturated soils are present at time of placing structural backfill under foundations, a high strength geotextile (Mirafi HP 27) or Engineer-approved equivalent) shall be placed between subgrade and fill to assist in stabilizing the subgrade.
6. Do not place backfill against walls until:
 - a. Walls have been cast full height of structure and concrete has reached the specified strength.
 - b. Connecting slabs and beams have been cast, and concrete has reached the specified strength.
7. Prior to backfilling:
 - a. Remove forms.
 - b. Clean trash and debris from the excavation site.
8. After inspection of foundation, walls, and pipes, place backfill symmetrically around structures to prevent eccentric loading of structures.

B. Embankments:

1. After clearing is completed, scarify entire areas that underlie embankments to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
2. Recompect scarified areas to density specified for embankments before placing of embankment material.
3. If embankment areas have cemented rock, cobbles, or boulders, do not scarify the top 6 inches prior to compaction. Moisten the native soil and compact the coarse fill as specified in this Section.

- C. Fills:
 - 1. After clearing is completed, scarify entire areas that underlie fill sections or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
 - 2. Recompect scarified areas to density specified for compacted fills before placing of fill material or concrete.
 - 3. If fill areas have cemented rock, cobbles, or boulders, do not scarify the top 6 inches prior to compaction. Moisten the native soil and compact the coarse fill as specified in this Section.
- D. Roadway fills:
 - 1. After clearing is completed, scarify entire areas that underlie roadway fills to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
 - 2. Recompect scarified areas to density specified for roadway fills before placing of roadway fill material.
- E. Sloped surfaces for fill or foundations:
 - 1. Foundations for fill having slopes in excess of 1 vertical to 4 horizontal:
 - a. Bench or terrace to adequately key existing ground and fill built thereon.
 - 2. Slopes of original hillsides and old fills: Bench minimum of 10 feet horizontally as fill is placed.
 - 3. Provision of new benches:
 - a. Start new bench wherever vertical cut of next lower bench intersects existing grade.
 - b. Recompect material thus cut out along with new embankment material at no additional cost to the Owner.

3.03 INSTALLATION

- A. General:
 - 1. Dispose of excavated materials that are not required or are unsuitable for fill and backfill in lawful manner.
 - 2. Dispose of surplus material on private property only when written permission agreement is furnished by the owner of the property. Submit copies of such agreements.
 - 3. Rocks, broken concrete, or other solid materials larger than 4 inches in greatest dimension: Remove from the Project Site at no additional cost to the Owner.
 - 4. Stabilization of subgrade: Provide materials used, or perform Work required, to stabilize subgrade so it can withstand loads that may be placed upon it by the Contractor's equipment.
- B. Borrow area: There is no borrow area on the Project Site.
 - 1. Where material is required, import material from source located off Project Site selected by the Contractor and subject to acceptance by the Engineer.
 - 2. There will be no additional cost to the Owner for use of imported material.
- C. Compaction:
 - 1. Provide specified compaction for backfills, cuts, embankments, fills, roadway fills, and other earthwork.

2. Perform confirmation tests to verify and confirm that Work has complied, and is complying at all times, with compaction requirements specified in this Section for initial compaction demonstration and field quality control testing.
 3. In-place density of compacted backfills, cuts, embankments, fills, and roadway fills determined in accordance with ASTM D1556, or with ASTM D6938.
 4. Maximum density, laboratory compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.
 5. To prevent damage to structures due to backfilling operations, place backfill with equipment that does not exceed AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading, within a distance from the face of the structure of not less than 1/2 the depth of backfill.
 - a. Depth of backfill is the distance between the level being compacted and the bottom of the excavation. Outside this distance, heavier compaction equipment may be used.
 6. Compact to percentage of maximum density as follows:
 - a. Backfill adjacent to structures: 95 percent.
 - b. Backfilling voids: 95 percent.
 - c. Embankments: 95 percent.
 - d. Demolition areas: As indicated on the Drawings.
 - e. Intermediate dikes and sludge bed sides: 90 percent.
 - f. Loose fill:
 - 1) No compaction other than by hauling vehicles will be required.
 - 2) Uniformly distribute travel of vehicles over fill area as required to provide uniformly compacted surface.
 - g. Other areas: 85 percent.
 - h. Spoil areas indicated on the Drawings: No minimum required.
 - i. Under present and future structures: 95 percent.
 - j. Under roadways, parking and storage areas, curbs, and sidewalks: 95 percent.
 - k. Upper 6 inches of cuts: 95 percent.
 - l. Fills: 95 percent.
- D. Dewatering: As specified in Section 31_23_19 - Dewatering.
- E. Excavation:
1. Blasting: Not permitted.
 2. Excavations for trenching: As specified in Section 31_23_35 - Trenching.
 3. Excavations for structures:
 - a. Provide excavations conforming to the dimensions and elevations indicated on the Drawings for each structure.
 - b. After clearing is complete, the Contractor will excavate per Section 01_57_29 – Integrated Excavation Plan and will only excavate down to elevations as approved by the Engineer in the approved Integration Excavation Plan.
 - c. Where soil is encountered having unsuitable bearing value, the Engineer may direct in writing that excavation be carried to elevations below those indicated on the Drawings.

- d. Where excavations are made below elevations indicated on the Drawings, adjust elevations of excavations in accordance with the following requirements:
 - 1) Under slabs: Restore to proper elevation in accordance with procedure specified for backfill in this Section.
 - 2) Under footings: Restore to the proper elevation using one of the following:
 - a) Aggregate base course.
 - b) Controlled low-strength material.
 - e. Excavation width:
 - 1) Extend excavations at least 2 feet clear from walls and foundations of structures to allow for placing and removal of forms, installation of services, and inspection.
 - 2) Do not undercut slopes.
 - f. Difficulty of excavation: No extra compensation will be made for removal of rock or any other material due to difficulty of excavation.
4. Excavation of lined channels:
- a. Excavations in open cut for lined channels may be made so as to place concrete directly against excavated surfaces providing faces of excavations are:
 - 1) Firm and unyielding.
 - 2) Will stand or can be made to stand without sloughing.
 - b. Excavations to provide subgrade for lined channel or subdrainage material: Excavate to lines and grades indicated on the approved Integrated Excavation Plan.
5. Excavation of unlined channels and basins:
- a. Excavate to lines and grades indicated on the approved Integrated Excavation Plan.
 - b. Perform excavation and grading so that finish surfaces are in uniform planes with no abrupt breaks in surface.
6. Excavation of ditches and gutters:
- a. Cut ditches and gutters accurately to cross sections and grades indicated on the approved Integrated Excavation Plan.
 - b. Take care not to excavate ditches and gutters below grades indicated on the Drawings.
 - c. Backfill excessive ditch and gutter excavations to grade with suitable material acceptable to the Engineer.
 - d. Do not deposit any material within 3 feet of edge of ditch unless otherwise indicated on the Drawings.
7. Necessary over excavation:
- a. Where it becomes necessary to excavate beyond normal lines of excavation in order to remove boulders or other interfering objects, backfill voids remaining after removal as specified in backfilling of voids below, or as acceptable to the Engineer.
 - b. Backfill voids with material acceptable to the Engineer:
 - 1) With acceptance of the Engineer, backfill with one of the following:
 - a) Aggregate base course.
 - b) Controlled low-strength material.

- F. Materials for backfills, embankments, fills, and roadway fills:
1. General:
 - a. Obtain import material from other sources if surplus materials from cuts and excavations obtained from within the Project Site do not conform to specified requirements or are not sufficient in quantity for construction of Project.
 2. Backfills:
 - a. Backfill adjacent to structures, slabs, or walls: Native material or imported material meeting the requirements of native material, unless otherwise specified or indicated on the Drawings.
 - b. Backfill material under concrete structures: Aggregate base course material, except in areas where controlled low-strength material or concrete encasement are indicated on the Drawings.
 - c. Extend backfill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
 3. Embankments:
 - a. Native material or imported material meeting the requirements of native material, unless otherwise specified or indicated on the Drawings.
 4. Fills:
 - a. Native material or imported material meeting the requirements of native material, unless otherwise specified or indicated on the Drawings.
 - b. Extend fill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
 5. Roadway fills: One of the following, unless otherwise specified or indicated on the Drawings:
 - a. Aggregate base course material.
 - b. Native material or imported material meeting the requirements of native material.
- G. Placement:
1. General:
 - a. Lines and grades:
 - 1) Construct backfills, embankments, fills, and road fills, at locations and to lines and grades indicated on the Drawings.
 - 2) Overbuild permanent fill slopes by at least 1 foot and then cut to final grade to provide adequate compaction of the remaining fill.
 2. Backfills:
 - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
 - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
 - c. Defective compacted backfills: Remove and recompact.
 - d. Adjacent to Structures: Hand operated equipment will only be used within a line extending upward from the base of the structure at 0.5 horizontal to 1 vertical (0.5H:1V, or at least 3 feet from the wall, whichever is greater).
 3. Fills:
 - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
 - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
 - c. Defective compacted fills: Remove and recompact.

4. Coarse fill:
 - a. When materials are coarsely graded so that performance of field density tests are impossible:
 - 1) Placement and compaction: Place material in lifts so as to obtain compacted thickness of 6 inches and roll with pneumatic roller or power roller.
 - 2) Moisture content: Provide moisture content of fraction of material passing 3/4-inch sieve within 2 percent of optimum moisture, as determined in accordance with ASTM D1557, Method C.
5. Embankments:
 - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
 - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
 - c. Defective compacted embankments: Remove and recompact.
6. Roadway fills:
 - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
 - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
 - c. Defective compacted roadway fills: Remove and recompact.
7. Loose fill:
 - a. In disposal areas as indicated on the Drawings, bring fill up in an essentially level layer over entire spoil area indicated:
 - 1) Continue filling spoil area until disposal of surplus excavated material is completed.
 - 2) Slope edges of fill area at between 1 and 2 horizontal to 1 vertical to the intersection with existing grade.
 - 3) Provide slopes that are smooth and uniform.
 - 4) Level finished surface of disposal area to within 4 inches of elevation indicated on the Drawings.
 - b. Clods or hard lumps of earth of 6 inches in greatest dimension: Break up before compacting material in embankments, except as provided as follows:
 - 1) When fill material includes large rocky material or hard lumps, such as hardpan or cemented gravel which cannot be broken readily, distribute such material throughout fill.
 - 2) Place sufficient earth or other fine material around larger material as it is deposited so as to fill interstices and produce dense, compact fill. Do not place such material within 2 feet of finish grade of fill.

3.04 FIELD QUALITY CONTROL

- A. Confirmation tests:
 1. Contractor's responsibilities:
 - a. Adequacy of compaction equipment and procedures:
 - 1) Demonstrate adequacy of compaction equipment and procedures.
 - 2) At each test location include tests for each type or class of backfill from bedding to finish grade.

- b. Compaction sequence requirements:
 - 1) Do not perform additional earthwork of the same kind until specified degree of compaction has been demonstrated.
 - c. Cost of confirmation tests: Paid for by the Contractor.
 - d. Qualifications of the Contractor's testing laboratory: Acceptable to the Engineer.
 - e. Copies of confirmation test reports: Submit promptly to the Engineer.
 - 2. Frequency of confirmation testing:
 - a. Maximum dry density versus moisture:
 - 1) Backfill: 1 per lift every 250 square feet.
 - 2) Cuts: 1 per lift every 500 square feet.
 - 3) Embankments: 1 per lift every 2,500 square feet.
 - 4) Fills: 1 per lift every 2,500 square feet.
 - 5) Roadway and trail fills: 1 per lift every 1,250 square feet.
 - 6) Miscellaneous small structures (manholes, vaults, catch basins, etc.): 1 per lift at each footprint.
 - b. Cost of confirmation tests:
 - 1) Paid for by the Contractor.
 - c. Qualifications of the Contractor's testing laboratory:
 - 1) Perform confirmation testing by soils testing laboratory acceptable to the Owner and Engineer. Copies of confirmation test reports: Submit promptly to the Engineer.
- B. Tolerances:
 - 1. Finish grading of backfills, cuts, embankments, fills, and roadway fills:
 - a. Perform fine grading under concrete structures such that finish surfaces are never above the grade or cross section indicated on the Drawings and are never more than 0.10 feet below.
 - b. Provide finish surface for areas outside of structures that are within 0.10 feet of grade or cross section indicated on the Drawings.
 - 2. Unlined channels and basins:
 - a. In both cut and fill, and levee and access road side slopes in cut: Vertical tolerance of none above and 3 inches below grade indicated on the Drawings on bottom and side slopes.
 - b. On top surface of levee and access road in both cut and fill, and levee and access road side slopes in fill: Vertical tolerance of none below and 3 inches above grade indicated on the Drawings.
 - 3. Areas which are not under structures, concrete, asphalt, roads, pavements, sidewalks, dikes, and similar facilities:
 - a. Provide finish graded surfaces of either undisturbed soil, or cohesive material not less than 6-inches deep.
 - b. Intent of proceeding is to avoid sandy or gravelly areas.
 - 4. Finish grading of surfaces:
 - a. Reasonably smooth, compacted, and free from irregular surface changes.
 - b. Provide degree of finish that is ordinarily obtainable from blade grader operations, except as otherwise specified.
 - c. Uniformly grade areas that are not under concrete.
 - d. Finish ditches and gutters so that they drain readily.

- C. Compliance tests:
 - 1. Frequency of testing: Periodic compliance tests will be made by the Engineer to verify that compaction is meeting requirements previously specified.

3.05 ADJUSTING

- A. Finish grades of excavations, backfills, and fills:
 - 1. Repair and reestablish grades to required elevations and slopes due to any settlement or erosion that may occur from action of the elements or any other cause prior to final acceptance.

3.06 PROTECTION

- A. Finish grades of backfills, cuts, excavations, and fills:
 - 1. Protect newly graded areas from erosion and deterioration by action of the elements.
- B. Ditches and gutters:
 - 1. Maintain ditches and gutters free from detrimental quantities of debris that might inhibit drainage until final acceptance.

END OF SECTION

SECTION 31_05_15

SOILS AND AGGREGATES FOR EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Material requirements for soils and aggregates.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C117 - Standard Test Method for Materials Finer than 75- μ m (No. 200) Sieve in Mineral Aggregates by Washing.
 - 2. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
 - 3. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - 4. C535 - Standard Test Method for Resistance to Degradation of Larger-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
 - 5. D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
 - 6. D2844 - Standard Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils.
 - 7. D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
 - 8. D4829 - Standard Test Method for Expansion Index of Soils.
 - 9. D5821 - Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.
- B. Utah Department of Transportation (UDOT):
 - 1. Standard Specifications for Road and Bridge Construction (Standard Specifications).

1.03 SUBMITTALS

- A. Product data:
 - 1. Material source.
 - 2. Gradation.
 - 3. Testing data.
- B. Quality control for aggregate base course:
 - 1. Test reports: As required by Sections of Standard Specifications and Manual of Standard Specifications.
 - 2. Certificates of compliance: As required by Sections of Standard Specifications and Manual of Standard Specifications.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Storage and protection: Protect from segregation and excessive moisture during delivery, storage, and handling.
- B. Comply with Standard Specifications storage requirements, if applicable.

PART 2 PRODUCTS

2.01 MATERIALS - GENERAL

- A. Provide material having maximum particle size not exceeding 4 inches and that is free of trash, lumber, debris, leaves, grass, roots, stumps, and other organic matter.
- B. Materials derived from processing demolished or removed asphalt concrete are acceptable only under new pavement as allowed by the specifications.
- C. Comply with soil and aggregate material requirements in the Standard Specifications, unless specified otherwise.

2.02 NATIVE MATERIAL

- A. Native soil-select:
 - 1. Sound earthen material.
 - 2. Sum of plasticity index when tested in accordance with ASTM D4318 and the percent of material by weight passing a No. 200 sieve shall not exceed 23 when tested in accordance with ASTM C136.
 - 3. Organic content not be greater than 3 percent by volume.
 - 4. Corrosion resistance requirements:
 - a. Resistivity minimum (wet aggregates): 5,000 ohm-cm.
 - b. pH: 5.0 to 12.0.
 - c. Chlorides maximum: 100 parts per million.
 - d. Sulfates maximum: 200 parts per million.

2.03 AGGREGATE BASE COURSE

- A. Material requirements:
 - 1. Untreated base course as specified in the APWA Utah Manual of Standard Specifications Grade 1-1/2.
 - 2. Consists of hard durable particles of fragments of stone or gravel; screened or crushed to required size and grading; and free from organic matter, contamination from chemical or petroleum products, or other deleterious matter.
 - 3. When sampled and tested in accordance with specified test methods, material shall comply with the following requirements:
 - a. Percentage of wear: Not to exceed 50 percent after 500 revolutions when tested in accordance with AASHTO TP 95.
 - b. Plasticity index: Shall not be more than 6 when tested in accordance with AASHTO T 90.

- c. Conforms to size and grade within the following limits when tested in accordance with AASHTO T 11 and AASHTO T 27:

Sieve Sizes (Square Openings)	Percent by Weight Passing Sieve
1 inch	100
3/4 inch	-- -
1/2 inch	-79 - 91
3/8 inch	-- -
No. 4	-49 - 61
No. 16	-27 - 35
No. 200	7 - 11

2.04 GRAVEL

- A. Material requirements:
1. Consist of hard, durable particles of stone or gravel, screened or crushed to the specified sizes and gradations.
 2. Free of organic matter, lumps or balls of clay, and other deleterious matter.
 3. When sampled and tested in accordance with specified test methods, material shall comply with the following:
 - a. Durability: Percentage of wear not greater than 40 percent when tested in accordance with ASTM C 131.
 - b. Plasticity Index: Not greater than 54 when tested in accordance with ASTM D4318.
 - c. Liquid Limit: Not greater than 25 percent when test in accordance with ASTM D4318.
 4. Conform to sizes and grade within the limits as follows when tested in accordance with ASTM C 117 and C 136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve	
	Type A	Type B
3 inch	100	--
1-1/2 inch	--	100
Number 4	30-75	30-70
Number 30	10 - 40	10 - 40
Number 200	0-12	0-12

2.05 DRAIN ROCK

- A. Material requirements:
1. Durability: Percentage of wear not greater than 40 percent when tested in accordance with ASTM C 131.

2. Consist of hard, durable particles of stone or gravel, screened or crushed to the specified size and gradation.
3. Provide free of organic matter, lumps or balls of clay, and other deleterious matter.
4. Crush or waste coarse material and waste fine material as required to meet gradation requirements.
5. Conform to size and grade within the limits as follows when tested in accordance with ASTM C 117 and C 136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
2 inch	100
1-1/2 inch	90-100
1 inch	20-55
3/4 inch	0-15
3/8 inch	0-15

2.06 GRADING ROCK

- A. Material requirements:
1. Consist of hard, durable particles of stone or gravel, screened or crushed to the specified size and gradation.
 2. Provide free of organic matter, lumps or balls of clay, and other deleterious matter.
 3. Crush or waste coarse material and waste fine material as required to meet gradation requirements:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
1-1/2 inch	100
1 inch	90-100
1/2 inch	25-60
Number 4	0-10

2.07 STRUCTURAL FILL

- A. Material requirements:
1. Consist of hard, durable particles of stone or gravel, screened or crushed to the specified size and gradation.
 2. Provide free of organic matter, lumps or balls of clay, and other deleterious matter.
 3. When sampled and tested in accordance with specified test methods, material shall comply with following requirements:
 - a. Plasticity Index: Non-plastic or not greater than 6 when tested in accordance with ASTM D4318.
 - b. Sand Equivalent: Not less than 75 when tested in accordance with ASTM D2419.

4. Conforms to size and grade within the following limits when test in accordance with ASTM C117 and C136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
1-1/2 inch	100
1 inch	90-100
1/2 inch	25-60
Number 4	0-10

2.08 SAND

- A. Clean, coarse, natural sand.
- B. Non-plastic when tested in accordance with ASTM D4318.
- C. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and ASTM C136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
1/2 inch	100
No. 200	0 - 10

2.09 PEA GRAVEL

- A. Pea gravel bedding shall be a clean mixture free from organic matter and conforming to the following gradation when tested in accordance with ATM D-422.

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
1-1/2 inch	100
3/4 inch	30-75
1/2 inch	15-55
1/4 inch	0-5

2.10 STABILIZATION MATERIAL

- A. Material requirements:
1. Consist of hard, durable particles of stone or gravel, screened or crushed to the specified size and gradation.
 2. Provide free of organic matter, lumps or balls of clay, and other deleterious matter.
 3. Shall be free of slaking or decomposition under the action of alternate wetting and drying.
 4. The portion of material retained on the 3/8-inch sieve shall contain at least 50 percent of particles having 3 or more fractured faces. Not over 5 percent shall be pieces that show no such faces resulting from crushing. Of that portion which passes the 3/8-inch sieve but is retained on the Number 4 sieve,

not more than 10 percent shall be pieces that show no faces resulting from crushing.

5. When sampled and tested in accordance with specified test methods, material shall comply with following requirements:
 - a. Durability: Percentage of wear not greater than 40 percent when test in accordance with ASTM C131.
6. Conforms to size and grade within the following limits when test in accordance with ASTM C117 and C136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
1 inch	100
3/4 inch	90-100
Number 4	0-10
Number 200	0-2

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 31_09_13

GEOTECHNICAL INSTRUMENTATION AND MONITORING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Requirements for the installation, monitoring, and removal of geotechnical instrumentation for monitoring of ground movements within and around existing utilities and structures adjacent to excavation and earthwork work for new structures.
- B. Scope of work to be performed under this Section includes:
 - 1. Installing geotechnical instrumentation as indicated on the Drawings.
 - 2. Monitoring, by survey, the geotechnical instrumentations at the frequencies and to the precision stated this Section.
 - 3. Removing the geotechnical instrumentation as described in this Section.
 - 4. Labor, material, tools, equipment, and incidentals necessary to complete the work described above.

1.02 REFERENCES

- A. Occupational Safety and Health Administration (OSHA).

1.03 GENERAL

- A. Give the Owner or Engineer a minimum of 10 days advance notice of the start of the Work.
- B. Perform all Work in the presence of the Owner or Engineer, unless the Engineer has granted prior approval in writing to perform such work in his absence.
- C. Perform Work in accordance with current applicable regulations and codes of federal, state, and local agencies:
 - 1. In the event of conflict, comply with the strictest or most restrictive applicable requirements.
- D. Designate an instrumentation specialist to be in charge of installation and monitoring of instrumentation:
 - 1. Develop the instrumentation plan then supervise and be responsible for the instrument installation and monitoring.
 - 2. In charge of procurement, installation, monitoring, and removal or abandonment of instrumentation.
 - 3. Direction of and review of surveys associated with the geotechnical instrumentation.

- E. Minimum instrumentation and monitoring requirements are presented in this Section.
 - 1. Conduct additional instrumentation and monitoring as necessary to control the Work and ensure the safety of the Work.
- F. Remove or abandon in place all instrumentation in accordance with applicable laws, regulations, guidelines, and Owner requirements; and restore the ground at the completion of the Project.
 - 1. As a minimum, instrumentation shall be demolished within 5 feet of the ground surface and resulting holes or voids filled with cementitious grout to the ground surface.
- G. Perform a preconstruction survey prior to commencement of work at the site.

1.04 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. All Submittals, including Drawings and calculations, shall be required for the sole purpose of providing the Owner and Engineer sufficient details to confirm that the Contractor's planned work and work in progress is in accordance with Contract Documents.
 - 1. Owner and Engineer's review shall not be construed to relieve the Contractor in any way of responsibilities under the Contract.
 - 2. Do not begin work on any item requiring a Submittal until the required relevant Submittals have been reviewed and approved by the Owner and Engineer.
- C. At least 4 weeks prior to the start of the Work, submit the following:
 - 1. Name and qualifications of the Contractor(s) that will perform the Work with descriptions of reference projects, including Owner's name and contact information.
 - a. Contractor shall have performed, installed, and monitored geotechnical instrumentations for a minimum of 5 years on at least 3 separate projects.
 - 2. Name and qualifications of the surveyor who will perform the Work.
 - a. Contractor's instrumentation surveyor must be licensed by the State of **Utah** and have previous similar experience surveying for the detection of structural or surface deformations.
 - b. Surveyor shall be a licensed professional surveyor in the State of **Utah**.
 - 3. Name and qualifications of the instrumentation specialist:
 - a. Shall have at least 3 years of experience with the installation, maintenance, and monitoring of geotechnical instrumentation similar to that specified in this Section.
 - 4. Name and qualifications of the safety supervisor:
 - a. Shall have at least 5 years of experience in safety management on at least 3 separate projects.
- D. At least 4 weeks prior to the start of the Work, submit a health and safety plan/accident prevention program, including a code of safe practices and an emergency plan.

- E. At least 4 weeks prior to the start of the Work, submit a Geotechnical Instrumentation and Monitoring Work Plan, including at least the following:
 - 1. Description of methods and materials for installing and protecting instruments.
 - 2. Materials and mixture proportions for cement-bentonite grout for installing and backfilling extensometers.
 - 3. For instrumentation installed in borings, a proposed schedule for installing instruments, detailed step by step procedures for installation, including post installation acceptance test, together with a sample installation record sheet. Installation procedures shall include:
 - a. Method to be used for cleaning the inside of casing or augers.
 - b. Specifications for proposed grout mixtures, including commercial names, proportions of admixtures and water, mixing sequence, mixing methods and duration, pumping methods and tremie pipe type, size and quantity.
 - c. Drill casing or auger type and size.
 - d. Depth increments for backfilling boreholes with sand and granular bentonite.
 - e. Method for overcoming buoyancy of instrumentation components during grouting.
 - f. Method of sealing joints in pipes and casing to prevent ingress of grout.
 - 4. Product data and samples:
 - a. Submit applicable manufacturer's literature describing operation and maintenance procedures for the instrumentation.
 - b. Provide manufacturer's brochures on each product.
 - c. Provide product description and drawings, along with samples where applicable.
 - 5. List permits, third party approvals, and approval Contract Submittals required to perform the Work.
- F. Prior to starting shaft or tunnel excavation in any reach, submit the initial readings of geotechnical instruments in that reach and the results of the preconstruction survey.
- G. Prior to instrument installation submit, as applicable, a certificate issued by the instrument's manufacturer stating that the manufacturer has inspected, calibrated, and tested each instrument before it leaves the factory to see that the instrument is working correctly and has no defects or missing parts.
- H. Submit the following during construction within the specified time restrictions:
 - 1. Installation records:
 - a. Within 5 calendar days of installation of each instrument, submit Drawings showing the installed location, the instrument identification number, the instrument type, the installation date and time, established elevations, initial elevations, offset and stationing, initial coordinates, boring logs, and the anchor to tip elevation and instrument length, when applicable.
 - b. Furnish details of installed instruments showing dimensions and materials used, a separate statement describing installation procedures for each instrument, and as-built drawings of each instrument including depths, lengths, elevations, and dimensions of key elements.
 - 2. Reporting:
 - a. Provide data from readings of instruments to the Engineer within 1 working day of obtaining the information.

- b. Data shall include, but are not limited to, the following:
 - 1) A copy of the data sheets containing a cumulative history of readings, proximity of the excavation to the instrument location itself at the time of each reading.
 - 2) A copy of the plot of measured values versus time, including a time history of construction activity likely to influence such readings.
- 3. Interpretation:
 - a. Provide interpretations of monitoring data and submit them to the Engineer along with the data.
 - b. Data or interpretations shall not be published or disclosed to other parties without advance written permission of the Engineer.
 - c. Engineer may make his/her interpretations of the data available to the Contractor.

1.05 QUALITY CONTROL

- A. Quality control as specified in Section 01_45_00 - Quality Control.

PART 2 PRODUCTS

2.01 SURFACE PROTECTION

- A. Shall be flush with the ground surface in areas where the instrument may be damaged or be an impediment to other activities.
 - 1. Roadway or lock boxes shall be provided for utility monitoring points.

2.02 MATERIALS

- A. Surface monitoring points:
 - 1. As indicated on the Drawings and to the conditions at the ground surface.
 - 2. Installed in pavement shall be rebar that is driven or drilled through the pavement.
 - 3. Deep anchors installed in soil areas.
 - 4. Each shall have a tag or marking indicating the identification number, tunnel station and/or offset from centerline.
- B. Utility monitoring points:
 - 1. As indicated on the Drawings.
 - 2. Each shall consist of a plastic pipe casing that exposes the utility and retains the ground to allow for multiple readings throughout the work.
 - 3. Provide a protective cover (roadway box).
- C. Extensometer:
 - 1. Fixed multiple point rod type extensometers in protective casings as indicated on the Drawings.
 - 2. Multiple point rods with either hydraulic or groutable anchors as recommended by the manufacturer for the ground conditions present.
 - 3. Anchor depths shall be as indicated on the Instrumentation Schedule in the Drawings.
 - 4. Protect the extensometer head with a roadway box or other suitable cover.

PART 3 EXECUTION

3.01 PREPARATION AND INSTALLATION

- A. Instrumentation installation: At the locations indicated on the Drawings, or as directed or approved by the Engineer.
- B. Instrumentation within 100 feet of the Work to be performed shall be installed and the initial reading taken a minimum of 7 days prior to start of excavation.
- C. Access: Provide and facilitate safe access to the instrumentation to the Owner including keys for lock boxes.
- D. Existing conditions:
 - 1. Locate conduits and underground utilities in areas where subsurface geotechnical instrumentation is to be drilled and installed.
 - 2. Subsurface geotechnical instrumentation locations shall be modified, as approved by the Owner and Engineer, to avoid interference with existing conduits, utilities, and foundation elements.
- E. Instrument designation:
 - 1. A unique instrument identification number shall be assigned to each instrument and each point.
 - 2. Instrument identification number shall be clearly marked on each instrument in a nondestructive manner.
 - 3. Both protective housing and box or vault covers shall be marked.
- F. Instrument protection: Instruments and markings shall be protected to avoid being obstructed or otherwise damaged by construction operations or the general public.
- G. Surveying:
 - 1. Immediately following installation, the location of the top of all instruments shall be surveyed to provide horizontal and vertical coordinates.
 - 2. Data shall be provided to the Owner and Engineer.
 - 3. Re-surveying from control points shall be required monthly or more frequently to address potential disturbance or resolve conflicting data.
- H. Drilling from the ground surface:
 - 1. Instrumentation holes drilled from the ground surface shall be subject to the same permitting and drilling requirements as those for geotechnical exploration boreholes.
 - 2. Obtain necessary permits for each such instrument and conform to the permit requirements during drilling, installation, monitoring, and abandonment.
- I. Installation:
 - 1. Install instruments within 3 feet of the horizontal location indicated on the Drawings, or as approved or directed by the Engineer.
 - 2. Should actual field conditions prevent installation of instruments at the location and elevations indicated on the Drawings or specified in this Section, obtain prior acceptance from the Owner and Engineer for new instrument location and elevation.

3.02 SAFETY REQUIREMENTS

- A. Methods of construction shall be such as to ensure the safety of the workers, project participants, the public, third parties, and adjacent property, whether public or private.
 - 1. Contractor is solely and completely responsible for maintaining safe working conditions at the site at all times.
- B. Safety supervisor shall administer a health and safety plan/accident prevention program, including a code of safe practices and an emergency plan.
 - 1. Hold safety meetings and provide safety instruction for new employees.
- C. Work shall be in accordance with the requirements of OSHA:
 - 1. Perform Work in accordance with the current applicable regulations of the federal, state, and local agencies.
 - 2. In the event of conflict, comply with the more restrictive applicable requirements.
- D. Conduct construction by methods and with equipment that will control noise, dust, fumes, vapors, gases, fibers, fogs, mists, and other atmospheric impurities in accordance with applicable federal, state, and local laws, safety codes, regulations, and ordinances.
 - 1. Provide adequate ventilation, as necessary, and shall design the ventilating system to include such factors as the volume required to furnish fresh air and the volume to remove dust and vapor to safe levels.
- E. Work areas shall have sufficient lighting to facilitate proper performance and inspection of work in accordance with applicable federal, state, and local laws, safety codes, regulations, and ordinances.

3.03 MAINTENANCE

- A. Keep the site clean and tidy at all times.
 - 1. Site improvements shall be protected from damage or becoming soiled through suitable temporary covering.
- B. Upon completion of the Work, waste shall be removed from the site and the site restored to as near its original condition as possible.
 - 1. Any remnants of drilling fluid or grout that may have splattered on improvements shall be completely removed.

3.04 INSTALLATION

- A. Project survey datum shall be as indicated on the Drawings.
- B. Surface monitoring points:
 - 1. Located as indicated on the Instrumentation Schedule in the Drawings.
 - 2. After completion of installation, the as-built location in horizontal position shall be determined to an accuracy of within 1 foot and the elevation to an accuracy of within 0.01 feet.
- C. Utility monitoring points:
 - 1. Install on utilities as indicated on the Instrumentation Schedule in the Drawings.

2. Location of the utility in the field shall be determined and the borehole advanced to the top of the utility.
 - a. Contractor shall be responsible for any damage to the utility during installation of the utility monitoring point.
 3. After completion of installation, the as-built location in horizontal position shall be determined to an accuracy of within 0.1 foot and the elevation of the top of the utility to an accuracy of within 0.01 feet.
- D. Extensometers:
1. Install at as close as practical to the locations and with anchor point locations as indicated on the Instrumentation Schedule in the Drawings.
 2. Conduct drilling operations using appropriate methods that are consistent with subsurface conditions presented.
 - a. Provide drill casing if required to hold drill hole open.
 - b. Drill hole or inside of casing, if applicable, shall provide a clear opening as recommended by the manufacturer.
 - c. A log of the soils encountered during drilling shall be accurately documented and a copy shall be provided to the Engineer.
 3. Install extensometers and anchors in accordance with the manufacturer's recommendations and as indicated on the Drawings.
 - a. Backfill the annulus between extensometer rod sheaths and the ground in accordance with the manufacturer's recommendations.
 4. Grouting and filling shall be done with a grout tube inside the casing beginning at the bottom and working up to ensure complete backfilling.
 5. Protection:
 - a. Install protective housing consisting of flush-mounted roadway box or vault so as not to obstruct vehicle or foot traffic with locking cap and padlock, and provide the Engineer with a key.

3.05 MONITORING

- A. Take initial readings of instruments to establish a baseline and provide the Engineer with this data.
- B. Frequency:
1. Read required instrumentation and provide the Engineer with these data.
 2. As a minimum, maintain the following schedule:

Instrument Type	Inside Active Zone/ Period ^(a,b,c)	Outside Active Zone/ Period ^(a,b,c)
Surface Monitoring Points	Daily	Weekly/Monthly ^(d)
Utility Monitoring Points	Daily	Weekly/Monthly ^(d)
Extensometers	Daily	Weekly/Monthly ^(d)
Notes: (a) Active zone/period for tunnels is within 50 feet of microtunneling boring machine. (b) Active zone/period for shafts is when the instrument is within 50 feet of the shaft, and from the beginning of shaft excavation and 2 weeks following the end of shaft backfilling. (c) Active zone/period for soil preparation is when the instrument is within 50 feet of any drilling, probing, and/or grout injection is occurring and shall extend a minimum of 48 hours after completion of any soil preparation work.		

Instrument Type	Inside Active Zone/ Period^(a,b,c)	Outside Active Zone/ Period^(a,b,c)
(d) Monthly prior to the instrument being in an Active Zone/Period, weekly once the instrument has passed the Active Zone/Period until movement substantially stops, and monthly thereafter until the project is complete.		

3. Perform additional monitoring as necessary to control construction and to ensure the safety of the Work.

3.06 MAINTENANCE

- A. Damaged installations:
 1. Protect the instruments from damage.
 2. Damaged installations shall be replaced or repaired prior to continuing excavation.
- B. Maintain instruments by draining water and flushing debris from under protective covers and keeping covers locked and sealed at all times.

3.07 FINAL DISPOSITION

- A. Surface monitoring points:
 1. Remove points installed in soil.
 2. Points in pavement may remain or be removed and the pavement patched, at the option of the governing agency.
- B. For underground instrumentation and instrumentation installed in bore holes:
 1. Remove protective housings and caps,
 2. Restore surface to the conditions existing prior to installation of the instruments.
 3. Drill out and grout, or backfill grout in accordance with permits, and environmental laws and regulations.

3.08 RESPONSE VALUES

- A. Abide by the following response values:

Instrument	Threshold Value^(a)	Shutdown Value^(a)
Surface Monitoring Points	0.04 feet vertical	0.08 feet vertical
Utility Monitoring Points	Threshold and shutdown values shall be set by the Contractor with review of the Owner and Engineer based on the sensitivity of the utilities identified as requiring monitoring.	
Extensometers	Lowest point: 0.08 feet vertical Intermediate point: 0.06 feet vertical Highest point: 0.04 feet vertical	Lowest point: 0.13 feet vertical Intermediate point: 0.08 feet vertical Highest point: 0.06 feet vertical
Notes:		
(a) Threshold and Shutdown Values shall be considered for both settlement and heave.		

- B. When a given response value is reached, the Contractor shall as follows:
1. Threshold value: Meet with the Owner and Engineer within 24 hours of the occurrence to:
 - a. Review interpretation of the data and results,
 - b. Review the construction means and methods, and
 - c. Determine what changes shall be made to control ground movement.
 2. Shutdown value: Stop tunnel or shaft excavation immediately and meet with the Owner and Engineer to develop a plan of action before excavation can be resumed.

END OF SECTION

SECTION 31_23_19

DEWATERING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Installation and maintenance of dewatering systems as necessary based on geotechnical reports of the project site to maintain groundwater (perched or otherwise) below construction work.
 - 2. Disposal of water entering excavation or other parts of the work.

1.02 REFERENCES

- A. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

1.03 COORDINATION REQUIREMENTS

- A. Coordinate the dewatering system design with excavation and shoring designs.
 - 1. Excavation and shoring design shall consider changes in groundwater conditions and associated earth pressure in compliance with geotechnical report requirements.
- B. Do not place concrete or masonry foundation or concrete slabs in water. Do not allow water to rise over these elements until concrete or mortar has set for at least 24 hours.
 - 1. Maintain operation of dewatering system:
 - a. Until complete structure has been constructed, including walls, slabs, beams, struts, and other structural elements.
 - b. Concrete has attained its specified compressive strength.
 - c. Backfill has been completed to finished grade.

1.04 SUBMITTALS

- A. Combine dewatering plan submittals with earthwork, excavation, shoring and geotechnical instrumentation and monitoring submittals and provide one submittal for Engineer and Owner review as this work is inter-related.
- B. Dewatering plan:
 - 1. Dewatering design analysis.
 - 2. Required permits.
 - 3. Arrangement, location, and depths of dewatering system components.
 - 4. Type and sizes of filters.
 - 5. Identify proposed alignment, support, and protection for discharge pipe. Identify location of discharge and provide details for that location. For pipes discharging to manholes, provide details of pipe entry at manhole.

- C. Well construction logs. Include:
 - 1. Descriptions of actual materials encountered, categorized in accordance with Unified Soil Classification System.
 - 2. Construction details.
 - 3. Well development procedures and results.
 - 4. Deviations from original design.
- D. Qualifications:
 - 1. Dewatering contractor.
 - 2. Dewatering design engineer.
 - 3. Testing laboratory.
- E. Control Points.
 - 1. Location and details of control points and method and schedule of measurement.
 - 2. All structures or facilities located within the radius of influence of the dewatering operation shall have control points established to detect any settlement which may develop.
 - 3. Within 24 hours of constructing control points, survey and submit measurements at each control point. Submit copy of field notes with measurements.
 - 4. Survey and submit measurements of control points every 7 days. Submit the following measurements within 24 hours for each control point:
 - a. Current measurement and the change in measurement from first measurement taken.
 - b. Show graphical plot of movements.

1.05 QUALITY ASSURANCE

- A. Dewatering plan and dewatering system analysis:
 - 1. Prepared by a qualified Civil Engineer, licensed in the state where the Project is located.
 - a. The dewatering design engineer shall have at least 8 years of experience in designing similar systems.
- B. Dewatering Contractor shall have at least 8 years of experience in installing similar systems.
- C. Testing laboratory shall meet discharge permit testing laboratory qualifications.
- D. Regulatory requirements:
 - 1. Obtain required water discharge permits.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Design requirements:
 - 1. Keep excavations reasonably free from water. Draw down static groundwater level to minimum of 3 feet below anticipated bottom of excavations before the excavation reaches bottom elevation.
 - 2. Dewatering design analysis. Include the following:
 - a. Evaluation of anticipated subsurface conditions.
 - b. Required well spacing.
 - c. Diameter of wells.
 - d. Depth to screen, screen height, and mesh size.
 - e. Backfill and filter pack.
 - f. Pump size.
 - g. Drawdown duration.
 - h. Drawdown and steady state flow rates.
 - i. Plans for de-silting of groundwater before discharge.
 - j. Standby pumping equipment and required power supply equipment.
 - k. Header piping size, material and piping alignments.
 - l. Anticipated area influenced by dewatering system and potential impacts to adjacent structures, existing and proposed. Mitigation measures needed to prevent any expected settlements. Contingency plan for restoring nearby structures if settlement is observed as result of dewatering operations.
 - m. Expected settlements.
 - 3. Include water drawdown curves in dewatering calculations.
 - 4. Coordinate dewatering design with excavation and shoring design. Excavation and shoring design shall consider changes in groundwater conditions and associated earth pressures.
 - 5. Do not place concrete or masonry foundations or concrete slabs in water. Do not allow water to rise over these elements until concrete or mortar has set for at least 24 hours.
 - 6. Maintain operation of dewatering system until complete structure -- including walls, slabs, beams, struts, and other structural elements -- has been constructed; concrete has attained its specified compressive strength; and backfill has been completed to finished grade.
 - 7. Provide standby power to ensure continuous dewatering in case of power failure.
- B. Dewatering shored excavations:
 - 1. Dewater from within shoring.
 - 2. Use impermeable shoring system to minimize lowering of groundwater outside shoring.
 - 3. Extend impermeable shoring below bottom of excavation sufficient amount to:
 - a. Minimize lowering of groundwater outside shoring.
 - b. Prevent unstable excavation due to piping and heave.
 - 4. To minimize settlement outside shoring due to dewatering, do not lower groundwater outside shoring more than 1 foot. Provide groundwater recharge if required to maintain this groundwater elevation outside of shoring.

5. Provide monitoring wells located outside shoring for monitoring groundwater elevation.
- C. Obtain written permission from Engineer before locating wells, well points, or drain lines for dewatering within the limits of a structure's foundation.
- D. Locate dewatering facilities where they will not interfere with utilities and construction work to be performed by others.
- E. Discharge:
 1. Discharge water to City stormwater system as allowed through permitting.

PART 3 EXECUTION

3.01 INSTALLATION

- A. The responsibility for conducting the dewatering operation in a manner which will protect adjacent structures and facilities rests solely with Contractor.
- B. During construction, provide and maintain ample means and devices to promptly remove and properly dispose of water entering excavation or other parts of the work, whether water is surface water or underground water.
- C. Keep excavations reasonably free of water.
- D. Make provisions to maintain continuous dewatering:
 1. Provide standby power to maintain dewatering during power outages and interruptions.
 2. Provide 24-hour monitoring by personnel skilled in operation and maintenance of the system, and capable of providing or obtaining work required to maintain system operation.
- E. Intercept and divert precipitation and surface water away from excavations. Use dikes, curb walls, ditches, pipes, sumps, or other means acceptable to Engineer.
- F. Disposal of water:
 1. Dispose of water from the work in suitable manner without damage to adjacent property.
 2. Do not drain water into work built or under construction.
 3. Properly dispose of discharge water in accordance with Federal, State, and local requirements and permits and in such manner that it will not be a menace to public health or safety.
 4. For discharge of water into holding tanks or infiltration ponds, include a means of overflow protection that is acceptable to Engineer.
- G. Wells, well points, and drain lines for dewatering:
 1. Provide after receiving Engineer's written acceptance.
 2. Fill dewatering wells, pipes, and French drains to be left in place within structure foundation limits with Class "C" concrete as specified in

Section 03_30_00 - Cast-in-Place Concrete or grout as specified in
Section 03_60_00 - Grouting.

3.02 CONSTRUCTION

- A. Prior to release of groundwater to its static level: Confirm that:
 - 1. All groundwater pressure relief devices for structure are fully operational.
 - 2. Construction of structure is complete and concrete has reached its specified compressive strength.
 - 3. Backfill of structure is complete.
- B. Control release of groundwater to its static level to prevent disturbance of natural foundation soils or compacted backfills and fills and to prevent flotation or movement of structures, pipelines, or other facilities.

3.03 FIELD QUALITY CONTROL (NOT USED)

END OF SECTION

SECTION 31_23_24

CONTROLLED LOW STRENGTH MATERIAL (CLSM)

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Controlled low strength material (CLSM), also known as flowable fill.

1.02 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 229R - Report on Controlled Low-Strength Materials.
 - 2. 301 - Specifications for Structural Concrete.
- B. ASTM International (ASTM):
 - 1. C33 - Standard Specification for Concrete Aggregates.
 - 2. C94 - Standard Specification for Ready Mix Concrete.
 - 3. C143 - Standard Test Method for Slump of Hydraulic Cement Concrete.
 - 4. C150 - Standard Specification for Portland Cement.
 - 5. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
 - 6. C403 - Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance.
 - 7. C494 - Standard Specification for Chemical Admixtures for Concrete. C618 - Standard Specification for Coal Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
 - 8. D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)).
 - 9. D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³)).
 - 10. D4832 - Standard Test Method of Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
 - 11. D5971 - Standard Practice for Sampling Freshly Mixed Controlled Low Strength Material.
 - 12. D6023 - Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material.

1.03 SUBMITTALS

- A. Product data: Submit data completely describing materials in the mix and demonstrating compliance with the requirements of this Section.
 - 1. Cement: Mill tests. Indicate alkali content representative of each shipment.
 - 2. Coal ash: Identify source and type.
 - 3. Water: Identify source and quality if not from a municipal treatment source.
 - 4. Admixtures: Manufacturer's product data indicating suitability for use in CLSM mixes and recommended dosage rates.

- 5. Aggregate:
 - a. Submit source, type, and sieve analyses. Include testing to demonstrate that materials in accordance with ASTM C33 requirements.
 - b. Resubmit at any time there is a significant change in grading of materials.
- B. Mix design:
 - 1. Submit full details, including mix design calculations for mix proposed for use.
 - 2. Trial batch test data:
 - a. Submit compressive strength data for each test cylinder.
 - b. Submit data that identifies mix and slump for each test cylinder.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Store or stockpile cement, coal ash, and aggregate in accordance with ACI 301.
- B. Store admixtures in accordance with the manufacturer's recommendations.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Mixture of portland cement, water, pozzolan, fine aggregate and admixtures, proportioned in accordance with the recommendations of ACI 229 to produce a homogeneous mixture that is flowable, that will readily work into corners and angles; that will not segregate in the plastic state; and that is self-compacting at the time of placement without the use of mechanical vibration.
- B. Performance requirements:
 - 1. Air content, total calculated in accordance with ASTM D6023: Not less than 8.0 percent, nor greater than 12.0 percent.
 - 2. Compressive strength, measured in accordance with ASTM D4832 at 28 days: Not less than 50 pounds per square inch, nor greater than 150 pounds per square inch.
 - 3. Wet density: Not greater than 132 pounds per cubic foot.
 - 4. Slump, measured in accordance with ASTM C143 at the point of placement: Greater than 9 inches and that allows CLSM to flow freely and to be self-compacting during placement.

2.02 MATERIALS

- A. Cement:
 - 1. Portland cement in accordance with ASTM C150, Type II.
 - 2. Having total alkali content not more than 0.60 percent.
- B. Coal ash: Class C or Class F in accordance with ASTM C618.
- C. Water:
 - 1. Potable water: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.

- D. Admixtures: Products of a single manufacturer, specifically manufactured or recommended by that manufacturer for use in CLSM.
 - 1. Air-entraining admixture: In accordance with ASTM C260.
 - 2. Water-reducing admixture: In accordance with ASTM C494, Type A.
- E. Aggregate:
 - 1. Non-expansive, non-reactive, inert natural sand conforming to the following requirements:
 - a. Not more than 12 percent passing a No. 200 sieve.
 - b. No plastic fines present.
 - c. Including pea gravel no larger than 3/8 inch.

2.03 MIXES

- A. See the Design and Performance Criteria article in this Section for performance requirements of the plastic and hardened mix.

2.04 SOURCE QUALITY CONTROL

- A. Trial batch:
 - 1. After mix design has been accepted by the Engineer, have trial batch of the accepted mix design prepared by testing laboratory acceptable to the Engineer.
 - 2. Prepare trial batches using the specific cement, coal ash, admixtures, aggregates, and water proposed for the Work.
 - 3. Prepare trial batch with quantity sufficient to determine slump, workability, and consistency; and to provide test cylinders as indicated in this Section.
- B. Trial batch testing:
 - 1. Determine slump in accordance with ASTM C143, with the following modifications:
 - a. Do not rod the concrete material.
 - b. Place material in slump cone in one semi-continuous filling operation, slightly overfill, tap lightly, strike off, and then measure and record slump.
 - 2. Prepare and test trial batch specimens in accordance with ASTM D4832, with the following modifications:
 - a. Provide cylindrical test specimens, each 6 inches in diameter by 12 inches high.
 - b. Provide a minimum of 8 cylinders for testing of each trial batch.
 - c. Fill the molds to overflowing and tap sides lightly to settle the mix.
 - d. Do not rod the mix for consolidation in the cylinder.
 - e. Strike off the excess material.
 - 3. Place test cylinders in a moist curing room. Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
 - 4. Do not remove the test cylinder from mold until that cylinder is to be capped and tested.
 - a. Perform the capping carefully to prevent premature fractures.
 - b. Do not perform initial compression test until the cylinders reach a minimum age of 3 days.

5. Provide compressive strength tests:
 - a. Test 4 test cylinders at 7 days after casting, and another 4 cylinders at 28 days after casting.
 - b. Compression strength of the 4 test cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength.
- C. If the trial batch tests do not meet the Specifications for strength or density, revise and re-submit the mix design, prepare additional trial batch(es), and complete additional trial batch tests. Repeat until an acceptable trial batch that conforms to the specifications is produced.
 1. All trial batches and acceptability of materials shall be paid by the Contractor.
 2. After acceptance, do not change the mix design without submitting a new mix design, trial batches, and test information.

PART 3 EXECUTION

3.01 PREPARATION

- A. Do not place CLSM until preparation and condition of surfaces receiving the fill have been observed and accepted by the Engineer.
- B. Remove debris, foreign matter, and standing or running water from excavations and areas receiving CLSM before placement.

3.02 INSTALLATION

- A. Pipes and trenches.
 1. Install CLSM as indicated on the Drawings and specified.
 2. Where CLSM is placed around and over pipes, secure pipes in place, or place CLSM in lifts to prevent pipe flotation.
 3. Where CLSM is placed in long, open trenches, confine material using bulkheads of sandbags, earth dams, or stiffer concrete at open ends of placement.
 4. Place CLSM at specified access points in the abandoned in-place pipe.
- B. Soil preparation:
 1. Prior to placement of CLSM, prepare underlying soils as follows:
 - a. Scarify surface to a depth of 8 inches.
 - b. Adjust moisture content to or slightly above the optimum in accordance with ASTM D1557.
 - c. Re-compact scarified surface to a minimum of 95 percent relative density in accordance with ASTM D1557.

3.03 MEASURING, BATCHING, MIXING, AND TRANSPORTING

- A. Measure, batch, mix, and transport CLSM in accordance with the requirements of ASTM C94 and as specified in this Section.
- B. Mix until there is uniform distribution of materials.

- C. Discharge mixer completely prior to recharging.
- D. After trial batch testing and mix acceptance, maintain slump during construction within 1 inch of the design slump.

3.04 PLACING

- A. Place CLSM by method that preserves the quality of the material in terms of compressive strength and density.
- B. Maintain fluid properties of the mix during placement.
 - 1. At point of placement, provide material that flows easily around, beneath, or through walls, pipes, conduits, or other structures.
 - 2. Do not place CLSM that has partially hardened or that has been contaminated by foreign materials.
 - 3. Handle and place CLSM using methods that minimize segregation of the mix.
 - 4. Deposit mix as near its final position as possible to avoid segregation due to rehandling or flowing.
 - 5. Contain and confine mix while it is fluid. Design containment structures and bracing at walls and forms to withstand lateral pressures of wet mix.
- C. Lifts:
 - 1. Limit lift heights of CLSM placed against structures and other facilities that could be damaged due to the pressure from the CLSM, to the lesser of 3 feet or the lift height indicated on the Drawings.
 - 2. Do not place another lift of CLSM until the last lift of CLSM has set and gained sufficient strength to prevent additional lateral load against the forms or structure due to the weight of the next lift of CLSM.
- D. Water conditions:
 - 1. Do not place CLSM in standing or flowing water.
 - 2. Do not permit water to flow over the surface of freshly placed or un-hardened CLSM.
 - 3. Do not submerge CLSM in water within 24 hours after placement.
- E. Manage CLSM bleed water.
 - 1. Grade top surface of CLSM to drain away from the fill.
 - 2. Provide side containment that permits bleed water to drain to a contained management area away from the fill.

3.05 CURING AND PROTECTION

- A. Curing:
 - 1. Prior to and during curing, install barriers to prevent equipment or personnel from falling into or becoming entrapped in CLSM.
- B. Protect CLSM from:
 - 1. Damage from the elements.
 - 2. Damage of any nature during surrounding construction operations.
 - 3. Freezing: Do not use salt, manure, or other chemicals to provide protection from cold temperatures.

3.06 FIELD QUALITY CONTROL

- A. Provide quality control over the Work of this Section as specified in Section 01_45_00 - Quality Control and Section 01_45_17 - Contractor Quality Control Plan, and as specified in this Section.
- B. General:
 - 1. Engineer inspection and acceptance required prior to placement.
 - 2. Make provisions for and furnish all material for the test specimens, and provide manual assistance to assist the Owner's testing laboratory in preparing said specimens.

3.07 FIELD QUALITY ASSURANCE

- A. Provide quality assurance over the Work of this Section as specified in Section 01_45_00 - Quality Control and Section 01_45_17 - Contractor Quality Control Plan.
- B. Field inspections:
 - 1. Engineer shall provide on-site inspection for the Work of this Section.
 - 2. Advise the Engineer of readiness to proceed at least 24 hours prior to each placement of CLSM.
 - 3. Required inspections:
 - a. Engineer will observe the prepared areas. Do not place CLSM until the Engineer has observed and accepted preparations.
 - 4. Record of inspections.
- C. Field sampling and testing:
 - 1. During construction, the Contractor shall provide sampling and testing to determine whether the CLSM, as produced and placed, complies with the requirements specified.
 - 2. Sample CLSM for testing in accordance with ASTM D5971.
 - 3. Required tests:
 - a. Air content: Prepare sample and test in accordance with ASTM D6023.
 - b. Compressive strength: Prepare and test cylinder specimens in accordance with ASTM D4832.
 - 1) Prepare 6-inch diameter by 12-inch high specimens for testing.
 - a) Provide 1 set of specimens for each 150 cubic yards of CLSM placed, but not less than 1 set for each half day's placement.
 - b) Prepare and test not less than 3 cylinders for each set.
 - c) Place CLSM in the molds in accordance with ASTM D4832. Do not rod or otherwise consolidate the material in the mold.
 - d) In accordance with ASTM D4832 recommendations for displacing bleed water at the top of the molds and refilling the molds before covering with a lid. Do not use air-tight lids.
 - 2) Place the cylinders in a safe location away from construction activities.
 - a) Protect cylinders from bumping and impact.
 - b) Maintain temperature surrounding cylinders between 60 and 80 degrees Fahrenheit until delivery to the laboratory for testing.

- c) After the first day, surround molds with a high humidity environment by covering with wet burlap or equivalent highly absorptive material.
 - (1) Maintain saturation of the cover.
 - (2) Do not sprinkle water directly on the cylinders.
- 3) After 4 days, place the cylinders in a protective container for transport to the laboratory for testing.
 - a) Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
 - b) Transport container may be a box with a Styrofoam or similar lining that will limit jarring and bumping of the cylinders.
- 4) Upon receipt at the testing laboratory, place test cylinders in a moist curing room until dates for testing.
- 5) Do not remove test cylinders from molds until the day that cylinders is to be capped and tested.
- 6) Cap and test for compressive strength in accordance with ASTM D4832.
 - a) Do not perform initial compression test until the cylinders reach an age of at least 4 days.
 - b) Test 1 cylinder at 7 days and 2 cylinders at 28 days.
- 7) Compressive strength of the cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength specified.

3.08 NON-CONFORMING WORK

- A. When testing or observation indicates CLSM with properties outside the specified and accepted range, the Engineer will issue instructions regarding disposition of non-conforming materials.
- B. The Owner or Engineer may:
 - 1. Reject CLSM represented by those test specimens and require its removal and replacement.
 - 2. Require modification of the mix design to provide CLSM with the properties specified.
- C. Make such modifications at no additional expense to the Owner and with no adjustment to the schedule.

END OF SECTION

SECTION 31_23_35

TRENCHING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Trench excavation and trench backfill for pipelines, manholes, vaults, and appurtenances.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³).
 - 2. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Backfill: Material placed in trench above the pipe embedment zone.
 - 2. Bedding: Material placed under, around, and over pipes or ducts in trenches.
 - 3. Fine grading: Bedding material placed directly below pipes or ducts to provide support at the bottom of the trench and to bring those elements to required grades and elevations.
 - 4. Flexible pipe: Includes steel, ductile iron, thermoplastics such as polyvinyl chloride (PVC) and high-density polyethylene (HDPE), thermosetting plastics such as fiberglass-reinforced polymer (FRP), bar-wrapped concrete cylinder pipe, and corrugated steel pipes.
 - 5. Haunch zone: Material placed below and beside the pipe up to the pipe springline.
 - 6. Lift: A layer of soil or aggregate material, measured before compaction.
 - 7. Maximum density, Field Compaction: Soil density and water content when tested in accordance with ASTM D1556 or ASTM D6938.
 - 8. Maximum density, Laboratory Compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.
 - 9. Pavement section: Includes pavement plus underlying courses such as base course and subgrade.
 - 10. Pipe embedment zone: Includes bedding, fine grading, and haunch zone.
 - 11. Pipe foundation: Material placed at the bottom of trench to provide support.
 - 12. Pipe springline: A horizontal reference line located at mid-height, or halfway point, of a circular conduit, pipe, or tunnel. It is the maximum horizontal dimension or diameter of a circular conduit, pipe, or tunnel.

13. Rigid pipe: Includes reinforced non-cylinder concrete, reinforced concrete cylinder, prestressed concrete cylinder, vitrified clay, polymer concrete, cast iron, asbestos cement and cast-in-place pipes.

1.04 SUBMITTALS

- A. As specified in Section 01_33_00 - Submittal Procedures.
- B. Product data on soils and aggregates.
 1. Material source.
 2. Gradation.
 3. Test data to demonstrate compliance with requirements as specified in this Section.
- C. Samples:
 1. Provide 50-pound sample of materials when requested by the Engineer.
- D. Confirmation testing:
 1. Certification of Contractor's testing laboratory.
 2. Record copy report for tests performed by the Contractor's testing laboratory.

PART 2 PRODUCTS

2.01 MATERIALS

- A. As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
- B. Class C concrete: As specified in Section 03_30_00 - Cast-in-Place Concrete.
- C. Controlled low-strength material: As specified in Section 31_23_24 - Controlled Low Strength Material (CLSM).

PART 3 EXECUTION

3.01 PREPARATION

- A. Stabilize excavations as specified in Section 31_50_00 - Excavation Support and Protection.
- B. Perform subsurface utility engineering (SUE) for utility locating and verification prior to any excavation work and as specified in Section 33_05_01 - Subsurface Utility Engineering.

3.02 DEWATERING

- A. As specified in Section 31_23_19 - Dewatering.

3.03 TRENCH EXCAVATION

- A. Excavate bottom of trench to depth indicated on the Drawings.

- B. Areas of new fill or embankment:
1. Prior to laying pipes or electrical service, place fill and compact as specified to not less than 2 feet above top of pipe, conduit, or duct bank.
 2. Excavate through fill for pipe trench.

C. Trench widths as specified in the following table:

Buried Pipe or Accessory	Minimum Trench Width	Maximum Trench Width
Nominal Pipe Diameter: 4 inch to 24 inch	OD + 18 inches	OD + 24 inches
Nominal Pipe Diameter: Greater than 24 inch	OD + 24 inches	OD + 36 inches
Manholes, vaults, valves, or other accessories	12 inches between outer surface and trench side or shoring	Not applicable

- D. Potable water pipe and appurtenances:
1. Lay in trenches separate from those used for sewers and recycled water.
 2. Unless otherwise specified or indicated on the Drawings, lay in trenches having cover of not less than 3 feet below surface of ground located at distance of not less than 10 feet clear horizontally from any parallel sewer and 10 feet clear vertically above any parallel sewer.
- E. At road crossings or existing driveways:
1. Provide notification, vehicular access, and traffic control as required by permits and special conditions.
 2. Provide temporary asphalt or plating for traffic or access at the end of each work day unless approved in writing by the Engineer.
 3. If unexpected utility conflicts or changed Site conditions require trenchless technologies or temporary bridges, immediately notify the Engineer in writing. Approval is required before proceeding with construction.
 4. When trench width at top of pipe is increased beyond width specified in this Section because of soil conditions, safety requirements, or other reasons, Engineer approval for remedy is required without additional cost to the Owner.
 - a. Remedy may include upgrade laying conditions or install stronger pipe designed in accordance with Specifications.

3.04 TRENCH BACKFILL - GENERAL

- A. Trench area terminology and locations as indicated on the Drawings.
- B. Place material, except CLSM and concrete, in maximum 6-inch lifts, measured before compaction.
- C. Backfilling of manhole excavation: In accordance with backfilling requirements for trenches as specified in this Section.

3.05 PIPE FOUNDATION

- A. Provide trench bottom with firm, dry, uniform bearing surface at the grade indicated on the Drawings.
- B. Excess excavation below elevation indicated on the Drawings will require installation of pipe foundation material to bring the trench bottom back to the elevation indicated on the Drawings at no additional cost to the Owner.
 - 1. Materials and placement:
 - a. Stabilization material:
 - 1) Wrap stabilization material as specified in Section 31_32_18.04 - Stabilization Fabric.
- C. If bottom of trench excavation consists of soil:
 - 1. Scarify bottom of trench to a depth of 6 inches below the grade indicated on the Drawings.
 - 2. Materials and placement:
 - a. Recompect scarified material to 95 percent of maximum density.
- D. If bottom of trench excavation consists of rock or any material that, by reason of its hardness, cannot be excavated to provide uniform bearing surface:
 - 1. Remove such rock or other material to a depth of not less than 4 inches below pipe embedment zone.
 - 2. Materials:
 - a. CLSM.
 - b. Class C concrete.
- E. If bottom of trench excavation consists of mud or other soft unstable material:
 - 1. Remove such unacceptable material to a depth of not less than 18 inches below pipe embedment zone.
 - 2. Material and placement:
 - a. Lightweight material.
 - b. Stabilization material:
 - 1) Wrap stabilization material as specified in Section 31_32_18.04 - Stabilization Fabric.

3.06 PIPE EMBEDMENT ZONE

- A. Pipe displacement:
 - 1. Take necessary precautions in placement and compaction of bedding material to prevent displacement of piping.
 - 2. In event there is movement or floating of the piping, re-excavate, re-lay, and backfill the pipe.
- B. Fine grading:
 - 1. Place 6 inches of approved haunch zone bedding material from the trench bottom to the bottom of the pipe or duct to provide support at the bottom of the trench and to bring those elements to required line and grade.

- C. Depressions for joints or couplings:
 - 1. Excavate holes in the fine grading material at the bottom of the trench.
 - 2. Provide holes of sufficient width to provide ample room for grouting, banding, or welding as necessary for making joints and to ensure that pipe rests upon prepared trench bottom and not supported by any portion of the joint.
- D. Rigid pipe:
 - 1. Pipe embedment zone: Below pipe springline:
 - a. Materials and placement:
 - 1) Aggregate base course compacted to 95 percent maximum dry density.
 - 2) Sand compacted with a sand plate vibrator.
 - 3) Pea Gravel.
 - 2. Pipe embedment zone: Above pipe springline:
 - a. Compacted to a depth above pipe: 12 inch minimum.
 - b. Materials and placement:
 - 1) Aggregate base course compacted to 95 percent maximum dry density.
 - 2) Sand compacted with a sand plate vibrator.
 - 3) Pea Gravel.
- E. Flexible pipe:
 - 1. Pipe embedment zone:
 - a. Compacted to a depth above pipe: 12 inch minimum.
 - b. Materials and placement:
 - 1) Aggregate base course compacted to 95 percent maximum dry density.
 - 2) CLSM. Place gravel bags to support and set pipe to line and grade prior to CLSM placement. Place CLSM in lifts as necessary to prevent floatation.
 - 3) Sand compacted with a sand plate vibrator.

3.07 BACKFILL

- A. Trenches:
 - 1. Materials and placement:
 - a. Native soil compacted to 95 percent maximum dry density.
 - b. Imported fill compacted to 95 percent maximum dry density.
 - c. Aggregate base course compacted to 95 percent maximum dry density.
 - d. CLSM.
- B. Trenches in rock:
 - 1. Backfill to top of rock.
 - a. Materials and placement:
 - 1) CLSM.
 - 2) Class C concrete.
 - 2. Backfill from top of rock to grade, if applicable:
 - a. Materials and placement:
 - 1) Aggregate base course compacted to 95 percent of maximum density.

- C. Trenches below or within 10 feet of the outside perimeter of structures:
 - 1. Backfill to underside of structural fill below structure, as specified in Section 31_00_00 - Earthwork.
 - 2. Materials and placement:
 - a. Aggregate base course compacted to 95 percent of maximum density.
 - b. CLSM.
- D. Trenches in roadways and paved areas:
 - 1. Backfill trench to underside of pavement.
 - 2. Materials and placement:
 - a. Aggregate base course compacted to 95 percent of maximum density.
 - b. CLSM.
- E. Trenches in areas outside the improved section of roadways or in open country:
 - 1. Backfill to finished grade.
 - 2. Materials and placement:
 - a. Native soil, native soil - select, imported material, or aggregate base course compacted to 90 percent of maximum density.
- F. Trenches under existing intersecting pipes, duct banks, or conduits larger than 3 inches in diameter:
 - 1. Backfill from above top of new pipe embedment zone to springline of intersecting pipe or conduit.
 - a. Extend backfill at least 2 feet on either side of intersecting pipe or conduit to ensure backfill material remains in place while other backfill is being placed.
 - b. Materials and placement:
 - 1) CLSM, unless otherwise indicated on the Drawings.
 - 2. Backfill remainder of trench:
 - a. Materials and placement:
 - 1) CLSM.
 - 2) Class C concrete.

3.08 EXCESS MATERIAL

- A. Remove excess excavated material from the Project Site as specified in Section 31_00_00 - Earthwork.

3.09 FIELD QUALITY CONTROL

- A. Provide field quality control for the Work as specified in Section 01_45_00 - Quality Control.
- B. Confirmation tests: As specified in Section 31_00_00 - Earthwork.
 - 1. Minimum frequency of confirmation testing:
 - a. At each test location include tests for each type or class of backfill from bedding to finished grade.
 - b. For trenches: 1 location every 200 linear feet.
 - c. In open fields: 2 locations every 1,000 linear feet or 1 location every 200 cubic yards.

- d. Along dirt or gravel road or off traveled right-of-way: 1 location at every 500 linear feet.
 - e. Crossing paved roads: 1 location at each crossing.
 - f. Under pavement cuts or within 2 feet of pavement edges: 1 location every 400 linear feet.
- C. Compliance tests:
- 1. Make periodic compliance tests to verify that compaction is meeting requirements as specified in this Section.
 - 2. Perform remedial work if compaction test fails to meet specified requirements using one of the following methods:
 - a. Remove and replace backfill at the proper density.
 - b. Other means acceptable to the Engineer.
 - 3. Retesting:
 - a. Costs of retesting: Contractor is responsible for the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
 - b. Contractor's confirmation tests during performance of remedial work:
 - 1) Performance: Perform tests in manner acceptable to the Engineer.
 - 2) Frequency: Double amount specified for initial confirmation tests.
- D. Piping system testing:
- 1. As specified in Section 40_05_00.09 - Piping Systems Testing.

END OF SECTION

SECTION 31_32_18.02

FILTER FABRIC

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Nonwoven filter fabric.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. D4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
 - 2. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
 - 3. D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
 - 4. D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
 - 5. D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
 - 6. D5261 - Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
 - 7. D6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Filter fabric: Nonwoven geotextile fabric manufactured from polypropylene fibers.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product Submittals:
 - 1. As specified in Section 01_60_00 - Product Requirements.
 - 2. Product data.
 - 3. Manufacturer's instructions.
- C. Samples.

- D. Quality Control Submittals:
1. Manufacturer's representative qualifications.
 2. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_00 - Product Requirements and the manufacturer's instructions.
- B. Storage and protection:
1. Furnish filter fabric in protective covers capable of protecting the fabric from ultraviolet rays, abrasion, and water.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.
- B. Take field measurements to determine the lengths and dimensions of the surfaces to receive the fabric.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
1. Propex, Geotex 401.
 2. Ten Cate Geosynthetics, Mirafi 140N.

2.02 MATERIAL REQUIREMENTS

- A. Physical properties: Meet the following minimum requirements:

Property ⁽¹⁾	Test Method	Unit	Requirements ⁽¹⁾
Minimum Weight	ASTM D5261	oz/yd ²	4.0
Grab Tensile Strength	ASTM D4632	lbs	100
Grab Elongation	ASTM D4632	%	50
Trapezoid Tear Strength	ASTM D4533	lbs	50
CBR Puncture Resistance	ASTM D6241	lbs	300
UV Resistance (strength retained at 500 hrs)	ASTM D4355	%	70
Apparent Opening Size (AOS)	ASTM D4751	U.S. sieve	70
Permittivity	ASTM D4491	sec ⁻¹	1.7
Flow Rate	ASTM D4491	gpm/ft ²	130
<u>Notes:</u> (1) Minimum average roll values.			

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that conditions are satisfactory for the installation of filter fabric.

3.02 PREPARATION

- A. Surface preparation:
 - 1. During grading operations, take care not to disturb the subgrade.
 - 2. This may require use of lightweight dozers for low strength soils such as saturated, cohesionless, or low cohesion soils.
- B. Prior to placement of fabric:
 - 1. Prepare surface to smooth condition free of debris, depressions, or obstructions that may damage the fabric.

3.03 INSTALLATION

- A. Install the filter fabric in accordance with the manufacturer's instructions and this Section.
- B. Place smoothly without folds or wrinkles.
- C. Use special care when placing the filter in contact with the soil so that no void spaces occur between the filter and the prepared surface.
- D. Overlap the parallel rolls and ends of rolls a minimum of 24 inches and not less than the manufacturer's instructions.
- E. Do not drag filter fabric across subgrade.
- F. Make overlaps at ends of rolls in the direction of the aggregate placement with the previous roll on top.
- G. Use lightweight dozers if necessary. Do not allow equipment directly on filter fabric.
- H. Furnish Manufacturer's Certificate of Installation Verification.

3.04 FIELD QUALITY CONTROL

- A. Inspection:
 - 1. Before covering, the condition of the fabric will be observed by the Engineer to determine that no holes or rips exist in the fabric.
 - 2. Repair holes and rips by placing a new layer of fabric extending beyond the defect in all directions a distance equal to the minimum overlap required for adjacent rolls.

END OF SECTION

SECTION 31_32_18.04
STABILIZATION FABRIC

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Woven stabilization fabric used for subgrade enhancement.

1.02 REFERENCES

- A. ASTM International (ASTM):
1. D4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
 2. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
 3. D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
 4. D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
 5. D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
 6. D6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.

1.03 DEFINITIONS

- A. Stabilization Fabric: Woven geotextile fabric manufactured from polypropylene yarns.

1.04 SUBMITTALS

- A. Product data.
- B. Samples.
- C. Quality control submittals:
1. Certificates of Compliance.
 2. Manufacturer's Installation Instructions.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Storage and protection:
1. Furnish stabilization fabric in protective covers capable of protecting the fabric from ultraviolet rays, abrasion, and water.

1.06 PROJECT CONDITIONS

- A. Field measurements:
1. Take field measurements to determine the exact lengths and dimensions of the surfaces to receive the fabric.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
1. Propex, Geotex 315ST.
 2. Ten Cate Geosynthetics, Mirafi 600X.

2.02 MATERIAL REQUIREMENTS

- A. Physical properties: Meet the following minimum requirements:

Property ⁽¹⁾	Test Method	Unit	Requirements ⁽¹⁾
Grab Tensile Strength	ASTM D4632	lbs	315
Grab Elongation	ASTM D4632	%	15
Trapezoid Tear Strength	ASTM D4533	lbs	120
CBR Puncture Resistance	ASTM D6241	lbs	900
UV Resistance (strength retained at 500 hrs)	ASTM D4355	%	70
Apparent Opening Size (AOS)	ASTM D4751	US sieve	40
Permittivity	ASTM D4491	sec ⁻¹	0.05
Flow Rate	ASTM D4491	gpm/ft ²	4
(1) Minimum average roll values.			

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions: Verify that conditions are satisfactory for the installation of stabilization fabric.

3.02 PREPARATION

- A. Surface preparation: During grading operations, take care not to disturb the subgrade. This may require use of lightweight dozers for low strength soils such as saturated, cohesionless, or low cohesion soils.
- B. Prior to placement of fabric: Prepare surface to smooth condition free of debris, depressions, or obstructions that may damage the fabric.

3.03 INSTALLATION

- A. Follow manufacturer's installation instructions and as complimented in this Section.
- B. Place the stabilization fabric smoothly without folds or wrinkles.
- C. Use special care when placing the stabilization fabric in contact with the soil so that no void spaces occur between the stabilization fabric and the prepared surface.
- D. Overlap the parallel rolls and ends of rolls a minimum of 24 inches and not less than recommended by manufacturer.
- E. Do not drag stabilization fabric across subgrade.
- F. Make overlaps at ends of rolls in the direction of the aggregate placement with the previous roll on top.
- G. Use lightweight dozers, if necessary. Do not allow equipment directly on stabilization fabric.

3.04 FIELD QUALITY CONTROL

- A. Inspection: Before covering, the condition of the fabric will be observed by the Engineer to determine that no holes or rips exist in the fabric. Repair all holes or rips by placing a new layer of fabric extending beyond the defect in all directions, a distance equal to the minimum overlap required for adjacent rolls.

END OF SECTION

SECTION 31_50_00

EXCAVATION SUPPORT AND PROTECTION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Designing, providing, maintaining, and removing excavation support and protection.

1.02 REFERENCES

- A. American Society of Civil Engineers (ASCE):
 - 1. Guidelines of Engineering Practice for Braced and Tied-Back Excavations.
- B. Department of the Navy Naval Facilities Engineering Command (NAVFAC):
 - 1. Design Manual 7.2 - Foundations and Earth Structures.
 - 2. Design Manual 7.3 - Soil Dynamics and Special Design Aspects.
- C. United States Steel Corporation (USS):
 - 1. Steel Sheet Piling Design Manual.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. General engineering design practice: In area of the Project, performed in accordance with recent engineering literature on subject of shoring and stability of excavations.
 - 2. Shoring: A temporary structural system designed to support vertical faces, or nearly vertical faces, of soil or rock for purposes of excavation. Shoring includes cantilevered sheet piling, internally braced sheet piling, slurry walls, soldier piles and lagging, and other similar shoring systems. Sloping of the soil is not shoring.
 - 3. Support levels: Level of tiebacks, wales, rakers, bottom of excavation, and other types of support.

1.04 SUBMITTALS

- A. Provide one combined submittal that addresses requirements listed in Section 31_23_19 - Dewatering, Section 31_00_00 - Earthwork and Section 31_09_13 - Geotechnical Instrumentation and Monitoring work for Owner and Engineer review and approval.

- B. Shop Drawings and calculations:
 - 1. Assumed Design Loading Conditions: The following existing structures will remain in service during construction and be full of water:
 - a. Both existing Gravity Thickeners.
 - b. Both existing Settling Ponds.
 - c. The Centrate Pump Station.
 - 2. Calculations for different load, support, and other conditions that occur during the sequence of installation of shoring, construction of facilities protected by shoring, and sequence of removal of shoring.
 - 3. Sketches showing the condition at various stages of installation and removal of shoring.
 - 4. Show on plan shoring, structures, pipelines, and other improvements located near shoring.
 - 5. When utilities penetrate shoring, show location of penetrations on elevation of sides of shoring.
 - 6. Show details for ground support and sealing around utility penetrations.
 - 7. Indicate method used for installing driven shoring.
- C. Control points and schedule of measurements:
 - 1. Submit location and details of control points and method and schedule of measurements.
 - 2. Survey data.
- D. Detailed sequence of installation and removal of shoring:
 - 1. Consider effects of ground settlement in sequence of installation and removal of shoring.
 - 2. Provide sketches showing conditions at various stages in sequence of installation and removal of shoring.
- E. Furnish Submittals for excavation support and protection as complete package and include items required in this Section:
 - 1. Incomplete Submittals will not be reviewed and will be returned for resubmittal as a complete package.
- F. Furnish dewatering Submittals as specified in Section 31_23_19 - Dewatering with Submittals for excavation support and protection.

1.05 SEQUENCING

- A. Do not begin construction of any shoring or excavation operations until:
 - 1. Submittals for shoring and dewatering have been accepted.
 - 2. Control points as specified in this Section and on existing structures and other improvements as indicated on the Drawings have been established and surveyed to document initial elevations and locations.
 - 3. Materials necessary for installation are on site.
- B. Furnish Submittals a minimum of 30 days prior to scheduled date to begin excavation work.

PART 2 PRODUCTS

2.01 DESIGN CRITERIA

- A. Where general engineering design practice is specified, provide Drawings and calculations that are performed and signed by civil or structural engineer registered in the state where the Project is located:
 - 1. Clearly disclose assumptions made, criteria followed, and stress values used for materials being used in design calculations.
 - 2. Submit list of references acceptable to the Engineer that substantiate appropriateness of design assumptions, criteria, and stress values.

- B. General requirements:
 - 1. Dewatering:
 - a. Dewater soil inside shoring as specified in Section 31_23_19 - Dewatering.
 - b. Do not lower groundwater outside of shoring more than 1 foot.
 - c. Recharge groundwater outside shoring to limit groundwater draw down outside of shoring to amount specified above.
 - 2. When electing to design with material stresses for temporary construction higher than allowable stresses prescribed in building code as specified in Section 01_41_00 - Regulatory Requirements, increase in such stresses shall not exceed 10 percent of value of prescribed stresses.
 - 3. Minimum safety factor used for design shall not be less than 1.5.
 - 4. Calculated minimum depth of penetration of shoring below bottom of excavation shall be increased not less than 30 percent if full value of allowable passive pressure is used in design.
 - 5. Maximum height of cantilever shoring above bottom of excavation shall not exceed 15 feet. Use braced shoring when height of shoring above bottom of excavation exceeds 15 feet.
 - 6. Location of point of fixity for shoring shall not be less than half calculated minimum embedment depth below bottom of excavation.
 - 7. Generally acceptable references for design of shoring and excavations are as follows:
 - a. ASCE Guidelines of Engineering Practice for Braced and Tied-Back Excavations.
 - b. NAVFAC Design Manual 7.2.
 - c. NAVFAC Design Manual 7.3.
 - d. USS Steel Sheet Piling Design Manual.
 - 8. Maximum total deflection of shoring at any point on shoring shall not be more than 3/4 inch.
 - 9. Shoring geotechnical or engineering firm shall obtain errors and omissions insurance for the Project for an amount of not less than 500,000 dollars.

- C. Soldier piles and lagging:
 - 1. Provide lagging over full face of excavation. Joints between pieces of lagging shall be tight to prevent loss of soil.
 - 2. Provide full face lagging around penetrations through lagging.
 - 3. If the soldier piles are installed in predrilled holes and are not concrete encased, fill predrilled holes with controlled low strength material as specified

- in Section 31_23_24 - Controlled Low Strength Material (CLSM) after soldier piles are installed.
4. Assumed effective width for passive soil resistance:
 - a. Effective width of driven soldier piles shall not exceed 2 times width of pile.
 - b. Effective width of CLSM encased soldier piles in drilled holes shall not exceed 2 times width of pile.
 - c. Effective width of concrete encased soldier piles shall not exceed 2 times width of concrete encasement.
 5. Fill voids behind lagging with gravel or other material acceptable to the Engineer.
 6. Apply loads from tie back soil, rock, or deadman anchors concentrically to soldier piles or wales spanning between soldier piles:
 - a. Wales shall be back-to-back double channels or other members acceptable to the Engineer.
 - b. Do not eccentrically load structural section of soldier piles or wales.
 7. Design soldier piles for downward loads, including vertical loads from tieback anchors.
- D. Soil anchors, rock anchors, and deadman anchors:
1. Design tieback anchors for a safety factor of not less than 2 times calculated load from shoring.
 2. Proof load production anchors to 125 percent of calculated load from shoring.
 3. Lock off production anchors at calculated load from shoring.
 4. Length of soil anchors used to calculate resistance to load from shoring shall not include any length within potential active pressure soil failure zone behind face of shoring.
 5. Design tie rods for tieback anchors for 130 percent of calculated load from shoring.
 6. Design tie rods for tieback anchors for 150 percent of the calculated load from shoring when tie rod couplers are used and for other conditions where stress concentrations can develop.
- E. Set inside face of shoring back from structure not less than greater of following:
1. 5 feet from face of wall.
 2. 2 foot-6 inches from edge of foundation.
 3. Depth of excavation below bottom of foundation.

2.02 PERFORMANCE REQUIREMENTS

- A. Support faces of excavations and protect structures and improvements in vicinity of excavations from damage and loss of function due to settlement or movement of soils, alterations in ground water level caused by such excavations, and related operations.
- B. Specified provisions:
1. Complement, but do not substitute or diminish, obligations of the Contractor for furnishing of safe place of work pursuant to provisions of the Occupational

Safety and Health Act of 1970 and its subsequent amendments and regulations and for protection of work, structures, and other improvements.

2. Represent minimum requirement for:
 - a. Number and types of means needed to maintain soil stability.
 - b. Strength of such required means.
 - c. Methods and frequency of maintenance and observation of means used for maintaining soil stability.
- C. Provide safe and stable excavations by means of sheeting, shoring, bracing, sloping, and other means and procedures, such as draining and recharging groundwater and routing and disposing of surface runoff, required to maintain stability of soils and rock.
- D. Provide support for trench excavations for protection of workers from hazard of caving ground.
- E. Provide shoring:
 1. Where, as result of excavation work and analysis performed pursuant to general engineering design practice, as defined in this Section:
 - a. Excavated face or surrounding soil mass may be subject to slides, caving, or other types of failures.
 - b. Stability and integrity of structures and other improvements may be compromised by settlement or movement of soils, or changes in soil load on structures and other improvements.
 2. For trenches 5 feet and deeper.
 3. For trenches less than 5 feet in depth, when there is potential for cave-in.
 4. Where indicated on the Drawings.
- F. For safe and stable excavations, use appropriate design, construction, and maintenance procedures to minimize settlement of supported ground and to prevent damage to structures and other improvements, including:
 1. Using stiff shoring systems.
 2. Following appropriate construction sequence.
 3. Using shoring system that is tight enough to prevent soil loss through the shoring.
 4. Using shoring system that extends far enough below bottom of excavation to prevent piping, heave, or flow of soil under shoring.
 5. Design for safety factor of not less than 1.50.
 6. Providing surface runoff routing and discharge away from excavations.
 7. Where dewatering inside shoring is necessary, recharge groundwater outside shoring as necessary to prevent settlement in area surrounding shored excavation.
 8. Where sheet piling is used, use interlocking type sheets:
 - a. Sheet piles shall be continuous and driven in interlock.
 - b. If bottom of the excavation is located below the water table, use "ball and socket" or "thumb and finger" type interlock.
 9. Not applying shoring loads to existing structures and other improvements.
 10. Not changing existing soil loading on existing structures and other improvements.

11. Provide welded steel packing between soil retaining members such as sheet piles and wales and similar members when gap exceeds 1/2 inch before wales are loaded.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install means for providing safe and stable excavations as indicated in Submittals.

3.02 REMOVAL OF SHORING

- A. Except for slurry walls, and similar shoring systems, remove shoring by completion of the Work.
- B. Select shoring system and method of removal, which will minimize soil that sticks to shoring from creating voids and causing settlement.
- C. To prevent settlement caused by pulling shoring, fill voids with pressure injected grout:
 1. Inject grout starting at bottom of void and progressively fill void to grade.
 2. Minimize length of shoring removed ahead of grouting operation and limit time void is left ungrouted to prevent void from closing up before being grouted.
- D. Pressure preservative treated wood lagging may be left in place if acceptable to the Engineer.

3.03 CONTROL POINTS

- A. Establish control points on shoring and on structures and other improvements in vicinity of excavation for measurement of horizontal and vertical movement:
 1. Set control points on shoring support system:
 - a. Set points at distances not exceeding 25 feet at each support level.
- B. Promptly upon completion of construction of control points survey control points. Submit copy of field notes with measurement.
- C. Perform horizontal and vertical survey and measurement of control points at least once every week.
 1. Field notes shall show current measurement and change in measurement from first measurement taken.
- D. Set control points on corners of existing structures and on curbs, manholes, and other improvements at the locations indicated on the Drawings.
- E. Provide plumb bobs with horizontal targets indicating original position of plumb bobs in relation to shoring at control points.

3.04 MAINTENANCE

- A. Where loss of soil occurs, plug gap in shoring and replace lost soil with fill material acceptable to the Engineer.
- B. Where measurements and observations indicate possibility of failure or excessive movement of excavation support, determined in accordance with general engineering design practice, take appropriate action immediately.

END OF SECTION

SECTION 32_01_15

PAVEMENT RESTORATION AND REHABILITATION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Resurfacing roads and paved surfaces in which surface is removed or damaged by installation of new work.

1.02 SUBMITTALS

- A. Mix designs:
 - 1. Prior to placement of asphalt concrete, submit full details, including design and calculations for the asphalt concrete mix proposed.
 - 2. Submit gradation of aggregate base.
 - 3. Submit proposed mix design of portland cement concrete.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Performance requirements:
 - 1. Limiting dimensions:
 - a. Determine the exact lengths and dimensions of such roads, pavements, parking areas, and walks that will require removal and replacement for new work.
 - b. Join existing surfaces to terminals of new surfacing in smooth juncture.

2.02 MATERIALS

- A. Aggregate base course: As specified in Section 31_05_15 - Soil and for Earthwork.
- B. Asphalt pavement: As specified in Section 32_12_15 - Asphaltic Concrete Paving.
- C. Portland cement concrete replacement material: Class A concrete as specified in Section 03_30_00 - Cast-in-Place Concrete.

2.03 EQUIPMENT

- A. Roads, pavements, parking areas, and walks:
 - 1. Equipment requirements: Good condition, capable of performing work intended in satisfactory manner.

2.04 ACCESSORIES

- A. Material for painting asphalt concrete pavement: Tack coat as specified in Section 32_12_15 - Asphaltic Concrete Paving.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Aggregate surface removal replacement:
 - 1. When trench cut is in aggregate surfaced areas, replace aggregate base course material with material matching existing material compacted to 95 percent of its maximum density.
- B. Pavement removal and temporary asphalt replacement:
 - 1. Install temporary asphalt pavement or first course of permanent pavement replacement immediately following backfilling and compaction of trenches that have been cut through existing pavement.
 - 2. Except as otherwise provided, maintain this temporary pavement in safe and reasonably smooth condition until required permanent pavement is installed.
 - 3. Remove and dispose of temporary paving from project site.
 - 4. Where longitudinal trench is partly in pavement, replace pavement to original pavement edge, on a straight line, parallel to centerline of roadway.
 - 5. Where no part of longitudinal trench is in pavement, surfacing replacement shall only be required where existing surfacing materials have been removed.
- C. Asphalt pavement replacement:
 - 1. Replace asphalt pavement to same thickness as adjacent pavement and match as nearly as possible adjacent pavement in texture, unless otherwise indicated on the Drawings.
 - 2. Cut existing asphalt pavements to be removed for trenches or other underground construction by wheel cutter, clay spade, or other device capable of making neat, reasonably straight and smooth cut without damaging adjacent pavement. Cutting device operation shall be subject to acceptance of Engineer.
 - 3. Cut and trim existing pavement after placement of required aggregate base course and just prior to placement of asphalt concrete for pavement replacement, and paint trimmed edges with material for painting asphalt concrete pavement immediately prior to constructing new abutting asphalt pavements. No extra payment will be made for these items, and costs incurred in performing this work shall be incidental to pipe laying or pavement replacement.
 - 4. Conform replacement of asphalt pavement to contour of original pavement.
- D. Portland cement concrete pavement replacement:
 - 1. Where trenches lie within portland cement concrete section of streets, alleys, sidewalks, and similar concrete construction, saw cut such concrete (to a depth of not less than 1-1/2 inches) to neat, vertical, true lines in such manner adjoining surfaces are not damaged.

2. Place portland cement concrete replacement material to dimension as indicated on the Drawings.
 3. Provide expansion joints that match existing.
 4. Before placing replacement concrete, thoroughly clean edges of existing pavement and wash with neat cement and water.
 5. Surface finish: Wood float finish.
- E. Curb, gutter, and sidewalk replacement:
1. Where any concrete curb, gutter, or sidewalk has been removed or displaced, replace to nearest construction joints with new Class A curb, gutter, or sidewalk to same dimensions and finish as original construction that was removed:
 - a. Provide expansion joints of same spacing and thickness as original construction.
- F. Asphalt pavements:
1. Trim existing asphalt pavements which are to be matched by pavement widening or pavement extension to neat true line with straight vertical edges free from irregularities with saw specifically designed for this purpose. Minimum allowable depth of cut shall be 1-1/2 inches.
 2. Cut and trim existing pavement after placement of required aggregate base course and just prior to placement of asphalt concrete for pavement widening or extension, and paint trimmed edges with material for painting asphalt concrete pavement immediately prior to constructing new abutting asphalt concrete pavements.
 3. No extra payment will be made for these items and costs incurred in performing this work shall be incidental to widening or pavement extension.

3.02 FIELD QUALITY CONTROL

- A. Tests:
1. Asphalt concrete as specified in Section 32_12_15 - Asphaltic Concrete Paving.
 2. Concrete as specified in Section 03_30_00 - Cast-in-Place Concrete.
- B. Inspection:
1. Asphalt concrete:
 - a. Lay 10-foot straightedge parallel to centerline of trench when the trenches run parallel to street, and across pavement replacement when trench crosses street at angle.
 - b. Remove and correct any deviation in cut pavement replacement greater than 1/4 inch in 10 feet.
 2. Portland cement concrete replacement pavement:
 - a. Lay 10-foot straightedge either across pavement replacement or longitudinal with centerline of gutter or ditch.
 - b. Remove and correct any deviation in cut pavement replacement greater than 1/4 inch in 10 feet.

END OF SECTION

SECTION 32_12_15

ASPHALTIC CONCRETE PAVING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Asphalt concrete pavement on prepared subgrade or aggregate base course, and on existing pavement, to lines, grades, compacted thicknesses, and cross sections indicated on the Drawings.

1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. Standard Specifications for Transportation Materials and Methods of Sampling and Testing:
 - a. MP1: Specification for Performance Graded Asphalt Binder.
- B. ASTM International (ASTM):
 - 1. C117 - Standard Test Method for Material Finer than 75- μ m (No. 200) Sieve in Mineral Aggregates by Washing.
 - 2. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
 - 3. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - 4. D977 - Standard Specification for Emulsified Asphalt.
 - 5. D2041 - Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.
 - 6. D2950 – Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods.
 - 7. D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
 - 8. D4748 – Standard Test Method for Determining the Thickness of Bound Pavement Layers Using Short-Pulse Radar.
- C. Utah Department of Transportation (UDOT):
 - 1. Standard Specifications for Road and Bridge Construction (Standard Specifications).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Bituminous Prime Coat: Consist of application of hot bituminous material on previously prepared base course.

1.04 SUBMITTALS

- A. Proposed mix design and gradation of materials.
- B. Quality control Submittals:
 - 1. Certificate of Compliance.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Asphalt concrete delivery:
 - 1. Transport the mixture from the mixing plant to the point of use in vehicles having tight bodies previously cleaned of foreign materials.
 - 2. Treat bodies as necessary to prevent material from sticking to the bodies.
 - 3. Cover each load with canvas or other suitable material of sufficient size and thickness to protect the asphalt mixture from the weather.
- B. Comply with Standard Specifications storage requirements, if applicable.

1.06 PROJECT CONDITIONS

- A. Environmental requirements:
 - 1. Asphalt concrete:
 - a. Place only when surface is dry, and when atmospheric temperature in the shade is 40 degrees Fahrenheit and rising, or above 50 degrees Fahrenheit if falling.
 - b. Do not place when weather is foggy or rainy or when base on which material is to be placed is in wet or frozen condition.
 - 2. Prime coat:
 - a. Do not apply when atmospheric temperature is below 60 degrees Fahrenheit.
 - b. Apply only when base course is dry or contains moisture not in excess of that which will permit uniform distribution and desired penetration.

1.07 SEQUENCING AND SCHEDULING

- A. Prime coat:
 - 1. Prior to requesting Engineer's acceptance for application, inspect area to be coated to determine its fitness to receive bituminous priming material.
 - 2. Do not begin application before area to be coated has been accepted for application by the Engineer.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Performance requirements:
 - 1. Compact the asphalt concrete to at least 95 percent of the density of the theoretical maximum density in accordance with ASTM D2041.

2.02 MATERIALS

- A. Subgrade material: Stabilization material as specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
 - 1. Thickness: 12 inches.
 - 2. Maximum lift thickness: 4 inches.
 - 3. Compaction: Minimum 98 percent of the AASHTO T-180 maximum dry density.
- B. Base material: Aggregate base course material as specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
 - 1. Thickness: 8 inches.
 - a. Maximum lift thickness: 4 inches.
 - 2. Compaction: Minimum 98 percent of the AASHTO T-180 maximum dry density.
- C. Sand: Acceptable to the Engineer.
- D. Tack coat: Grade SS-1h anionic emulsion in accordance with ASTM D977.
- E. Asphalt concrete materials:
 - 1. Asphalt cement: Conform to requirements for asphalt cement, PG 58-28 AASHTO MP1.
 - 2. Mineral aggregate:
 - a. Consist of coarse aggregate of crushed stone or gravel composed of hard, durable particles, sand, and filler as follows:
 - 1) Coarse aggregate: Portion of material retained on Number 8 sieve.
 - 2) Fine aggregate: That portion passing Number 8 sieve.
 - b. Provide composite material that is uniformly graded from coarse to fine and that complies with requirements of one of the following gradings when tested in accordance with ASTM C136.
 - c. As indicated on the Drawings, 2-course plant mix for asphalt concrete having an overall thickness of 2 1/2 inches or more if not indicated. If less than 2-1/2 inches of asphalt concrete, use single-course plant mix.

Plant Mix, Two Course				Plant Mix, Single Course	
Seal, 3/4-inch Thick Minimum		Base, 1-3/4-inch Thick Minimum		1-1/2-inch Thick Minimum	
Sieve Size	Percent Passing	Sieve Size	Percent Passing	Sieve Size	Percent Passing
1/2"	100	1-1/4"	100	3/4"	100
3/8"	95 - 100	1"	87 - 100	1/2"	75 - 95
No. 4	50 - 70	3/4"	75 - 90	3/8"	65 - 85
No. 8	35 - 55	3/8"	55 - 72	No. 4	50 - 65
No. 30	15 - 30	No. 4	40 - 60	No. 8	35 - 50
No. 100	5 - 15	No. 8	30 - 50	No. 30	15 - 30
No. 200	3 - 8	No. 30	15 - 30	No. 100	5 - 15
		No. 100	5 - 15	No. 200	3 - 8

Plant Mix, Two Course				Plant Mix, Single Course	
Seal, 3/4-inch Thick Minimum		Base, 1-3/4-inch Thick Minimum		1-1/2-inch Thick Minimum	
Sieve Size	Percent Passing	Sieve Size	Percent Passing	Sieve Size	Percent Passing
		No. 200	3 - 8		

3. Coarse aggregate:
 - a. Consist of at least 70 percent by weight of each size aggregate and consist of particles that have at least one rough, angular surface produced by crushing:
 - 1) Have percentage of wear of not more than 50 at 500 revolutions, in accordance with ASTM C131.
 - b. Aggregate plasticity index: Not more than 2 in accordance with ASTM D4318.
 - c. Sand may be added to crusher or pit-run product to supply any deficiency in Number 8 sieve and filler may be added to supply any deficiency in Number 200 sieve material. If aggregate contains an excess of sand, wasting will be required.
 - d. Filler:
 - 1) Use finely powdered limestone, Portland cement, or other artificially or naturally powdered mineral dust acceptable to the Engineer.
 - 2) Weigh filler and add separately to each batch at time of proportioning.
 - 3) Use filler that is free from deleterious matter of any kind.
 - 4) Fineness that meet the following requirements:
 - a) Passing Number 50 sieve: 100 percent.
 - b) Passing Number 200 sieve: At least 75 percent.
 - 5) Determine amount of material passing the Number 200 sieve in accordance with ASTM C117.
 - e. Provide composite aggregate that is free from vegetable matter, lumps or balls of clay, adherent films of clay, or other matter which would prevent thorough coating of asphalt cement.
 - f. Materials derived from processing demolished, or removed asphalt concrete, are not acceptable.

F. Fog sealing: Asphalt emulsion, Grade SS-1h.

2.03 EQUIPMENT

- A. Bituminous distributor: Designed and equipped so as to distribute bituminous material uniformly at even heat on variable widths of surface at readily determined and controlled rate with pressure range of 25 to 75 pounds per square inch.
- B. Liquid asphalt distributor:
 1. Designed and operated to distribute asphaltic material in uniform spray without atomization.
 2. Equipped with bitumeter having dial registering feet of travel per minute.
 - a. Locate dial so that it is visible to truck driver so that he can maintain constant speed required for application at specified rate.

3. Equip pump with tachometer having dial registering gallons per minute passing through nozzles.
 - a. Locate dial so that it is readily visible to operator.
 4. Provide means for accurately indicating temperature of asphaltic material in distributor at all times.
 - a. Locate thermometer well so that it is not in contact with, or close to, heating tube.
 5. Have spray bar having normal width of application of not less than 12 feet and capable of providing for application of lesser width when necessary.
 6. Provided with hose and spray nozzle attachment for applying asphaltic material to patches and areas inaccessible to spray bar.
 7. Equipped with heating attachments and capable of circulating asphaltic material through spray bar during entire heating process.
- C. Asphalt concrete mixing plants:
1. Equipment:
 - a. Use screen and storage bins at plant of sufficient capacity to furnish the necessary amount of aggregates, when operating at the maximum capacity of the plant, with no periods of undue waiting for material.
 - 1) Use bins consisting of at least 2 compartments, so proportioned as to ensure adequate storage of appropriate fractions of the aggregate.
 - 2) Provide each compartment with an overflow pipe of such size and at such location as to prevent any backing up of material into other compartments.
 - b. Dryer:
 - 1) Designed to heat and dry the aggregate to Specification requirements and to agitate it continuously during the heating.
 - 2) Capable of preparing aggregates at a rate equal to the full-rated capacity of the plant.
 - c. Dust collector:
 - 1) So constructed as to waste or return uniformly to the hot elevator all or any part of the material collected.
 - d. Mixer:
 - 1) Adequate capacity, with twin shafts.
 - e. Thermometers:
 - 1) Furnished for determining the temperature of the mix.
 - f. Weighing and measuring equipment:
 - 1) Weighing or volumetric measuring equipment of sufficient capacity.
 - 2) Devices to permit easy readjustment of any working part needing readjustment, so that the equipment will function properly and accurately.
 - 3) Attach scales for weighing to the bucket.
 - 4) Test and seal weighing equipment by a representative of the Inspector of Weights and Measures having jurisdiction, as often as the Engineer may deem necessary to ensure accuracy.
 - g. Tanks for storage of bituminous material:
 - 1) Capable of heating the material under effective and positive control at all times to temperatures within the range stipulated.

2. Asphalt concrete plant operation:
 - a. Mineral aggregate:
 - 1) Dry and heat mineral and then screen into at least 2 fractions and conveyed into separate compartments ready for proportioning and mixing.
 - 2) When combined with asphalt cement.
 - b. Aggregate:
 - 1) Contain not more than 2 percent moisture by weight.
 - 2) Be at a temperature within the range of that specified for the asphalt cement but not more than 25 degrees Fahrenheit above the temperature of the asphalt cement.
 - c. Combine dry aggregate in the plant in the proportionate amounts of each fraction of aggregate required to meet the specified grading.
 - 1) Introduce the asphalt cement into the mixer in the amount and at the temperature for the particular material being used.
 - 2) Continue mixing for at least 30 seconds, and for such longer period as may be necessary to coat the particles.
 - d. When a continuous mixer is used, determine the mixing time by weight method using the following formula:
 - 1) $\text{Mixing time in seconds} = \frac{\text{Pugmill dead capacity in pounds}}{\text{Pugmill output in pounds per second}}$
 - 2) Pugmill output in pounds per second.
- D. Asphalt-concrete-placing equipment:
 1. Use equipment for placing, spreading, shaping, and finishing asphalt concrete consisting of a self-contained power machine operating in such manner that no supplemental spreading, shaping, or finishing is required to provide surface that complies with requirements for smoothness contained in this Section.
 - a. In areas inaccessible to the machine, hand spreading may be permitted.
 2. Furnish 1 self-propelled, pneumatic-tired roller, and one 8-ton (minimum), smooth-wheel tandem roller.
 - a. When spreading is in excess of 100 tons per hour, furnish 1 additional roller of either type for each additional 100 tons, or fraction thereof, spread per hour.

2.04 MIXES

- A. Asphalt cement:
 1. Do not mix at temperatures lower than 275 degrees Fahrenheit or higher than 325 degrees Fahrenheit.
 2. Usual amount of asphalt cement, by weight, to be added to aggregate be 5.4 to 5.8 percent of weight of mixture.
- B. Asphalt concrete:
 1. Before being delivered to the site, mix aggregate with asphalt cement at the central mixing plant.
 2. Use mixing plants that are in good working order with no excessively worn parts and so equipped that:
 - a. Temperatures of aggregates leaving dryer, of asphalt cement entering mixer, and of mix leaving mixer can be readily determined and positively controlled within Specification limits at all times.

- b. Weights of different sizes of aggregates and of asphalt cement as set by the Engineer can be consistently introduced into the mixer.
- c. Asphalt cement can be uniformly distributed throughout the mixture with aggregate completely coated.
- d. Mixing time can be positively controlled to minimum specified.
- e. Bin samples of aggregate can be readily obtained.
- f. Provide means of calibrating weighing devices.

PART 3 EXECUTION

3.01 PREPARATION

- A. Protection:
 - 1. Prime-coated surfaces:
 - a. Maintain surfaces until succeeding layer of pavement has been placed.
 - b. During this interval, protect primed surfaces against damage and repair any broken spots.
- B. Surface preparation:
 - 1. Prime coat:
 - a. Where portions of base course prepared for immediate treatment are excessively dry, sprinkle such portions lightly with water immediately in advance of prime coat application.
 - b. Immediately following preparation of base course, apply bituminous material by means of bituminous distributor at the temperature previously specified.
 - c. Apply priming material in manner that results in uniform distribution being obtained at all points of surface to be primed.
 - d. Following the application of prime material, allow the surface to dry for a period of not less than 48 hours without being disturbed, or for such additional period of time as may be necessary to obtain penetration into the base course and drying out or evaporation of the volatiles from prime material.
 - e. Spread sufficient sand on areas that show an excess of bituminous material to effectively blot up and cure the excess.
 - 2. Base courses:
 - a. Thoroughly clean base and apply prime coat before placing asphalt concrete.
 - b. Thoroughly clean any existing base, surfacing, or pavement prior to placing plant-mixed surfacing.
 - c. Where existing pavement is being widened or extended, cut to straight vertical face and treat with asphalt paint binder prior to paving operations.
 - d. When asphalt concrete is to be applied over existing pavement and local irregularities in existing surface would result in course of more than specified thickness, bring surface of existing pavement to uniform contour by patching with asphalt concrete thoroughly tamped or rolled until it conforms with surrounding surface, and then apply tack coat.

3.02 APPLICATION

- A. At existing asphalt to be paved over: Apply tack coat at minimum rate of 0.10 gallons per square yard.
- B. Placing and compacting asphalt concrete:
 - 1. Placing and compacting asphalt mixture: Progress in sections generally not more than 750 linear feet in length.
 - 2. Spreading of mixture:
 - a. Spread, shape, and finish by specified equipment.
 - b. Spread each successive strip adjacent to previously spread strip.
 - c. Do not compact minimum 6-inch width of each strip adjacent to new strip until after new strip has been placed.
 - d. Spread as nearly continuous as possible.
 - e. Laying against vertical surfaces such as gutters: Roughen and clean face of vertical surfaces as required for proper bonding and then paint with light coating of asphalt cement or emulsified asphalt.
 - f. At terminations of new surface courses: Feather asphalt mixture into existing surface over such distance as may be required to produce smooth riding transition.
 - g. Base-course and single-course construction: Joined by vertical butt joints, finished and rolled to smooth surface.
 - h. Rolling:
 - 1) Perform initial or "breakdown" rolling with tandem power roller and follow spreading operation when mixture has reached temperature where it does not "pick up" on rolls.
 - 2) Keep rolls properly moistened but do not use surplus of water.
 - 3) Follow initial rolling with pneumatic roller when mixture is in proper condition and when rolling does not cause undue displacement, cracking, or shoving.
 - 4) Begin rolling at sides and progress gradually to center, lapping each preceding track until entire surface has been rolled.
 - 5) Terminate alternate trips of roller in stops at least three feet distant from any preceding stop.
 - 6) At any place not accessible to roller, thoroughly compact mixture with tampers and finish, if necessary, with hot iron to provide uniform layer over entire width being paved.
 - 3. Provide finish surface having uniform texture.

3.03 FIELD QUALITY CONTROL

- A. Base course density tests:
 - 1. Taken at locations suitable to confirm compliance with compaction requirements.
 - 2. Take a minimum of 1 test per 1,000 square yards for each lift.
- B. Placement:
 - 1. Place the mixture on the roads, pavements, or walks at a temperature not less than 225 degrees Fahrenheit.

- C. Curing time:
 - 1. Allow asphalt concrete to cure for the following time periods:
 - a. Minimum 24 hours before foot traffic is allowed.
 - b. Minimum 5 days before vehicle traffic is allowed.
 - c. Minimum 10 days before overnight parking is allowed.
 - d. Minimum 20 days before heavy construction vehicle traffic is allowed.
 - 2. Provide barricades and signs as required to enforce curing time.
- D. Asphalt tests:
 - 1. Provide sampling and control testing for the asphalt concrete.
 - a. Location, type, and size of the samples: Suitable to determine conformance with stability, density, thickness, compaction, and other specified requirements.
 - b. Use an approved power saw or core drill for cutting samples.
 - c. Furnish tools, labor, and materials for cutting samples, testing, and replacing the pavement where samples were removed.
 - d. Take a minimum of 1 sample per 200 tons of asphalt concrete placed.
- E. Inspection:
 - 1. Asphalt concrete:
 - a. Test with a 10-foot straightedge laid on the surface parallel with the centerline of the road. Variation of the surface from the testing edge of the straightedge not to exceed 1/4 inch.
 - b. Test each course with running water applied on the surface of the pavement. Water shall flow in the direction indicated on the Drawings. After stopping the water, the pavement surface shall have no areas with standing water.

END OF SECTION

SECTION 32_16_14

CONCRETE CURBS, GUTTERS, AND SIDEWALKS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Concrete curbs, gutters, sidewalks, driveways, access ramps, and alley intersections.

1.02 SUBMITTALS

- A. Product data: Submit data completely describing products.
- B. Samples: Submit samples when requested.

1.03 PROJECT CONDITIONS

- A. Existing conditions.
 - 1. New curb and gutter profile to match existing curb and gutter to be removed as well as possible. Blend in new profile into existing.

1.04 SEQUENCING AND SCHEDULING

- A. Concrete curb, gutter, and sidewalk is to be placed after the work is complete but before paving. Adequate time between placing site concrete and paving should be provided to allow for curing of concrete.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. Performance requirements: Construct various types of concrete curb, gutter, sidewalk, driveways and alley intersections to dimensions and details indicated on the Drawings.

2.02 MATERIALS

- A. Concrete: Class A, as specified in Section 03_30_00 - Cast-In-Place Concrete.
- B. Curb finishing mortar: 1 part portland cement to 2 parts sand.
- C. Form release material: Light oil or other releasing agent of type which does not discolor concrete or interfere with the application of finishing mortar to curb tops and faces.

- D. Joint materials:
 - 1. Expansion: As specified in Section 03_15_00 - Concrete Accessories.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions:
 - 1. Verify field conditions, including subgrade condition and interferences, before beginning construction.

3.02 PREPARATION

- A. Surface preparation:
 - 1. Subgrade:
 - a. Construct and compact true to grades and lines indicated on the Drawings and requirements as specified Section 31_05_00 - Soils and Aggregates for Earthwork.
 - b. Remove soft or unsuitable material to depth of not less than 6 inches below subgrade elevation and replace with satisfactory material.
 - 2. Forms and subgrade: Water immediately in advance of placing concrete.

3.03 INSTALLATION

- A. Special techniques:
 - 1. Contractor's option:
 - a. Construct concrete curbs and gutters by conventional use of forms, or by means of curb and gutter machine when acceptable to the Engineer.
 - b. When use of machines designed specifically for work of this Section are accepted by the Engineer, results must be equal to or better than those produced by use of forms.
 - c. Applicable requirements of construction that apply to use of forms also apply to use of machines.
 - d. Discontinue use of machines when results are not satisfactory to the Engineer.
- B. Forms:
 - 1. Carefully set to line and grade and securely stake in position forms conforming to dimensions of items to be constructed.
 - 2. Thoroughly clean prior to each use and coat with form releasing material.
- C. Expansion and weakened-plane joints:
 - 1. Expansion joints:
 - a. Construct vertically, and at right angles to centerline of street and match joints in adjacent pavement or sidewalks.
 - b. Constructed at radius points, driveways, alley entrances, and at adjoining structures.
 - c. Fill joints with expansion joint filler material.
 - 2. Weakened-plane joints:
 - a. Construct as indicated on the Drawings.

- b. Match joint locations and details in adjacent curbs, gutters, and sidewalks.
- D. Concrete:
- 1. Placing:
 - a. Thoroughly spade concrete away from forms so that no rock pockets exist next to forms and so that no coarse aggregate will show when forms are removed.
 - 2. Compacting:
 - a. Compact by mechanical vibrators accepted by the Engineer.
 - b. Continue tamping or vibrating until mortar flushes to surface and coarse aggregate is below concrete surface.
 - 3. Form removal:
 - a. Front form faces: Do not remove before concrete has taken initial set and has sufficient strength to carry its own weight.
 - b. Gutter and rear forms: Do not remove until concrete has hardened sufficiently to prevent damage to edges. Take special care to prevent damage.
 - 4. Finishing and curing: Comply with requirements as specified in Section 03_35_29 - Concrete Finishes, except as modified here:
 - a. As soon as curb face forms are stripped, apply finishing mortar to the top and face of curb and trowel to a smooth, even finish. Finish with fine haired broom in direction of work.
 - b. Where curb is installed without integral gutter, extend finish 2 inches below grade.
 - c. Edge concrete at expansion joints to 1/4-inch radius.
 - d. Flow lines of gutters shall be troweled smooth 4 inches out from curb face for integral curb and gutter and 4 inches on both sides of flowline for gutters without curbs.
 - e. Sidewalks and ramps: Broom finish.
- E. Backfilling:
- 1. Unless otherwise specified, backfill behind curbs, gutters, or sidewalks with soil native to area and to lines and grades indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

- A. Tests:
- 1. Curbs and gutters:
 - a. Test face, top, back, and flow line with 10 foot straightedge or curve template longitudinally along surface.
 - b. Correct deviations in excess of 1/4 inch.
 - 2. Gutters:
 - a. Frequency of testing: When required by the Engineer, where gutters have slope of 0.8 foot per 100 feet or less, or where unusual or special conditions cast doubt on capability of gutters to drain.
 - b. Test method: Establish flow in length of gutter to be tested by supplying water from hydrant, tank truck, or other source.
 - c. Required results:
 - 1) 1 hour after supply of water is shut off, inspect gutter for evidence of ponding or improper shape.

- 2) In event water is found ponded in gutter to depth greater than 1/2 inch, or on adjacent asphalt pavement, correct defect or defects in manner acceptable to the Engineer without additional cost to the Contract.

3.05 ADJUSTING

- A. Repair portions of concrete damaged while stripping forms or, when damage is severe, replace such work at no additional cost to the Contract. Evidence of repairs shall not be noticeable in the finished product.
- B. Remove and replace sections of work deficient in depth or not conforming to requirements indicated on the Drawings and specified in the Specifications at no additional cost to the Contract. Removal and replacement shall be the complete section between 2 joints.

END OF SECTION

SECTION 33_05_01
SUBSURFACE UTILITY ENGINEERING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Requirements for subsurface utility engineering (SUE) as part of the Work for new pipelines.

1.02 REFERENCES

- A. American Society of Civil Engineers (ASCE):
 - 1. 38-22 - Standard Guideline for Investigating and Documenting Existing Utilities.

1.03 TERMINOLOGY

- A. Terminology used in this Section is in accordance with ASCE 38-22.

1.04 REQUIREMENTS

- A. Existing utilities indicated on the Drawings are approximate only and are provided based on the best information available by use of reports listed in Document 00_73_00 - Supplementary Conditions.
- B. Existing utilities are shown for the convenience of the Contractor only.
 - 1. It is the Contractor's responsibility to field verify the vertical and horizontal location of all utilities, including those not indicated or incorrectly indicated on the Drawings.
- C. Contractor is responsible for reviewing geotechnical reports, record drawings, and Contract Documents.
- D. Coordinate with utility locator, such as CALL BEFORE YOU DIG, and other affected entities when they have jurisdiction over the Project Site.
- E. Contractor is responsible for protecting all utilities encountered.
 - 1. Before any excavation, follow requirements specified in Section 01_14_00 - Work Restrictions.
 - 2. If a conflict exists between what is indicated on the Drawings and what exists in the field, the Contractor shall notify the Owner and Engineer immediately.
- F. Requirements: SUE shall entail the following at a minimum:
 - 1. Review of existing record drawings.
 - 2. Soft excavation to locate known utilities along the proposed pipeline alignment.
 - 3. Open trench excavation to locate unknown utilities along the proposed pipeline alignment.

4. Utilization of field survey by a Professional Land Survey licensed Utah for determination of vertical and horizontal locations.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Shop Drawings:
 1. Submit SUE information as follows:
 - a. Plan drawings that clearly illustrate vertical and horizontal location of known and unknown utilities.
 - 1) Horizontal location shall include northing and easting coordinates.
 - b. Identifies size and material and service for known utilities.
 - c. Identify size and material for unknown utilities.
 2. Review of Shop Drawings and calculations by the Engineer and Owner are for record only.
 3. Field survey information shall be performed, stamped, and endorsed by a surveyor registered in Utah.
- C. Detailed sequence of SUE:
 1. Schedule for SUE events that shows start, end, and intermediate milestones.
 2. Include sketches showing the conditions at various stages in the sequence of SUE.
- D. Submit complete package, including stability of excavations and all items required in this Section.
 1. Incomplete Submittals will not be reviewed and will be returned for resubmittal as a complete package.

1.06 SEQUENCING AND SCHEDULING

- A. Coordinate all Work with restrictions specified in Section 01_14_00 - Work Restrictions.
- B. Do not begin Work until Submittals have been accepted by the Owner and Engineer and until equipment and materials necessary for installation are onsite.
- C. Furnish Submittals a minimum of 30 days prior to the scheduled date to begin excavation work.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SUE SCHEDULE

A. Provide SUE services for the following pipelines and utilities.

Description	Reference Drawings
12-inch Thickener Effluent (TE) from each Gravity Thickener	02DC01, 02C01
6-inch Thickened Sludge (SL) from each Gravity Thickener	02DC01, 02C01
1-inch Natural Gas (NG)	02DC01 and 02C01
6-inch Centrate (CC)	02DC01, 02CO1
2-inch Utility Water (UW2)	02DC01, 02C01
Electrical Ductbank	02DC01

END OF SECTION

SECTION 33_05_33.14

HIGH DENSITY POLYETHYLENE (HDPE) PIPE: AWWA C906

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: High Density Polyethylene Pipe (HDPE), and fittings, 4-inch through 63-inch size.

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.
- C. International Organization of Standardization (ISO):
 - 1. 10863 - Non-destructive testing of welds - Ultrasonic testing - Use of time-of-flight diffraction technique (TOFD).
- D. Plastic Pipe Institute (PPI):
 - 1. PE 4710.

1.03 ABBREVIATIONS

- A. HDPE: High-density polyethylene.

- B. ID: Inside diameter of piping or tubing.
- C. OD: Outside diameter.
- D. SDR: Standard dimension ratio.

1.04 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - 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 33_05_00.01 - Common Work Results for General Piping:
 - 1. Describe materials and installation equipment including fusion machine.
 - a. Include optimum range of fusion conditions such as fusion temperature, interface pressure, and cooling time.
 - 2. Pipe loads and structural calculations.
 - 3. Installation instructions.
- D. Qualifications of installation crew for high-density polyethylene pipe including qualifications of the fusion machine technician. Furnish proof of training in the use of fusion equipment.

1.05 QUALITY ASSURANCE

- A. Markings on the pipe shall be in accordance with AWWA C906.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect piping materials from sunlight, scoring, and distortion.
- B. Do not allow surface temperatures on pipe and fittings to exceed 120 degrees Fahrenheit.
- C. Store and handle HDPE 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. Fittings: Same material as the pipe and of equal or greater pressure rating.

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 or indicated on Drawings, or, if not given, minimum thickness shall be SDR 9.
 - b. Pipe Diameter: IPS dimensions as specified in Section 33_05_00.01 - Common Work Results for General Piping Pipe Schedule or 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 (Chevron Phillips Chemical Company): DriscoPlex 4000/4100 Series.
 - b. ISCO Industries.
2. Polyethylene: As listed by the PPI under the designation PE 4710; and have a minimum cell classification, in accordance with ASTM D3350, of 445574C:
 - a. Pipe and fittings: Manufactured from material with the same cell classification.
 - b. Manufacturer shall certify that pipe and fittings meet the above classifications.
3. Polyethylene fittings and custom fabrications:
 - a. Molded or fabricated.
 - b. Butt fusion outlets shall be made to the same outside diameter, wall thickness, and tolerances as the mating pipe.
 - c. All fittings and custom fabrications shall be fully rated for the same internal pressure as the mating pipe.
 - d. Pressure de-rated fabricated fittings are prohibited.
4. Molded fittings:
 - a. Manufactured in accordance with ASTM D3261, Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing, and shall be so marked.
 - b. Each production lot of molded fittings shall be subjected to the tests required under ASTM D3261.
5. X-ray inspection: The Manufacturer shall submit samples from each molded fittings production lot to x-ray inspection for voids, and shall certify that voids were not found.
6. Fabricated fittings:
 - a. Made by heat fusion joining specially machined shapes cut from pipe, polyethylene sheet stock, or molded fittings.
 - b. Rated for internal pressure service at least equal to the full service pressure rating of the mating pipe.
7. Polyethylene flange adapters:
 - a. Flange adapters shall be made with sufficient through-bore length to be clamped in a butt fusion joining machine without the use of a stub-end holder.

- b. The sealing surface of the flange adapter shall be machined with a series of small v-shaped grooves to provide gasketless sealing, or to restrain the gasket against blowout.
- 8. Back-up rings and flange bolts:
 - a. Flange adapters shall be fitted with Type 316 stainless steel back-up rings pressure rated equal to or greater than the mating pipe.
 - 1) Back-up rings shall be convoluted style for 150-pound bolt hole pattern.
 - 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 33_05_00.01 - 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: Only allowed at terminal connections to wall pipes cast into concrete walls or floors of structures.
 2. Installation:
 - a. General:
 - 1) The Manufacturer shall package products for shipment in a manner suitable for safe transport by commercial carrier.
 - 2) When delivered, a receiving inspection shall be performed, and any shipping damage shall be reported to the Manufacturer within 7 days.
 - 3) Damaged pipe shall be promptly removed from the job site.
 - 4) Installation shall be in accordance with Manufacturer's recommendations, and this specification.

- 5) Prior to making a terminal connection of each individual run of HDPE pipe, the temperature of the pipe should be allowed to approach the service temperature at which the pipe is intended to operate.
- 6) All necessary precautions shall be taken to ensure a safe working environment in accordance with applicable codes and standards.
- b. Large diameter fabricated fittings: Fabricated fittings shall be butt fused to the end of a pipe.
- c. Mechanical joint and flange installation where used at terminal connections only:
 - 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:

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 in accordance with Plastic Pipe Institute and Manufacturers recommendations.
 - 2. Test pressures as specified in the Piping Schedule and indicated on the drawings.
 - 3. Temperature of test water shall be no more than 73 degrees Fahrenheit.

END OF SECTION

SECTION 40_05_00.01

COMMON WORK RESULTS FOR GENERAL PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:

1. Basic materials and methods for metallic and plastic piping systems.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):

1. B1.1 - Unified Inch Screw Threads (UN, UNR, and UNJ Thread Forms).
2. B18.2.1 - Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series).
3. B18.2.2 - Nuts for General Applications: Machine Screw Nuts; and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series).
4. PCC-1 - Pressure Boundary Bolted Flange Joint Assembly.

B. American Water Work Association (AWWA):

1. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
2. C110 - Ductile-Iron and Gray-Iron Fittings.
3. C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
4. C115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
5. C151 - Ductile-Iron Pipe, Centrifugally Cast.

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. B88 - Standard Specification for Seamless Copper Water Tube.
6. D395 - Standard Test Methods for Rubber Property—Compression Set.
7. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension.
8. D573 - Standard Test Method for Rubber—Deterioration in an Air Oven.
9. D1149 - Standard Test Methods for Rubber Deterioration—Cracking in an Ozone Controlled Environment.
10. D1330 - Standard Specification for Rubber Sheet Gaskets.
11. D2513 - Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing and Fittings.
12. F37 - Standard Test Methods for Sealability of Gasket Materials.

13. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 14. F594 - Standard Specification for Stainless Steel Nuts.
 15. 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. 61 - Drinking Water System Components - Health Effects.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. Buried pipes: Pipes that are buried in the soil with or without a concrete pipe encasement.
 2. Exposed pipe: Pipes that are located above ground, or located inside a structure, supported by a structure, or cast into a concrete structure.
 3. Pipes adjacent to a wet wall: Pipe centerline within 10 inches of the wet wall.
 4. Underground pipes: Buried pipes - see 1. above.
 5. Underwater pipes: Pipes below the top of walls in basins or tanks containing water.
 6. Wet wall: A wall with water on at least one side.

PART 2 PRODUCTS

2.01 GENERAL

- A. Pipes:
1. Provide new pipe.
 2. Piping provided from manufacturers/distributors inventory is subject to the following condition:
 - a. Provide proof pipe manufactured more than 6 months prior to delivery was stored properly and the material and/or coating was not subjected to ultraviolet (UV) degradation.
 3. Mark each piece of pipe in accordance with applicable standards.
- B. Coatings and linings requirements shown in the Pipe Schedule, as modified in the individual pipe Technical Sections, and as specified in Section 09_96_01 - High-Performance Coatings.

2.02 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.

2.03 FLANGE BOLTS AND NUTS

- A. General:
 1. Washer: Provide for each nut.
 - a. Shall be of the same material as the nut.
 2. Nuts: Heavy hex-head.
 3. Cut and finish flange bolts to project:
 - a. Face of the bolt shall exceed face of nut by 1/8-inch minimum.
 - b. 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. Ductile iron pipe:
 1. On exposed pipes with pressures equal to or less than 150 pounds per square inch gauge (psig):
 - a. Bolts: In accordance with ASTM A307, Grade B.
 - b. Nuts: In accordance with ASTM A563, Grade A.
 - c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
 2. On exposed pipes with pressures greater than 150 psig:
 - a. Bolts: In accordance with ASTM A193, Grade B7.
 - b. Nuts: In accordance with ASTM A194, Grade 2H.
 - c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
 3. On underwater pipes and pipes adjacent to wet walls:
 - a. Bolts: In accordance with ASTM A193, Grade B8M.
 - b. Nuts: In accordance with ASTM A194, Grade 8M.
 4. On buried pipes:
 - a. Bolts: In accordance with ASTM A193, Grade B8M.
 - b. Nuts: In accordance with ASTM A194, Grade 8M for nuts.
 - c. Wrap buried coupling and flange bolts with polyethylene encasement before backfill.
- C. Plastic pipe:
 1. On exposed pipes:
 - a. Bolts: In accordance with ASTM A307, Grade B.
 - b. Nuts: In accordance with 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: In accordance with ASTM A193, Grade B8M.
 - b. Nuts: In accordance with ASTM A194, Grade 8M.

- D. Steel pipe:
 - 1. Exposed flange bolts, nuts, and washers:
 - a. Bolts: ASTM A193, Grade B7 Steel, ASME B1.1 Class 2A Threads, with dimensions in accordance with ASME B18.2.1.
 - b. Nuts: ASTM A194, Grade 2H Steel, ASME B1.1 Class 2A Fit, with square or heavy hex dimensions in accordance with ASME B18.2.2.
 - c. Washers: In accordance with ASME PCC-1, Appendix M, Type 4.
 - d. 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 Stainless Steel, ASME B1.1 Class 2A Threads, with dimensions in accordance with ASME B18.2.1.
 - b. Nuts: ASTM A194, Grade 8M Stainless Steel, ASME B1.1 Class 2A Fit, with square or heavy hex dimensions in accordance with ASME B18.2.2.

2.04 MECHANICAL JOINTS BOLTS AND NUTS

- A. Bolts, including T-bolts:
 - 1. High strength low alloy steel in accordance with AWWA C111.
 - 2. Type 304 stainless steel in accordance with ASTM F593.
- B. Heavy hex nuts:
 - 1. High strength low alloy steel in accordance with AWWA C111.
 - 2. Type 304 stainless steel in accordance with ASTM F594.

2.05 GASKETS

- A. General.
 - 1. 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. For flanged joints in ductile iron and steel piping for sewage service:
 - 1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, temperatures equal to and less than 250 degrees Fahrenheit, and raw sewage service.
 - 2. Material:
 - a. SBR or neoprene elastomer with minimum Shore A hardness value of 70.
 - b. Reinforcement: Cloth or synthetic fiber.
 - c. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe; minimum 1/8-inch thick for 10 inch and larger pipe.
 - 3. Manufacturers: One of the following or equal:
 - a. Pipe less than 48 inches in diameter:
 - 1) Garlock, Style 7797.
 - 2) John Crane, similar product.
 - b. Pipe 48 inches in diameter and larger:
 - 1) Garlock, Style 3760.
 - 2) John Crane, similar product.
- C. 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, EPDM, or other elastomer as recommended by the manufacturer for continuous service with the specified chemical.
 - b. Sewer and water: 0.125-inch thick SBR.
 3. Manufacturers: One of the following or equal:
 - a. Garlock.
 - b. John Crane, similar product.
- D. For flanged joints in low pressure air piping:
1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, temperatures equal to and less than 300 degrees Fahrenheit, and compressed air service.
 2. Material:
 - a. EPDM elastomer, 1/8-inch thick, 60 Shore hardness, smooth surface.
 3. Manufacturers: One of the following or equal:
 - a. Garlock, Style 8314.
 - b. John Crane, similar product.
- E. 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.
- F. For flanged joints in steel drinking water piping in accordance with NSF 61 requirements:
1. Material: EPDM elastomer, Sulphur cure.
 - a. Temperature range: -40 to 275 degrees Fahrenheit.
 - b. Operating pressure: 150 psig.
 - c. Durometer, Shore A (within 5): 80.
 - d. ASTM D412 tensile strength: 1,500 psi.
 - e. ASTM D412 elongation: 185 percent.
 - f. ASTM D395 B, compression set, 25 percent deflection, maximum percentage 22 hours at 158 degrees Fahrenheit: 25.
 2. Thickness, minimum:
 - a. 3/32-inch for less than 10-inch pipe.
 - b. 1/8 inch for 10 inch and larger pipe.
 3. Manufacturers: One of the following or equal:
 - a. Garlock, Style 98206.
 - b. John Crane.

- G. For flanged joints in ductile iron drinking water piping in accordance with NSF 61 requirements:
1. Application: Full faced type with one or more annular rings molded into the gasket as described in AWWA C110, C111, and C115.
 2. Material: Styrene butadiene copolymer (SBR).
 - a. Temperature range: 20 to 150 degrees Fahrenheit.
 - b. Operating pressure:
 - 1) Pipe size 4-inch through 24-inch: 350 psi.
 - 2) Pipe size 24 inch and greater: 250 psi.
 3. Thickness, minimum: 1/8 inch.
 4. Manufacturers: One of the following or equal:
 - a. American Cast Iron Pipe Co., Toruseal Flange Gasket.
 - b. U.S. Pipe, Flange-Tyte II.

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 the Contractor's field personnel.
 - b) Periodically visit the jobsite to verify the 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 one 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 the 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 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 after installing equipment and after piping and fitting locations have been determined.
 3. Route piping to preserve headroom, access space and workspace, and to prevent tripping hazards and clearance problems:
 - a. Install piping so it does not interfere with the proper and safe operation of equipment and does not block or interfere with ingress or egress, including hatches.
 4. Support piping: As specified in Section 40_05_07.01 - Pipe Supports, Section 40_05_07.03 - Preformed Channel Pipe Support System, and Section 40_05_07.05 - Non-Metallic Pipe Support System:
 - a. Do not transfer pipe loads and strain to equipment.
 5. 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.
6. 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. 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. 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 as specified in Section 09_96_01 - High-Performance Coatings.

- F. Restraining buried piping:
1. At valves and at fittings where piping changes direction, changes size, and at ends:
 - a. When piping is underground, use concrete thrust blocks, mechanical restraints, or push-on restraints.
 - b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
 2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
 - a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
 3. Place concrete thrust blocks against undisturbed soil.
 4. Place concrete so piping joints, fittings, and other appurtenances are accessible for assembly and disassembly.
 5. Provide underground mechanical restraints where specified in Attachment A - Pipe Schedule.
- G. Restraining above ground piping:
1. At valves and fittings where piping changes direction, changes size, and at ends:
 - a. When piping is aboveground or underwater, use mechanical or structural restraints.
 - b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
 2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
 - c. 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 the owner of the 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 between ferrous and nonferrous metals:
1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings, especially designed for the prevention of chemical reactions between dissimilar metals.
 2. Nonferrous metals include aluminum, copper, and copper alloys.

- J. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
 - 1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

3.02 CLEANING

- A. Piping cleaning:
 - 1. Upon completion of installation, clean piping interior of foreign matter and debris.
 - 2. Perform special cleaning when required by the Contract Documents.
- B. Conduct pressure and leak test, as specified.

3.03 PIPE SCHEDULE

- A. As indicated on the Drawings.

END OF SECTION

SECTION 40_05_00.03

PIPE IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pipe identification markers, flow direction arrows, tags, and bands.
 - 2. Underground warning tape.
 - 3. Tracer wire.
 - 4. Witness markers.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. A13.1 - Scheme for the Identification of Piping Systems.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product Submittals:
 - 1. As specified in Section 01_60_00 - Product Requirements.
 - 2. Product data.
 - 3. Samples.
 - 4. Manufacturer's installation instructions.
 - 5. Submit the following as specified in Section 01_77_00 - Closeout Procedures:
 - a. Operation and maintenance data.
 - b. Warranty.
 - 6. Tracer wire access plan.

PART 2 PRODUCTS

2.01 EXPOSED AND IN-CHASE PIPE IDENTIFICATION

- A. For piping with outer diameter greater than or equal to 3/4 inch, provide lettered pipe markers and flow direction arrows:
 - 1. General requirements:
 - a. Pipe markers shall include the following, at a minimum:
 - 1) Printed text identifying the pipe fluid.
 - a) Text shall be all capital letters matching the text listed in the "Service" column of the Pipe Schedule for the corresponding piping system.
 - 2) An arrow identifying the direction of fluid flow.
 - a) Arrow can either be integral to the text marker or provided separately. If provided separately, the arrow must be placed

immediately adjacent to each text marker, with the arrow aligned with the text such that the text and arrow are both visible from the same viewpoint.

- b) Arrow color shall match the text color, and the arrow background color shall match the text background color.
- b. Suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; in accordance with ASME A13.1 requirements.
- c. Lettering:

Outside Pipe Diameter, including Covering	Lettering Height
Less than 0.75 inches	N/A
0.75 to 1.5 inches	1/2 inch
1.5 to 2 inches	3/4 inch
2.5 to 6 inches	1-1/4 inches
8 to 10 inches	2-1/2 inches
Over 10 inches	3-1/2 inches

- d. Marker colors:

Marker Color System ID ⁽¹⁾	Fluid Service	Text/Arrow Color	Background Color
1	Flammable and oxidizing fluids	Black	Yellow
2	Potable, cooling, boiler feed, and other waters	White	Green
3	Compressed air	White	Blue
4	Fire quenching fluids	White	Red
5	Toxic and corrosive fluids	Black	Orange
6	Combustible fluids	White	Brown

Notes:

(1) See Pipe Schedule.

- 2. Self-adhesive type markers:
 - a. Manufacturers: One of the following or equal:
 - 1) Marking Services, Inc.
 - 2) Seton, (of Brady Corporation), Opti Code Pipe Markers.
 - b. Materials:
 - 1) Self-adhesive vinyl.
- 3. Snap-on markers:
 - a. Manufacturers: One of following or equal:
 - 1) Brady Snap-On.
 - 2) Seton (of Brady Corporation) Setmark.
- B. For piping with outer diameter less than 3/4 inch, provide identification tags and flow direction arrows:
 - 1. Manufacturer: The following or equal:
 - a. Seton (of Brady Corporation).

2. Tag and chain materials:
 - a. Copper piping: Brass.
 - b. Ferrous piping: Type 316 stainless steel.
 - c. Plastic piping: PVC
 3. Flow direction arrow colors shall adhere to the same requirements as for piping with outer diameter greater than or equal to 3/4 inch, as specified in this Section.
- C. Pipe bands:
1. When bands are required by the Pipe Schedule for a specific piping system, provide solid-colored 4-inch wide bands.
 - a. Color as specified in the Pipe Schedule.
 2. Self-adhesive type.
 3. Suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit.

2.02 BURIED PIPELINE IDENTIFICATION

- A. Underground warning tape:
1. Manufacturer: One of the following or equal:
 - a. Seton (of Brady Corporation).
 - b. T. Christy Enterprises, Inc.
 2. Material:
 - a. Polyethylene tape for prolonged underground use.
 - b. Minimum tape thickness: 4 mils.
 - c. Overall tape width: 4 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 American Wood Protection Association (APWA) colors.

Service	Color
Potable water	Blue
Reclaimed water, irrigation, and slurry lines	Purple
Sewers and drain lines	Green
Gas, oil, steam, petroleum, chemicals, or other service	Yellow

- B. Tracer wire:
1. Manufacturers: One of the following or equal:
 - a. Aegion Corpro.
 - b. Kris-Tech Wire.
 2. Materials:
 - 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: The following or equal:
 - 1) 3M, Model 82 A1N.

4. Station box:
 - a. Lid and collar materials: Cast iron.
 - b. Lid type: Locking.
 - c. Able to withstand heavy traffic loading.
 - d. Manufacturers: One of the following or equal:
 - 1) CP Test & Valve Products, Inc., Glenn Test Station.
 - 2) Farwest Corrosion Control.
- C. Witness markers:
 1. Manufacturers: One of the following or equal:
 - a. Carsonite Composites, Utility Marker.
 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 Underground Service Alert.
 - c. Phone number for the Owner in case of emergency.
 - d. Station number.
 - e. Offset: Only provide offset if marker is not directly over the pipe.
 - f. Name of appurtenance or fitting (e.g., 45, BO, ARV, etc.).

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify satisfactory conditions of substrate for applying identification.
- B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01_60_00 - Product Requirements.

3.02 PREPARATION

- A. Prepare and coat piping with the coating systems defined in the Pipe Schedule.
- B. Prepare surface in accordance with the identification product manufacturer's instructions.

3.03 EXPOSED AND IN-CHASE PIPING IDENTIFICATION

- A. Identify exposed and in-chase piping with flow direction arrows and lettering (for piping with outer diameter greater than or equal to 3/4 inch) or tags (for piping with outer diameter less than 3/4 inch).
- B. Provide lettering (or tags for pipes with outer diameter less than 3/4 inch) 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.

1. Label chemical tank fill pipelines at locations that are visible from chemical fill stations.
 2. Place markers on piping so they are visible from the operator's position in walkway or working platform near piping. Locate markers along horizontal centerline of pipe, unless better visibility is achieved elsewhere.
 3. Do not apply markers, arrows, or tags to piping that is regularly submerged.
- C. Where scheduled in the Pipe Schedule, space solid-color bands along piping at 10-foot intervals.
1. Do not apply bands to piping that is regularly submerged.

3.04 BURIED PIPING IDENTIFICATION

- A. Underground warning tape:
1. Non-detectable:
 - a. Place continuous run of warning tape in pipe trench, 12 inches above the pipe.
 2. Detectable:
 - a. Place continuous run of warning tape in pipe trench, 12 inches above the pipe or a greater height if necessary to limit the tape bury depth to 36 inches. Do not bury detectable warning tape deeper than 36 inches.
- 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.
 5. Install tracer wire access points at a maximum spacing of 500 LF. Locate station boxes in the median, sidewalk, or as indicated on the Drawings and approved by the Owner.
 6. Provide 2-foot minimum slack of coiled wire in the station box after meeting final grade.
 7. Ground the station box at dead ends such as manholes or dead-end pipe with 1.5 pound drive-in magnesium ground rod with a minimum of 20 feet of lead wire.
 8. It is the Contractor's responsibility to protect the tracer wire from damage during pipe installation and backfill. All costs associated with finding discontinuities in the tracer wire and repair of the connections shall be borne by the Contractor.
 9. Verify tracer wire installation by using low frequency (512 Hz or similar) line locating equipment.
 - a. Provide 2 days advance notice to the Owner prior to testing.
 - b. Test shall be witnessed and approved by the Owner.
 - c. Test tracer wire for continuity between test stations and/or valve boxes prior to final paving.
 10. As part of the as-built drawings, record station and pipe offset of station boxes.

- 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.

END OF SECTION

SECTION 40_05_00.09
PIPING SYSTEMS TESTING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Test requirements for piping systems.

1.02 REFERENCES

- A. American Water Work Association (AWWA):
 - 1. C600-17 - Installation of Ductile Iron Mains and Their Appurtenances.
 - 2. C605-21 - Underground Installation of PVC and PVCO Pressure Pipe and Fittings.
- B. Underwriters Laboratories Inc. (UL).

1.03 TESTING REQUIREMENTS

- A. General requirements:
 - 1. Testing requirements are stipulated in laws and regulations, specified in the Pipe Schedule in Section 40_05_00.01 - Common Work Results for General Piping, 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 the Contract Documents, except where requirements of the Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
 - 3. Test plumbing piping in accordance with laws and regulations, the plumbing code, as specified in Section 01_41_00 - Regulatory Requirements, and UL requirements.
 - 4. Air test of natural gas piping:
 - a. For less than 125 pounds per square inch gauge working pressure, test in accordance with mechanical code, as specified in Section 01_41_00 - Regulatory Requirements, or the National Fuel Gas Code, whichever is more stringent.
 - 5. 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 a 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. As specified in Section 01_50_00 - Temporary Facilities and Controls.
 - a. Use potable water for all potable waterlines.
 - b. Use UW2 utility water for all other pipes.
- D. Pipes to be tested:
 - 1. Test only those portions of pipes that have been installed as part of this Contract.
 - 2. Test new pipe sections prior to making final connections to existing piping.
 - 3. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections.
 - 4. Do not use existing valves as test plug or bulkhead.
- E. Unsuccessful tests:
 - 1. Correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
 - 2. Repeat testing until tests are successful.
- F. Test completion: Drain and leave piping clean after successful testing.
- G. Test water disposal:
 - 1. Dispose at a location in the treatment facility acceptable to Owner and Engineer in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site.
 - 2. Requirements and costs associated with notifications and obtaining any discharge permit or approvals shall be the responsibility of the Contractor.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - 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 the 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.
- C. Pipe system test report:
 - 1. Submit a report for all piping tested. At a minimum, the test report shall include the following information:
 - a. Description of piping being tested:
 - 1) Pipe material.
 - 2) Section of piping being tested:
 - a) Date and time of pipe test.
 - b) Name of person performing the pipe test.
 - c) Specified test method and testing requirements (low-head, high-head, test pressure, test duration, etc.).
 - d) Initial test pressure and time of pressure.

- e) Final test pressure and time of pressure.
- f) Status of test: Pass or fail.
- g) Signature of the Contractor and Owner's representative that witnessed the pipe test.

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 Pipe 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 -40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.
- C. Test at pressure as specified in the Pipe Schedule in Section 40_05_00.01 - Common Work Results for General Piping:
 - 1. Provide temporary pressure relief valve for piping under test:
 - a. Set at 110 percent of the test pressure.
 - 2. Gradually increase test pressure to an initial pressure of 1/2 the test pressure and inspect joint seals for leaks. If no leaks are found, gradually increase test pressure in 10 percent increments until target pressure is reached.
 - 3. At each step in the pressure, examine and test piping for leaks with soap solution.
 - 4. Consider examination complete when the 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 Pipe 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 a 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 the 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 polyvinyl chloride (PVC) gravity sewer pipe: 25 gallons per day per inch diameter per mile of piping under test.

- d) 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 Pipe Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated with "HH" in the Pipe 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 a minimum of 2 hours for visible leaks test and a minimum of 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.
 - 2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of a minimum of 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 in accordance with AWWA C605-21 or AWWA C600-17 by using the following formula:

$$L = \frac{SD\sqrt{P}}{148,000}$$

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 inch gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

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 with "LH" in the Pipe Schedule.
- B. General:
1. Test pressures shall be as scheduled in Section 40_05_00.01 - 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 a minimum of 2 hours for visible leaks test and a minimum of 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 Pipe Schedule.
 3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of a minimum of 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 Pipe Schedule, the procedure shall be as follows:
 - a. Allowed only for low head pressure piping.
 - b. Does not replace and is not in lieu of any testing of the piping system or trust restraints.
 - 2. May be performed with water or air.
 - 3. Joint test piping after completion of backfill and compaction to the top of the trench.
 - 4. Joint testing with water:
 - a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
 - b. Maintain test pressure for 1 minute.
 - c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
 - d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
 - e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.
 - 5. Joint testing with air:
 - a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
 - b. Maintain test pressure for 2 minutes.
 - c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION

SECTION 40_05_06.01

PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Piping specialties, including:
 - a. Flexible rubber connections.
 - b. Bellows type expansion joints.
 - c. Slip type expansion joints.
 - d. Rubber expansion joints.
 - e. Transition fittings.
 - f. Pipe saddles.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
- B. American Water Works Association (AWWA):
 - 1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
 - 2. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
- C. ASTM International (ASTM):
 - 1. A148 - Standard Specification for Steel Castings, High-Strength, for Structural Purposes.
 - 2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - 3. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - 4. A536 - Standard Specification for Ductile Iron Castings.
- D. NSF International (NSF):
 - 1. 61 - Drinking Water System Components - Health Effects, Includes Errata.
 - 2. 372 - Drinking Water System Components - Lead Content.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_00 - Product Requirements.
- 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.
- C. Installation instructions:
1. Provide manufacturer's installation instructions.
- D. Calculations:
1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.
- E. Quality Control Submittals:
1. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_00 - Product Requirements.

1.05 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_00 - Product Requirements.
- B. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

2.02 FLEXIBLE RUBBER CONNECTIONS

- A. Manufacturers: One of the following or equal:
1. Mercer Rubber Co., Type 150 Vibraflex.
 2. Red Valve Co., Inc., Part Number P-5.
- B. Provide flexible rubber connections with 3/8-inch thick neoprene rubber tube with full-faced flanged ends suitable to withstand a pressure of 150 pounds per square inch gauge.
- C. Provide complete flexible rubber connections, including galvanized retaining rings and control rods.

2.03 BELLOWS TYPE EXPANSION JOINTS

- A. For general service:
1. Flexible bellows type, or as otherwise specified or indicated on the Drawings.
 2. Manufacturers:
 - a. Expansion joints: One of the following or equal:
 - 1) Flex-Weld, Inc., Keflex, Series 308.

- 2) Senior Flexonics Pathway, Inc., Controlled Flexing Expansion Joint.
 - 3) Victaulic, Depend-o-Lok, Omniflex stainless bellows expansion joint.
- b. Pipe alignment guides: One of the following or equal:
 - 1) Flex-Weld, Inc.
 - 2) Senior Flexonics Pathway, Inc.
- c. Intermediate supports: Provide with protective saddles. One of the following or equal:
 - 1) Bergen-Paterson Pipe Support Corp.
 - 2) Unistrut Corporation, Roller-type.
- 3. Design:
 - a. Expansion joint rating: 150 pounds per square inch gauge, at 300 degrees Fahrenheit.
 - b. Bellows: Multi-ply (3 ply minimum) stainless steel, equipped with a self-draining liner guide.
 - c. Axial travel of expansion joints: Not less than 1.5 inches.
 - d. Ends: 150 pound ASME flanges, Victaulic, Depend-o-Lok Airmaster/Fluidmaster coupled ends, or plain suitable for welding connections, as required for piping in which installed.
- B. Copper piping expansion joints:
 - 1. As specified before, except externally guided, and provide for 3-1/4 inch expansion per 100 feet of piping.
- C. Roof drain expansion joints:
 - 1. Neoprene bellows between roof drain fitting and drain piping.
 - 2. Up to 12-inch static head.
 - 3. Complete with Type 316 stainless steel clamps.
 - 4. Manufacturers: One of the following or equal:
 - a. Flexicraft Industries, DWV.
 - b. Watts, Model RD-900.

2.04 SLIP TYPE EXPANSION JOINTS

- A. For steam cleaned piping:
 - 1. Manufacturers: One of the following or equal:
 - a. Dresser Industries, Inc., Style 63, Type 2.
 - b. Smith-Blair, Inc., Number 612 with slip pipe and without limit rods.
 - 2. Line and coat slip pipe and interior of body with fusion-bonded epoxy as specified in Section 40_05_19.01 - Ductile Iron Pipe with minimum thickness of 0.012 inch.
 - 3. Packing: Suitable for temperatures greater than 212 degrees Fahrenheit.
- B. PVC expansion joints:
 - 1. Flexible bellows type.
 - 2. Manufacturers: One of the following or equal:
 - a. Chemtrol.
 - b. NDS Flow Management, Quik-Fix.
 - 3. Materials: PVC with EPDM O-ring.
 - 4. Design:
 - a. 150 pounds per square inch pressure rating.
 - b. Double O-ring seal.

- c. Axial travel: Not less than 1.5 inches.
- d. Ends: 150 pound ASME flanges, or plain end suitable for solvent welding connections.

2.05 RUBBER EXPANSION JOINTS

- A. Manufacturers: One of the following or equal:
 - 1. Mercer Rubber Co., Style 500 or 700.
 - 2. Proco Products, Inc., Series 230 or 240.
 - 3. Red Valve Co., Inc., Type J-1.
- B. Provide rubber expansion joints complete with control units and split retaining rings.
- C. Design:
 - 1. Neoprene rubber, reinforced with embedded steel rings, and a strong synthetic fabric.
 - 2. Expansion rings, suitable for pressures of at least 125 pounds per square inch gauge, except as follows:
 - a. Expansion joints in pump suction piping and where indicated on the Drawings suitable for minimum 90 pounds per square inch gauge pressure, and minimum 30 inches mercury vacuum.
 - b. Ends of expansion joints: 1
 - c. 50 pound ASME flanges with drilling to match that of the piping.
 - 3. Bolts, nuts, control rods/plates, and retaining rings shall be galvanized steel unless otherwise specified.
 - 4. Bolts, nuts, control rods/plates, and retaining rings for low pressure air systems provide materials matching the piping system.
 - 5. Bolts, nuts, control rods/plates, and retaining rings submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures shall be Type 316 stainless steel in accordance with ASTM A193, Grade B8M for bolts, and in accordance with ASTM A194, Grade 8M, for nuts.

2.06 TRANSITION FITTINGS

- A. Manufacturers: One of the following or equal:
 - 1. Spears.
- B. Materials:
 - 1. Slip socket: Schedule 80 PVC.
 - 2. Collar: Type 316 stainless steel.
 - 3. Threaded insert: Type 316 stainless steel.

2.07 PIPE SADDLES

- A. For ductile iron pipe:
 - 1. Double strap brass type.
 - 2. Manufacturers: One of the following or equal:
 - a. A.Y. McDonald, Style 3825.
 - b. Mueller Company, Style BR2B.
 - c. The Ford Meter Box Company, Style 202B.

3. Materials:
 - a. Pipe saddle body, straps, and nuts: Brass or silicon bronze.
 - b. Gaskets: Rubber
- B. For PVC C900 or C905 pipe:
 1. Manufacturers: One of the following or equal:
 - a. Romac Industries, Inc., Style 202S.
 - b. Smith-Blair, Inc., Style 317.
 2. Materials:
 - a. Pipe saddles: Ductile iron with fusion bonded epoxy finish.
 - b. Straps, bolts, and nuts: Type 304 stainless steel with Teflon™ coating on nuts.
 - c. Gaskets: Rubber

PART 3 EXECUTION

3.01 GENERAL

- A. As specified in Section 01_60_00 - Product Requirements.
- B. Bellows type expansion joints and vibration control joints:
 1. Protect joints against damage during pressure test.

3.02 INSTALLATION

- A. Expansion control joints:
 1. Install bellows type expansion control joints at piping connections to mechanical equipment to prevent damaging stresses due to normal expansion and contraction with temperature changes in piping and connected equipment.
 2. Install bellows type expansion joints so as to allow 2-1/4-inch expansion per 100 linear feet of piping.
 3. Install expansion joints adjacent to an anchor, and provide 1 concentric guide on piping within 12 pipe diameters, but not more than 5 feet, from the end of the joint opposite the anchor.
 - a. Locate a similar guide approximately 30 diameters but not more than 10 feet from the first.
 4. For expansion joints not installed adjacent to an anchor provide 2 concentric guides similarly located at each end of the joint.
 5. Provide control rods and additional guides where indicated on the Drawings but at no greater intervals than recommended by the joint manufacturer in published instructions.
 6. Space intermediate supports a minimum of 10 feet, and tack weld the protective saddles to the pipe.
- B. Transition couplings:
 1. Application:
 - a. Use with function and design similar to flexible couplings and flanged coupling adapters for connecting piping having different outside diameters.
 2. Install products specifically designed and manufactured for that application.

- C. Pipe saddles:
 - 1. Coat threads on bolts with anti-gall coating prior to installation.
- D. Furnish Manufacturer's Certificate of Installation Verification.

3.03 FIELD QUALITY CONTROL

- A. Manufacturer services:
 - 1. Required only for:
 - a. Transition couplings.
 - b. Tapping sleeves for large diameter pipe.
- B. Field testing:
 - 1. As specified in Section 40_05_00.01 - Common Work Results for General Piping.
 - 2. Protect bellows type expansion joints and vibration control joints.

END OF SECTION

SECTION 40_05_06.03

PIPE COUPLINGS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pipe couplings for ductile iron piping.
 - 2. Pipe couplings for carbon steel piping.
 - 3. Pipe couplings for stainless 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. C213 - Standard for Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
 - 4. C219 - Bolted, Sleeve-Type Couplings For Plain-End Pipe.
 - 5. C227 - Bolted, Split-Sleeve Couplings.
 - 6. 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. A588 - Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi (345 MPa) Minimum Yield Point, with Atmospheric Corrosion Resistance.
 11. C425 - Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
 12. C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
 13. C564 - Standard Specification for Rubber Gasket for Cast Iron Pipe and Fittings.
 14. C1173 - Standard Specification for Flexible Transition Couplings for Underground Piping Systems.
 15. D1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.
 16. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
 17. D5926 - Standard Specification for Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems.
 18. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 19. F594 - Standard Specification for Stainless Steel Nuts.
 20. 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. Furnish Submittals as specified in Section 01_33_00 - 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.
 - g. For grooved joint couplings used in flexible radius-cut type joints, provide information on coupling axial and angular deflection values.
- C. Calculations:
1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.

1.04 WARRANTY

- A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_00 - 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 01_75_17 - 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. Kop-Coat Co., Inc., Bitumastic Number 50.
 - b. Tapecoat Co., Inc., T.C. Mastic.
 - 2. Thickness: Minimum 0.040 inch.

2.02 PIPE COUPLINGS FOR DUCTILE IRON 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: AWWA C207 steel pipe:
 - 1) ASTM A53 for sizes 3 inches to 12 inches.
 - 2) ASTM A36 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 or ASTM A53.
 - c. Follower ring: Ductile iron in accordance with ASTM A536.
 - d. Bolts and hex nuts:
 - 1) Aboveground: High strength, low alloy steel in accordance with ASTM A588.

- 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: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- B. Flanged coupling adapters: 12-inch size and smaller:
 - 1. Manufacturers: One of the following or equal:
 - a. Dresser, Inc., Style 227.
 - b. Romac Ind., Inc., Style FCA501.
 - c. Smith-Blair, Inc., Series 912.
 - 2. Materials:
 - a. Flanged body: Ductile iron in accordance with ASTM A536.
 - b. Follower ring: Ductile iron in accordance with ASTM A536.
 - c. Bolts and hex nuts:
 - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
 - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
 - 3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
 - 4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- C. Flanged coupling adapters: Greater than 12-inch size:
 - 1. Manufacturers: One of the following or equal:
 - a. Dresser, Inc., Style 128-W.
 - b. Romac Ind., Inc., Style FC400.
 - c. Smith-Blair, Inc., Series 913.
 - 2. Materials:
 - a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
 - b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
 - c. Bolts and hex nuts:
 - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
 - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
 - 3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
 - 4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- D. Flexible couplings:
 - 1. Manufacturers: One of the following or equal:
 - a. Dresser, Inc., Style 253.
 - b. Romac Ind., Inc., Style 501.
 - c. Smith-Blair, Inc., Series 441.

2. Materials:
 - a. Center rings: Ductile iron in accordance with ASTM A536.
 - b. Follower rings: Ductile iron in accordance with ASTM A536.
 - c. Bolts and hex nuts:
 - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
 - 2) Buried and underwater: Type 316 stainless steel in accordance with ASTM F593.
3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with the following table:

Nominal Pipe Size	Sleeve Length
3 inch and smaller	Manufacturer's standard
4 inch through 8 inch	7 inches
10 inch through 14 inch	12 inches
Greater than 16 inch	Use steel flexible coupling per pipe couplings for steel piping

- E. Flexible couplings (gravity flow):
 1. Manufacturers: The following or equal:
 - a. Fernco Flexible Coupling.
 2. Materials:
 - a. In accordance with ASTM D5926, ASTM C1173, and applicable portions of ASTM C443, C425, C564, and D1869.
 3. Requirements:
 - a. In underground and underwater installations, couplings shall be corrosion resistant or coated with a fusion applied epoxy coating in accordance with AWWA C213.
 - b. Bolts and hardware shall be stainless steel 18-8 Type 316.
- F. Restrained flange coupling adapter:
 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 and apply forces evenly.
 - 3) Restraining bolts:
 - a) Ductile iron in accordance with ASTM A536.
 - b) Bolt heads shall be designed to twist off when the proper torque has been applied.
 - c. Bolts and hex nuts:
 - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.

- 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
 3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
 4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- G. Grooved joint couplings:
1. Manufacturers: The following or equal:
 - a. Victaulic, Series 31 or equal.
 2. Materials:
 - a. Housings: Ductile iron in accordance with ASTM A536.
 - b. Gasket:
 - 1) Grade "M" FlushSeal® Elastomer in accordance with ASTM D2000.
 - 2) Halogenated butyl (brown color code).
 - 3) Temperature range: -20 to 200 degrees Fahrenheit.
 - 4) UL classified in accordance with NSF 61.
 - c. Bolts and nuts: Electroplated steel in accordance with ASTM A449.
 - d. Coating: As specified in Section 09_96_01 - High-Performance Coatings.
 3. For use with rigid or flexible radius cut grooved joints in accordance with AWWA C606.
 4. For connection to IPS steel pipe sizes: Victaulic transition coupling Style 307.

PART 3 EXECUTION

3.01 INSTALLATION

- A. In underground and underwater installations, coat the exterior of coupling with a protective coating in accordance with the 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 Pipe Schedule in Section 40_05_00.01 - Common Work Results for General Piping.

- E. Grooved joint couplings:
 - 1. Grooved ends: Clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
 - 2. Gaskets: Elastomer grade suitable for the intended service and molded and produced by the coupling manufacturer.
- F. Bolted, split-sleeve couplings:
 - 1. Inspect each coupling to ensure that there are no damaged portions of the coupling.
 - a. Pay particular attention to the sealing pad/sealing plate area.
 - b. Before installation, thoroughly clean each coupling of any foreign substance which may have collected thereon and shall be kept clean at all times.
 - 2. Wrenches:
 - a. Conform to manufacturer instructions.
 - b. Bolts and studs shall be tightened so as to secure a uniform gasket compression between the coupling and the body of the pipe with all bolts or studs tightened approximately the same amount.
 - c. Final tightening shall be done by hand (no air impact wrenches) and is complete when the coupling is in uniform contact with the outside surface of the pipe all around the circumference of the pipe.
 - 3. No joint shall be misfit in any plane.
 - 4. On fixed ends of bolted, split-sleeve couplings, shoulders shall bear on restraint rings all around with no visible gap.
 - 5. Ends of piping where coupler are installed shall be smooth and free of defects.
 - a. Remove weld splatter and grind smooth.
 - b. Grind pipe seam welds flush with pipe wall and smooth.

END OF SECTION

SECTION 40_05_06.55

PIPING INSULATION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Insulation for piping and related systems that are not plumbing systems.

1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. Standard Specifications for Highway Bridges.
- B. American Water Works Association (AWWA):
 - 1. C151 - Ductile-Iron Pipe, Centrifugally Cast.
- C. ASTM International (ASTM):
 - 1. C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
 - 2. C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
 - 3. C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
 - 4. C547 - Standard Specification for Mineral Fiber Pipe Insulation.
 - 5. C552 - Standard Specification for Cellular Glass Thermal Insulation.
 - 6. C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
 - 7. C929 - Standard Practice for Handling, Transporting, Shipping, Storage, Receiving, and Application of Thermal Insulation Materials for Use in Contact with Austenitic Stainless Steel.
 - 8. C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
 - 9. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
 - 10. E96 - Standard Test Methods for Water Vapor Transmission of Materials.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Buried: Piping that is installed below buildings, foundations, or finish grade, either in soil or encased in concrete in soil.
 - 2. Concealed: Piping above suspended ceilings and within walls, partitions, shafts, or service spaces and spaces not normally exposed to view but not buried.

3. Exterior: Piping that is installed outside a building or within a pipe trench or tunnel.
4. Flame spread and smoke density: Burning characteristics determined in accordance with ASTM E84.
5. Interior: Piping that is installed inside a building.
6. K-factor: Thermal conductivity determined in accordance with ASTM C177 or ASTM C518.
7. Mineral fiber: Fibers manufactured of glass, rock, or slag processed from a molten state, with or without a binder.
8. Water vapor permeance: Water vapor transmission determined in accordance with ASTM E96 and expressed in units of perm-inch.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_00 - Product Requirements.
- B. Product data:
 1. Insulation properties: Include K-factor, thickness, density, operating temperature limits, tensile strength, compressive strength, moisture absorption, flame spread, and smoke developed in accordance with ASTM E84 and corrosivity to stainless steel piping in accordance with ASTM C795.
 2. Jacket properties: Include covering material, cover thickness, tensile strength, tear strength, permeability in accordance with ASTM E96, flame spread, and smoke developed in accordance with ASTM E84, closure type or devices, and accessories.
 3. Insulating blankets: Include materials, performance characteristics, method of attaching to equipment, listing of locations where insulating blankets will be installed.
 4. Manufacturer's application instructions: Include assembly and application drawings and detailed instructions.

1.05 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_00 - Product Requirements with additional requirements in Section 46_05_10 Common Work Results for Mechanical Equipment and Section 23_05_00 - Common Work Results for HVAC.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. As specified in Section 46_05_10 Common Work Results for Mechanical Equipment and Section 23_05_00 - Common Work Results for HVAC.

- B. Provide insulation thickness in inches in accordance with the following table. Insulation thickness shown is nominal. Manufacturing tolerance of 15 percent variation is permissible.

Table 1. Required Insulation Thicknesses (inches)					
Service Temperature Range⁽¹⁾	Nominal Pipe Diameters				
	1 inch and Less	1.25 to 2 inches	2.5 to 4 inches	5 to 10 inches	Over 10 inches
Above 200 degrees Fahrenheit	2.0	2.5	3.0	3.5	3.5
100 to 200 degrees Fahrenheit	1.5	1.5	1.5	2.0	2.5
40 to 100 degrees Fahrenheit	0.5	1.0	1.0	1.5	2.0
Below 40 degrees Fahrenheit	1.0	1.0	1.5	2.0	2.0
Heat Traced Pipes	1.0	1.0	1.0	1.5	2.0
Aeration Air Pipes	0.5	0.5	1.0	1.0	1.0
Notes: (1) As designated in the Insulation Schedule at the end of this Section.					

2.03 PIPE INSULATION

- A. Insulation types: Provide in accordance with the insulation types listed and scheduled.
- B. Type 1:
- Material: Closed cell elastomeric insulation.
 - Minimum temperature range: -40 degrees Fahrenheit to 220 degrees Fahrenheit.
 - K-factor at 75 degrees Fahrenheit: Not more than 0.27 Btu-inch/hour-square feet-degrees Fahrenheit.
 - Fire ratings:
 - Flame spread: 25 or less.
 - Smoke density: 50 or less for insulation thicknesses up to 1.5 inches.
 - Joints: Seal with the manufacturer's recommended contact adhesive to form a continuous water barrier.
 - Manufacturers: One of the following or equal:
 - Aeroflex USA Inc., Aerocel® AC.
 - Armacell, AP Armaflex.

2.04 INSULATION JACKETS

- A. Type 1:
- Not used.
- B. Type 2:
- Material: Ultraviolet-resistant polyvinyl chloride jacketing, 20 mil minimum thickness.
 - Fire rating: 25 maximum flame spread, smoke developed 50 or less.
 - Color: White.
 - Overlap: 1 inch minimum at joints and fittings.

5. Joint seal: PVC solvent welded or adhesive as recommended by the manufacturer.
6. Fittings: Factory made with full thickness insulation.
7. Manufacturers: One of the following or equal:
 - a. Johns Manville, Zeston® 2000 PVC.
 - b. Proto Corp., LoSMOKE PVC.
 - c. Speedline® Corp., Smoke-Safe™ PVC.

2.05 VAPOR BARRIERS

- A. Type 1:
 1. Material: White Kraft paper bound to aluminum foil in accordance with ASTM C1136, Type 1.
 2. Permeability: 0.02 perms or lower.
 3. Maximum flame spread rating: 25.
 4. Edge seal: Pressure-sensitive tape lap seal.
 5. Circumferential joints: 4-inch wide tape or 4-inch overlap with adhesive seal.
- B. Type 2:
 1. Material: Mastic.
 2. Manufacturers: One of the following or equal:
 - a. Benjamin Foster, No. 30-76.
 - b. Childers Products CP10/11 VI-CRYL.
 - c. Foster Products, 36-10/46-10 Weatherite.
 - d. Insul-Coustic, No. I.C.-580.

2.06 RELATED MATERIALS

- A. Cover adhesive: Premium adhesive as recommended by the insulation cover supplier for heavy-duty service in corrosive, wet environments. Standard-duty adhesives are not permitted.

2.07 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

- A. As specified in Section 01_60_00 - Product Requirements.

PART 3 EXECUTION

3.01 GENERAL

- A. As specified in Section 01_60_00 - Product Requirements.
- B. Handle and store insulation for use on stainless steel in accordance with ASTM C929.

3.02 PREPARATION

- A. Pressure test piping and complete application of coating system before applying insulation.

- B. When piping is to be heat traced, install and functionally test heat tracing before installation of insulation.
- C. Before beginning installation of piping insulation, verify that the Engineer has accepted piping tests, pipe coating applications, and heat tracing tests.

3.03 INSULATION SCHEDULE

- A. The insulation schedule table below does not include insulation required for plumbing systems. Plumbing systems insulation is specified in Section 22_42_01 - Plumbing Systems.

Table 2. Insulation Schedule					
Service Designation ⁽¹⁾	Location ⁽²⁾	Insulation Type ⁽³⁾	Jacket Type ⁽³⁾	Service Temp. °F ⁽⁴⁾	Vapor Barrier
Utility Water	Exterior	1	2	70	Required
Notes: (1) Refer to the Pipe Schedule in Section 40_05_00.01 - Common Work Results for General Piping for service designations. (2) Insulation jackets are not required for interior installations that are concealed. See definitions for description of concealed locations. (3) Contractor may select from options listed.					

3.04 INSTALLATION

- A. Install insulation and jacket materials in accordance with the manufacturer's instructions.
- B. Apply insulation in a smooth, clean manner with tight and finished smooth joints. Fit insulation tightly against surfaces.
 - 1. Insulate each continuous run of pipe with full-length sections of insulation with a single piece cut to length to complete the run of pipe.
 - 2. Do not use cut pieces or scraps to complete the installation.
- C. Butt longitudinal and circumferential insulation joints firmly together.
- D. Maintain the integrity of vapor barrier jacketing. Do not use staples to hold vapor barrier overlaps in place.
- E. Apply sealant or cement when previous applications of adhesives and cement have thoroughly dried.
- F. Apply insulation to permit expansion or contraction of pipelines without damage to insulation or jacketing.
- G. Fittings:
 - 1. Insulate fittings by covering with mitered sections of insulation or utilize factory-made prefabricated fitting shapes.
 - 2. Terminate preformed pipe jackets or covering at sufficient distance from flanges to permit removal of bolts.

3. Overlap flange and flanged fitting insulation on adjacent pipe covering by at least 2 inches.
- H. Valves:
1. Insulate valves 3 inches in nominal size and larger with removable insulating blankets.
 2. Size blanket to extend up to packing gland only so that replacement of packing does not require removal of insulating blanket.
- I. Provide continuous insulation through and over pipe supports and provide protection saddles at supports.
- J. Extend insulation against insulation end protection shields or covers so that insulation voids do not exist and provide watertight end seals and covers where insulation terminates.
- K. Insulate pipeline strainers to permit removal of strainer basket without disturbing insulation on strainer body.
- L. Provide continuous pipe insulation and covering through sleeves or openings in walls and floors. When buried pipe enters a building through a below grade wall or slab penetration, begin insulation system on interior side of penetration.
- M. Apply pre-molded pipe insulation with extended legs when used on pipe traced with either tubing or electric cable type.
- N. Thermally isolate insulation closure locations (end caps, transitions, etc.) Type 1 or Type 2 jacket installation on piping with potential reach temperatures greater than 150 degrees Fahrenheit.
- O. Apply piping identification on jackets as specified in Section 40_05_00.03 - Pipe Identification.

END OF SECTION

SECTION 40_05_07.01

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. 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. Manufacturers Standardization Society (MSS):
 - 1. SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Anchor: Elements (including hardware) connecting hangers and supports to the structure.
 - 2. Hardware: Nuts, bolts, straps, clamps, threaded rod, etc.
 - 3. Supports: Structural member on which the pipe is mounted.

1.04 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Design features.
 - 2. Load capacities.
 - 3. Material designations by UNS alloy number or ASTM Specification and Grade.
 - 4. Catalog data.
- C. Delegated Design Submittals:
 - 1. Provide project-specific calculations and details based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.

1.05 WARRANTY

- A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_00 - Product Requirements.

2.02 MATERIALS

- A. General:
 - 1. Hot dip galvanized:
 - a. Fabricate as specified in Section 05_50_00 - Metal Fabrications.
 - b. Hot dip after fabrication of support in accordance with ASTM A123.
 - c. Repair galvanized surface as specified in Section 05_50_00 - Metal Fabrications.
 - 2. Stainless steel:
 - a. Fabricate as specified in Section 05_50_00 - Metal Fabrications.
 - 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 ASTM A967.
 - d. Field welding is prohibited unless specifically allowed by the Owner. All field welds shall be passivated.
- B. Outdoor areas: Areas exposed to the natural outdoor environment:
 - 1. Hot dip galvanized.
- C. Indoor areas: Areas exposed to an indoor environment, including galleries and tunnels:
 - 1. Hot dip galvanized.
- D. Submerged, 3 feet or less above water level in a structure, or inside a water bearing structure:
 - 1. Type 316 stainless steel.
- E. Stainless steel piping system:
 - 1. Type 316 stainless steel.
- F. Chemical containment areas and chemical piping:
 - 1. Provide materials compatible with the chemicals.
 - 2. Type 316 stainless steel.
- G. Fasteners:
 - 1. As specified in Section 05_50_00 - Metal Fabrications.

2.03 PIPE SUPPORTS

- A. Hanger rods: 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 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. Welded eyebolt rod:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) FM Stainless Fasteners.
 - 2) Nibco-Tolco, Figure 101.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 278.
 - 2) Bergen-Power, Figure 93.
 - 3) Cooper B-Line Systems, Inc., Figure B3210.
- D. Adjustable ring hangers: MSS SP-58, Type 7 or Type 9 (system dependent):
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Bergen-Power, Figure 100SS.
 - 2) Nibco-Tolco, Figure 1C.I.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 69.
 - 2) Cooper B-Line Systems, Inc., Figure B3172.
- E. Adjustable clevis hangers: MSS SP-58, Type 1:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure B3100 or B3102.
 - 2) FM Stainless Fasteners, Figure 60.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 260 or Figure 590.
 - 2) Bergen-Power, Figure 100.
 - 3) Cooper B-Line Systems, Inc., Figure B3100 or B3102.

- F. 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) Cooper B-Line Systems, Inc., Figure B3066.
 - 2) FM Stainless Fasteners, Figure 98.
 - 3) Nibco-Tolco, Figure 30M.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 195.
 - 2) Cooper B-Line Systems, Inc., Figure B3066.
- G. Brackets, heavy duty: MSS SP-58, Type 33 with back plate; rated for 3,000 pounds:
 - 1. Manufacturers: One of the following or equal:
 - a. Anvil International, Figure 199.
 - b. Cooper B-Line Systems, Inc., Figure B3067.
- H. Standard U-bolt: MSS SP-58, Type 24:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure B3188.
 - 2) FM Stainless Fasteners, Figure 37.
 - 3) Nibco-Tolco, Figure 110.
 - 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.
- I. 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.
- J. Pipe clamps: MSS SP-58, Type 4:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure 3140.
 - 2) Nibco-Tolco, Figure 4.
 - 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.

- K. Adjustable offset pipe clamp:
1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure B3149.
 - 2) FM Stainless Fasteners, Figure 63.
 - 3) Nibco-Tolco, Figure 4.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 100.
 - 2) Cooper B-Line Systems, Inc., Figure B3149.
- L. Offset pipe clamp:
1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure 3148.
 - 2) Nibco-Tolco, Figure 8.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 103.
 - 2) Cooper B-Line Systems, Inc., Figure B3148.
- M. 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) FM Stainless Fasteners, Figure 59.
 - 2) Nibco-Tolco, Figure 318.
 - 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.
- N. Spring hangers:
1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Bergen-Power, Figure 920.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure B-268, Type G.
 - 2) Bergen-Power, Figure 920.
- O. Welded beam attachment: MSS SP-58, Type 22:
1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure 3083.
 - 2) Nibco-Tolco, Figure 304.
 - 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.

- P. Heavy pipe clamp: MSS SP-58, Type 4:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 4H.
 - b. For all other piping, unless otherwise indicated on the Drawings:
 - 1) Anvil International, Figure 216.
 - 2) Bergen-Power, Figure 298.
- Q. PTFE pipe slide assembly: MSS SP-58, Type 35 with lateral and vertical restraint:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 426.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 257, Type 3.
 - 2) Cooper B-Line Systems, Inc., Figure B3893.
- R. Anchor bolts, concrete anchors, concrete inserts, powder-actuated fasteners, and sleeve anchors: As specified in Section 05_12_00 - Structural Steel Framing.

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. 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 pipes larger than 4 inches in diameter.

- K. Secure pipes with double nutted U-bolts or suspend pipes from hanger rods and hangers.
 - 1. For stainless steel piping, use stainless steel U-bolts.
 - 2. For all other piping, use galvanized U-bolts.
- L. Support spacing:
 - 1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
 - 2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
 - 3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
 - 4. Support tubing, PVC pipe 1-inch and smaller, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4-inch between supports.
 - 5. Do not suspend or support valves, pipe and fittings from another pipe or conduit.
- M. Install supports at:
 - 1. Any change in direction.
 - 2. Both sides of flexible pipe connections.
 - 3. Base of risers.
 - 4. Floor penetrations.
 - 5. Connections to pumps, blowers, and other equipment.
 - 6. Valves and appurtenances.
- N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.
- O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.
- P. Provide elbows or tees supported from floors with base fittings where indicated on the Drawings.
- Q. Support base fittings with metal supports or, when indicated on the Drawings, support on concrete piers.
- R. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.
- S. Support plumbing drainage and vents in accordance with plumbing code as specified in Section 01_41_00 - 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 thermal pipe shield in accordance with MSS SP-58, Type 40 on pipe supports for insulated pipes.

- W. Install riser clamps at floor penetrations and where indicated on the Drawings.
- X. Coat support system components as specified in Section 09_96_01 - High-Performance Coatings.

END OF SECTION

SECTION 40_05_07.03

PREFORMED CHANNEL PIPE SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Preformed channel pipe support system consisting of preformed channels, fittings, straps, and fasteners engineered to support piping.

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 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data.

1.04 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 DESIGN AND PERFORMANCE CRITERIA

- A. Design responsibility:
 - 1. The manufacturer of the preformed channel pipe support system is responsible for the design of the support system.
 - 2. Prepare design calculations utilizing the design criteria included in these Specifications.
 - 3. Prepare detailed shop drawings illustrating the layout of the support system and identifying the components of the support system.
- B. Design criteria:
 - 1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
 - 2. Minimum gauge thickness: 12-gauge.
 - 3. Allowable stress of channels:
 - a. Steel channels: The lesser of 25,000 pounds per square inch, or 0.66 times yield stress of steel.
 - b. Stainless steel channels: 0.66 times the yield stress of the stainless steel alloy.
 - 4. Maximum deflection: 1/240 of span.
 - 5. Allowable column loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
 - 6. Future loads:
 - a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.
 - b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
 - c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
 - 7. Seismic design criteria: As specified in Section 01_81_50 - 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.

2.03 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.

2.04 FABRICATION

- A. Hot-dip galvanize support system components after fabrication to required length and shape.
- B. Do not galvanize or paint stainless steel components.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install preformed channel concrete inserts for vertical support, quantity based on manufacturer's structural design calculations.
- B. Fasten preformed channel pipe supports to existing walls using Z-fittings and concrete anchors as indicated on the Drawings.
- C. Fasten preformed channel pipe supports to preformed channel concrete inserts embedded in ceiling using U-shaped fittings.
- D. Suspend threaded rods from concrete inserts embedded in ceiling. Support preformed channel pipe supports with threaded rods.
- E. Touchup cut or damaged galvanized surfaces.
- F. Prevent contact between pipes and support components of dissimilar metals. Utilize rubber coated, plastic coated, or vinyl coated components, stainless steel components, or wrap pipe with PVC or polyethylene tape.
- G. Install support as near as possible to concentrated loads.
- H. Install support within 2 feet of horizontal and vertical changes in pipe alignment.
- I. Adjust supports or install shims to obtain specified slope or elevation.

END OF SECTION

SECTION 40_05_19.01
DUCTILE IRON PIPE: AWWA C151

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Ductile iron pipe, joints, connections, fittings, and pipe linings and coatings.
- B. As specified in Section 40_05_00.01 - Common Work Results for General Piping.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- B. American Water Works Association (AWWA):
 - 1. C104 - Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
 - 2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
 - 3. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
 - 4. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - 5. C150 - Standard for Thickness Design of Ductile-Iron Pipe.
 - 6. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
 - 7. C153 - Standard for Ductile-Iron Compact Fittings for Water Service.
 - 8. C210 - Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
 - 9. C222 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.
 - 10. C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
 - 11. C606 - Standard for Grooved and Shouldered Joints.
- C. American Welding Society (AWS):
 - 1. D11.2 - Guide for Welding Iron Castings.
- D. ASTM International (ASTM):
 - 1. A536 - Standard Specifications for Ductile Iron Castings.
 - 2. 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.
 - 3. C33 - Standard Specification for Concrete Aggregates.
 - 4. C150 - Standard Specification for Portland Cement.
 - 5. C283 - Standard Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
 - 6. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
 - 7. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.

- E. Ductile Iron Pipe Research Association (DIPRA):
 - 1. Thrust Restraint Design Manual.
- F. International Organization for Standardization (ISO):
 - 1. 8179 - Ductile iron pipe, fittings, accessories and their joints - External zinc-based coating - Part 1: Metallic zinc with finishing layer.
- G. National Association of Pipe Fabricators, Inc. (NAPF):
 - 1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.
- H. NSF International (NSF):
 - 1. 61 - Drinking Water System Components - Health Effects.
- I. Society for Protective Coatings (SSPC):
 - 1. SP 5 - White Metal Blast Cleaning.
 - 2. SP 10 - Near White Wet Blast.
 - 3. SP 11 - Bare Metal Power Tool Cleaning.
 - 4. PA 2 - Measurement of Dry Coating Thickness with Magnetic Gages.
 - 5. QP 1 - Industrial Contractor Qualification.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data.
- C. Manufacturer's qualifications.
 - 1. Manufacturer qualifications and list of projects using the specified material: 5 years minimum.
 - 2. Plural component epoxy and plural component polyurethane field repair: SSPC-QP 1 certification required.
- D. Manufacturer's Quality Assurance Manual:
 - 1. Submit manufacturer's coating and lining application quality assurance manual to the Engineer prior to beginning coating application.
 - a. 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.
- E. Shop Drawings:
 - 1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, and connections to pipelines or structures.
 - 2. Thrust restraint systems.
 - 3. Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings.
- F. Calculations:
 - 1. Thrust restraint system design.

- G. Manufacturer's Certificate of Source Testing for ceramic epoxy, glass lined, plural component polyurethane, and zinc materials:
 - 1. Certify successful performance of holiday detection tests on 100 percent of lining in accordance with ASTM B1000.
 - 2. Identify each test piece by mark designation and show the actual test results during the final inspection by the manufacturer prior to shipment.
 - 3. Zinc coating: Regular measurements in accordance with ISO 8179 Part 4.4.
 - 4. Include the coating manufacturer's technical representative's reports.

1.04 QUALITY ASSURANCE

- A. Ductile iron pipe shall be supplied by a single manufacturer.
- B. Hydrostatically test each joint of ductile iron pipe in accordance with AWWA C151.
- C. Pre-installation meeting:
 - 1. Arrange for the coating manufacturer's technical representative to attend preconstruction conferences and to make periodic visits to the factory or shop to inspect surface preparation of pipe, fittings, and accessories; and to inspect application of linings to interior and coatings to exterior of pipe, fittings, and accessories.

1.05 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. Handle pipe from the outside if lined with ceramic epoxy, glass or plural component polyurethane.
 - 1. No forks, chains, straps, hooks, or other lifting device shall be placed inside the pipe or fittings for lifting, positioning, or laying.
- D. Protect gaskets and polyethylene encasement from long-term exposure to sunlight.
- E. Store piping, fittings, and other accessories such that they do not accumulate and hold rainwater, dirt, and debris.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

- A. Ductile iron piping:
 - 1. Manufacturers: One of the following or equal:
 - a. American Cast Iron Pipe Co.

- b. McWane Ductile.
- c. U.S. Pipe.

2.02 THRUST RESTRAINT SYSTEM DESIGN

- A. Length of pipe that must be restrained on each side of the focus of a thrust load as specified in the Pipe Schedule.
- B. Design pressure: 75 psi.
- C. Laying condition: Type 5 in accordance with AWWA C150.
- D. Soil type: Silt 1.
- E. Unit friction resistance for polyethylene encasement of pipe: DIPRA factor multiplied by a safety factor of 1.5.

2.03 CONCRETE THRUST BLOCK RESTRAINT

- A. Joint thrust restraint system designed by the Contractor.
 - 1. Concrete thrust blocks will only be permitted in certain locations where indicated on the Drawings.

2.04 DUCTILE IRON JOINTS AND CONNECTIONS

- A. General:
 - 1. Pressure class or special thickness class as specified in the Pipe Schedule provided in Section 40_05_00.01 - Common Work Results for General Piping.
 - 2. In accordance with AWWA C150 and AWWA C151.
- B. Joints:
 - 1. Flanged joints:
 - a. Screw-on flanges:
 - 1) Comply with the diameter, thickness, drilling, and other characteristics in accordance with ASME B16.1.
 - 2) Ductile iron.
 - 3) Long hub, threaded, and specially designed for ductile iron pipe.
 - 4) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
 - b. Bolt holes on flanges: 2-holed and aligned at both ends of pipe.
 - c. Cap screw or stud bolt holes: Tapped.
 - d. Bolts and nuts:
 - 1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
 - e. Gaskets:
 - 1) Standard styrene butadiene copolymer (SBR) unless specified otherwise in Section 40_05_00.01 - Common Work Results for General Piping.
 - 2. Grooved joints:
 - a. In accordance with AWWA C606, as complemented and modified below, radius-cut type.

- b. Couplings:
 - 1) Rigid type, cast from ductile iron in accordance with ASTM A536, Grade 65-45-12.
- c. Bolts and nuts:
 - 1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
- d. Gaskets:
 - 1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
- e. Fittings:
 - 1) In accordance with AWWA C606, rigid radius-cut groove.
 - 2) Center-to-center dimensions: In accordance with AWWA C110.
 - 3) Wall thickness and other characteristics: In accordance with AWWA C606.
- f. Flanged unit connections:
 - 1) Flanged to grooved joint adapters or a long enough spool with one end flanged and the other end grooved to prevent interference with the operation of adjacent valves, pumps, or other items.
- 3. Mechanical joints:
 - a. In accordance with AWWA C111.
 - b. Gaskets:
 - 1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
 - c. Bolts and nuts, including T-bolts:
 - 1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
- 4. Push-on rubber gasket joints:
 - a. In accordance with AWWA C111.
 - b. Gaskets:
 - 1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
- 5. Integrally restrained mechanical joints:
 - a. Manufacturers: Where restrained mechanical joints are required, use one of the following or equal:
 - 1) American Cast Iron Pipe Co., MJ Coupled Joint.
 - 2) U.S. Pipe, Bolt-Lok.
 - 3) U.S. Pipe, Mech-Lok.
 - b. Application:
 - 1) Where designated mechanical restraint.
 - 2) Mechanical joint is specified in the Pipe Schedule provided in Section 40_05_00.01 - Common Work Results for General Piping, supply a restrained mechanical joint piping system, which includes restrained mechanical joints where necessary based upon thrust calculations.
 - 3) Standard mechanical joints as specified above can be used where thrust calculations demonstrate restraint is not required.
 - c. Design:
 - 1) Integral retainer weldment type or lugged type joint with Type 304 stainless steel rods and nuts.
 - 2) Restrained mechanical joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.

- d. Gaskets:
 - 1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
- e. Bolts and nuts, including T-bolts:
 - 1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
- 6. Mechanical wedge action joint restraints:
 - a. Manufacturers: One of the following or equal:
 - 1) EBAA Iron, Inc., Megalug® Series 1100.
 - 2) Sigma Corp., One-Lok Model SLDE.
 - 3) Star Pipe Products, Split Stargrip Series 3000.
 - b. Materials:
 - 1) Gland body:
 - a) Ductile iron in accordance with ASTM A536.
 - 2) Wedges and wedge actuating components:
 - a) Ductile iron in accordance with ASTM A536.
 - b) Wedges shall be heat treated to a minimum of 370 BHN.
 - 3) Actuating bolts and nuts:
 - a) Ductile iron in accordance with ASTM A536.
 - b) Provide torque-limiting twist off components to ensure proper installation.
 - 4) Gaskets:
 - a) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
 - c. Coatings:
 - 1) Provide manufacturer-applied coating system.
 - 2) Manufacturers: One of the following or equal:
 - a) EBAA Iron Inc., Mega-Bond polyester powder applied by an electrostatic spray process.
 - b) Sigma Corp., Corrsafe™ Electro-deposition coating.
 - c) Star Pipe Products, Star-Bond™ TGIC polyester powder coating applied by an electrostatic spray process.
 - d. Working pressure:
 - 1) Shall include a minimum safety factor of 2:1.
 - 2) Sizes 3- through 16-inch: 350 pounds per square inch.
 - 3) Sizes 18- through 48-inch: 250 pounds per square inch.
 - e. Restraint shall consist of multiple gripping wedges incorporated into a follower gland meeting the requirements of AWWA C111.
 - f. Restraint shall allow post assembly angular deflection that is a minimum of 50 percent of the angular deflection allowed by the mechanical joint.
 - g. Restraint must be in accordance with applicable requirements of AWWA C110 and AWWA C111 for mechanical joints.
- 7. Integrally restrained push-on joints:
 - a. Application:
 - 1) Where designation restrained push-on is specified in the Pipe Schedule provided in Section 40_05_00.01 - Common Work Results for General Piping, supply a restrained push-on joint piping system, which includes restrained push-on joints where necessary based upon thrust calculations.
 - 2) Standard push-on rubber gasket joints as specified above can be used where thrust calculations demonstrate restraint is not required.

- b. Design:
 - 1) Restrained push-on joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
 - 2) Suitable for the following working pressures:
 - a) 4- through 24-inch pipe: 350 pounds per square inch gauge.
 - b) 30- through 54-inch pipe: 250 pounds per square inch gauge.
 - c. Gaskets:
 - 1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
 - d. Manufacturers: One of the following or equal:
 - 1) American Cast Iron Pipe Co., Flex Ring or Lok-Ring.
 - 2) McWane Ductile, TR Flex.
 - 3) U.S. Pipe, HDSS.
 - e. Limit buried joints to half the manufacturer's published allowable angular joint deflection for purposes of pipeline alignment and elimination of fittings.
8. Push-on joint restraint harnesses:
- a. Manufacturers: One of the following or equal:
 - 1) EBAA Iron, Inc., Megalug® Series 1700.
 - 2) Sigma Corp., One-Lok Model SLDEH.
 - 3) Star Pipe Products, Split Stargrip Series 3100S.
 - b. Materials:
 - 1) Restraint and backup ring: Ductile iron in accordance with ASTM A536.
 - 2) Wedges and wedge actuating components: Ductile iron in accordance with ASTM A536.
 - a) Wedges shall be heat treated to a minimum of 370 BHN.
 - 3) Actuating bolts and nuts:
 - a) Ductile iron in accordance with ASTM A536.
 - b) Provide torque-limiting twist off components to ensure proper installation.
 - 4) Tie rods:
 - a) Low alloy steel in accordance with AWWA C111.
 - 5) Bolts and nuts, including T-bolts:
 - a) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
 - c. Coatings:
 - 1) Provide manufacturer-applied coating system.
 - 2) Manufacturers: One of the following or equal:
 - a) EBAA Iron Inc., Mega-Bond polyester powder applied by an electrostatic spray process.
 - b) Sigma Corp., Corrsafe™ Electro-deposition coating.
 - c) Star Pipe Products, Star-Bond™ TGIC polyester powder coating applied by an electrostatic spray process.
 - d. Working pressure:
 - 1) Shall include a minimum safety factor of 2:1.
 - 2) For sizes 3- through 16-inch: 350 pounds per square inch.
 - 3) For sizes 18- through 48-inch: 250 pounds per square inch.
 - e. Restraint shall consist of a backup ring behind the ductile iron bell and a restraint ring consisting of multiple gripping wedges connected with number and type of tie rods as recommended by the manufacturer.

- f. Restraint shall allow post assembly deflection of a minimum of 50 percent of the deflection capability of the push-on joint.
- C. Connections:
 - 1. Tapping saddle as specified in the Owner's standard specification.
 - a. If the Owner does not have a standard specification, provide tapping saddles as specified in Section 40_05_06.01 - Piping Specialties.
 - 2. Tapping sleeve as specified in the Owner's standard specification.
 - a. If the Owner does not have a standard specification, provide tapping sleeves as specified in Section 40_05_06.01 - Piping Specialties.
 - 3. Welded outlet:
 - a. Not allowed without Engineer approval.
- D. Fittings:
 - 1. Ductile iron in accordance with AWWA C110 or AWWA C153.
 - 2. Joint type:
 - a. Same as that of the associated piping as specified in Section 40_05_00.01 - Common Work Results for General Piping.
 - 3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

2.05 ASPHALT VARNISH

- A. Coating:
 - 1. Factory apply.
- B. Primer:
 - 1. Factory applied for field coating.
- C. Compatible with materials as specified in Section 09_96_01 - High-Performance Coatings.

2.06 CEMENT MORTAR

- A. Line pipe with cement mortar in accordance with AWWA C104 and as specified in this Section.
- B. Cement:
 - 1. Cement: In accordance with ASTM C150, Type II.
- C. Water:
 - 1. In accordance with AWWA C104 and as specified in this Section.
- D. Sand and aggregate:
 - 1. In accordance with AWWA C104.
 - 2. Provide silica sand or other aggregate that is not subject to leaching in accordance with ASTM C33.
- E. Lining:
 - 1. Minimum thickness: Standard in accordance with AWWA C104.
 - 2. Apply cement mortar on clean bare metal surfaces.
 - 3. Extend to faces of flanges, ends of spigots, and shoulders of hubs.

4. Line special pieces or fittings by mechanical, pneumatic, or hand placement.
 - a. Extend to faces of flanges and ends of spigots.
 - b. Less than 12 inches in width: Coat with epoxy bonding agent prior to applying cement mortar.
 - c. 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.
5. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
6. Repair damage to the cement mortar lining, including disbondment, or cracking caused by improper curing, shipping, handling, or installation in accordance with AWWA C104 and approved by the Engineer.
 - a. 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:
 - 1) No. 12 gauge spaced at maximum 1-inch centers.
 - 2) No. 14 gauge steel wire at maximum 1/2-inch centers.

2.07 CERAMIC EPOXY

- A. Line pipe with ceramic epoxy.
- B. Manufacturers: One of the following or equal:
 1. PROTECTO 401.
 2. SP-2000W.
- C. Material:
 1. Amine cured Novolac epoxy containing at least 20 percent by volume of ceramic quartz pigment.
- D. Application:
 1. Lining shall only be applied by a manufacturer-authorized representative with no less than 5 years of experience in applying the specified material.
 2. Application of the lining shall be performed in accordance with the manufacturer's published specifications.
 3. Pipe and fittings shall be delivered to application facility with no interior lining.
 4. Interior of pipe shall be abrasive blasted in accordance with manufacturer instructions.
 5. Apply lining in accordance with manufacturer instructions.
 6. Minimum dry film thickness (DFT): 40 mils.
- E. Coverage:
 1. Gasket and spigot ends on joints:
 - a. Minimum coverage using joint compound: 6 mils.
 - b. Maximum coverage using joint compound: 10 mils.
 2. Mechanical joints:
 - a. Extend lining from spigot end to edge of gauging ring.
 3. Number of coats:
 - a. In accordance with manufacturer instructions.

- F. Source quality control:
1. Test pipe and fitting lining with a magnetic film thickness gauge in accordance with SSPC-PA 2 film thickness rating.
 2. Test lining integrity of pipes in accordance with coating manufacturer instructions using a holiday detection testing instrument set at the specified voltage.
 3. Discard pipe or reline pipe when pinholes or discontinuities are found.
 4. Repair holidays with joint compound in accordance with coating manufacturer instructions and re-test.

2.08 POLYETHYLENE ENCASEMENT

- A. General:
1. Polyethylene encasement shall be supplied by the pipe manufacturer.
- B. Materials: Supply one of the following polyethylene encasements:
1. 2 layers of linear low-density polyethylene (LLDPE) film, minimum thickness of 8 mils in accordance with AWWA C105; or,
 2. Single layer of high-density, cross-laminated polyethylene (HDCLPE) film, minimum thickness of 4 mils in accordance with AWWA C105.
 3. Single layer of V-Bio[®] enhanced polyethylene encasement (3 layers of coextruded LLDPE film with anti-microbial additive and volatile corrosion inhibitor infused on the inside surface), meeting all requirements of AWWA C105.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General:
1. Install ductile iron piping in accordance with AWWA C600, or as modified in Section 40_05_00.01 - Common Work Results for General Piping.
 2. For underground piping, the trenching, backfill, and compaction:
 - a. Inspect coating prior to backfill.
 - b. As specified in Section 31_23_35 - Trenching.
- B. Joints:
1. Install types of joints as specified in the Pipe Schedule provided in Section 40_05_00.01 - Common Work Results for General Piping.
 2. Mechanical joints are not acceptable in above ground applications.
 3. Field closure for restrained push-on pipe:
 - a. Locate field closures in areas where thrust calculations demonstrate restraint is not required.
 4. Grooved joints:
 - a. Install piping with grooved joints as specified in the Pipe Schedule provided in Section 40_05_00.01 - Common Work Results for General Piping.
 - b. Assemble grooved joints in accordance with the manufacturer's published instructions.

- c. Support grooved-end pipe in accordance with the manufacturer's published instructions.

- 1) Install at least 1 support between consecutive couplings.

C. Connection:

1. Tapping ductile iron pipe:

- a. Direct tapping of ductile iron pipe may be performed but is limited to the following conditions:

- 1) Maximum allowable tap diameter by pipe diameter and pressure class:

Pipe Size (inches)	Pressure Class				
	150	200	250	300	350
	Maximum Allowable Direct Tap Size (inches)				
3	-	-	-	-	3/4
4	-	-	-	-	3/4
6	-	-	-	-	1
8	-	-	-	-	1
10	-	-	-	-	1
12	-	-	-	-	1-1/4
14	-	-	1-1/4	1-1/2	1-1/2
16	-	-	1-1/2	2	2
18	-	-	2	2	2
20	-	-	2	2	2
24	-	2	2	2	2

- b. Maximum allowable tap diameter for pipelines greater than 24 inches is 2 inches.

- c. 2 layers of 3-mil thread sealant are required to minimize the torque required to effect a watertight connection.

2. When direct tapping of ductile iron pipe is not possible due to limited wall thickness, a saddle tap shall be used.

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-inch 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 the 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. Less than 8 inches in the greatest dimension.
 - b. Repair in accordance with the manufacturer's requirements.
3. Major repairs:
 - a. Exceed 8 inches in the greatest dimension.
 - b. Repair in accordance with the manufacturer's requirements.

3.03 POLYETHYLENE ENCASEMENT

- A. Wrap buried ductile iron pipe and fittings in 2 layers of loose low-density polyethylene wrap or a single layer of high-density polyethylene wrap in accordance with AWWA C105 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.
- F. Repair tears and make joints with 2 layers of plastic tape.
- G. Work shall be inspected prior to backfilling of pipe and associated items.

3.04 FIELD QUALITY CONTROL

- A. Testing ductile iron piping:
 1. Test as specified in Section 40_05_00.01 - Common Work Results for General Piping and Section 40_05_00.09 - Piping Systems Testing.
- B. Repair damaged cement mortar lining to match quality, thickness, and bonding of original lining in accordance with AWWA C104.
 1. When lining cannot be repaired or repairs are defective, replace defective piping with undamaged piping.
- C. Verify that interior surfaces of ceramic epoxy pipe and fittings have continuous coverage:
 1. Test random samples, as directed by the Engineer, in accordance with ASTM B1000.
 2. Discard lined piping and fittings found to have pinholes, crazing, or fish scales, which expose the metal substrate.

END OF SECTION

SECTION 40_05_24.02

STEEL PIPE: ASTM A53

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Steel pipe: Galvanized and black, ASTM A53.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.3 - Malleable-Iron Threaded Fittings: Classes 150 and 300.
 - 2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
 - 3. B16.9 - Factory-Made Wrought Buttwelding Fittings.
 - 4. B16.11 - Forged Fittings, Socket-Welding and Threaded.
- B. American Water Works Association (AWWA):
 - 1. C110 - Ductile-Iron and Gray-Iron Fittings.
 - 2. C203 - Coal-Tar Protective Coatings and Linings for Steel Water Pipelines-Enamel and Tape-Hot Applied.
 - 3. C205 - Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe-4 Inches and Larger-Shop Applied.
 - 4. C206 - Field Welding of Steel Water Pipe.
 - 5. C210 - Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
 - 6. C214 - Tape Coatings for Steel Water Pipe.
 - 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.
 - 9. C222 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.
 - 10. C606 - Standard for Grooved and Shouldered Joints.
- C. 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. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 5. A183 - Standard Specification for Carbon Steel Track Bolts and Nuts.
 - 6. A536 - Standard Specification for Ductile Iron Castings.
 - 7. C150 - Standard Specification for Portland Cement.
 - 8. D2000 - Standard Classification System for Rubber Products in Automotive Applications.

9. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
 10. E165 - Standard Practice for Liquid Penetrant Testing for General Industry.
- D. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.
- E. Society for Protective Coatings (SSPC):
1. SP 1 - Solvent Cleaning.
 2. SP 3 - Power Tool Cleaning.
 3. SP 5 - White Metal Blast Cleaning.
 4. SP 6 - Commercial Blast Cleaning.
 5. SP 10 - Near White Wet Blast.
 6. SP 11 - Bare Metal Power Tool Cleaning.
 7. QP 1 - Industrial Contractor Qualification.

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data: As specified in Section 40_05_00.01 - Common Work Results for General Piping.
- C. Manufacturer's qualifications.
1. Manufacturer qualifications and list of projects using the specified material: 5 years minimum.
- D. Manufacturer's Quality Assurance Manual.
1. Submit manufacturer's coating and lining application quality assurance manual to the 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.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

- A. Steel pipe:
1. General:
 - a. In accordance with ASTM A53.
 - 1) Type E - electric-resistance welded or Type S - seamless.
 - 2) Grade A or B.
 - b. Schedule:
 - 1) As indicated on the Drawings or as specified in Section 40_05_00.01 - Common Work Results for General Piping pipe schedule.
 - 2) Minimum Schedule unless otherwise indicated on the Drawings or as specified in Section 40_05_00.01 - Common Work Results for General Piping pipe schedule:
 - a) Pipe 6 inches and smaller: Schedule 40.

- b) Pipe greater than 6 inch to 12 inch: Schedule 20.
- c) Pipe greater than 12 inch: 0.25 inches.

B. Pipe fittings:

- 1. Flanged and welding fittings:
 - a. Butt-weld fittings in accordance with ASME B16.9.
 - b. Schedule of fittings: Same class or thickness as the pipe to which it connects.
- 2. Screwed fittings:
 - a. Malleable iron:
 - 1) Class 150 or Class 300 in accordance with ASME B16.3, as specified in Section 40_05_00.01 - Common Work Results for General Piping pipe schedule.
 - 2) Galvanized in accordance with ASTM A153 where used with galvanized pipe.
- 3. Grooved joint fittings:
 - a. Fittings for grooved joint steel piping: Rigid-grooved type.
 - b. Fittings for grooved joint piping:
 - 1) Manufacturers: One of the following or equal:
 - a) Anvil.
 - b) Grinnell.
 - c) Victaulic Co. of America.
 - 2) Ductile iron fittings:
 - a) Larger than 4 inches in diameter: In accordance with ASTM A536, Grade 65-45-12, long radius, in accordance with AWWA C110.
 - b) Less than 4 inches in diameter: Malleable iron in accordance with ASTM A47, Grade 32510.
 - 3) Where cast fittings are not made, forged steel in accordance with ASME B16.9, ASTM A105, Grade B with 0.375-inch minimum wall thickness.
 - a) Bends: Long radius.
 - 4) Furnished by the manufacturer of the grooved joint coupling.
 - 5) For rigid-grooved type joints.
 - 6) Connection to flanged units 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, minimum length, 4 inches.

C. Pipe joints:

- 1. General:
 - a. Use type of pipe joints as indicated on the Drawings or as specified in Section 40_05_00.01 - Common Work Results for General Piping pipe schedule.
 - b. In addition to the type of pipe joints indicated on the Drawings or as specified in Section 40_05_00.01 - Common Work Results for General Piping pipe schedule, use flexible couplings, unions or flanged joints to allow ready assembly and disassembly of the piping.

2. Flanged joints:
 - a. In accordance with ASME B16.5, steel, 150 pounds, slip-on or weld neck, galvanized in accordance with ASTM A153 where used with galvanized pipe.
 - b. Companion flanges:
 - 1) In accordance with ASME B16.5, steel.
 - 2) Class 150 pounds, slip-on or welding neck.
 - c. Weld flanges to pipe or fittings before applying lining.
 - d. Machine flanges or provide tapered filler for changes in grade or to slope lines for drainage.
 - e. Match pipe flanges to the valve flanges.
 - f. Flange bolts: As specified in Section 40_05_00.01 - Common Work Results for General Piping.
 - g. Gaskets: As specified in Section 40_05_00.01 - Common Work Results for General Piping.
3. Grooved joints:
 - a. Grooves: Cut grooves. Rolled grooves are not acceptable.
 - b. Couplings housing: 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.
 - c. Bolts and nuts: In accordance with ASTM A183, Grade 2.
 - d. Gaskets: Composition water sealing designed so that the internal piping pressure serves to increase the seal's watertightness.
 - 1) 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.
 - 2) 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.
 - e. Perform grooving of the pipe wall only on standard or heavier schedule weight pipe.
 - 1) For pipe with wall thickness less than standard weight, weld a shouldered end on the pipe in accordance with AWWA C606.
 - 2) Shoulder: Type B or D in accordance with AWWA C606.
 - f. Couplings and grooving:
 - 1) Manufacturers: One of the following or equal:
 - a) Anvil.
 - b) Grinnell.
 - c) Victaulic Co.
 - g. Grooved joint piping shall not be used in the following installations:
 - 1) In underground and underwater installations.
 - 2) In piping subject to test pressures of 150 pounds per square inch gauge, or more.
 - 3) In steam and gas piping.
4. Welded joints: Butt welds, 2 pass, full depth with beveled ends and no backing rings.

2.02 COATING AND LINING - GENERAL

- A. Coating and lining shall be as indicated on the Drawings or as specified in Section 40_05_00.01 - Common Work Results for General Piping.
- B. Extend pipe coatings for underground piping 6 inches above finished grade or 3 inches above finished floor, and neatly terminate.
- C. As specified in Section 01_60_01 - Product Requirements.
- D. Prepare, install, and repair in accordance with manufacturer's requirements.
- E. Contractor is responsible for:
 - 1. Material selection 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.

2.03 CEMENT MORTAR

- A. Line pipe with cement mortar in accordance with AWWA C205 and as specified in this Section.
 - 1. Cement:
 - a. In accordance with ASTM C150, Type II.
 - 2. Water:
 - a. In accordance with AWWA C205 and as specified in this Section.
 - 3. Sand and aggregate:
 - a. In accordance with AWWA C205, except that the total percentage of deleterious material shall not exceed 3 percent.
- B. Application location:
 - 1. Shop apply cement-mortar lining in accordance with AWWA C205.
- C. Lining:
 - 1. Line special pieces or fittings by mechanical, pneumatic, or hand placement.
 - a. Extend to faces of flanges and ends of spigots.
 - b. Less than 12 inches in width: Coat with epoxy bonding agent prior to applying cement mortar.
 - c. 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.
 - 2. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
 - 3. 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.
 - a. 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:
 - 1) No. 12 gage spaced at maximum 1-inch centers.
 - 2) No. 14 gage steel wire at maximum 1/2-inch centers.

2.04 HEAT SHRINK SLEEVES

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

- L. Shop prepare pipe joints for heat shrink sleeves with holdback primer as specified this Section.

2.05 FABRICATION

- A. Shop coat of primer:
 - 1. Flanges and portions of pipe not covered with cement-mortar shall be given a shop coating of primer.
 - 2. Primer compatible with finish coating system.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Joints:
 - 1. General:
 - a. Steel pipe joints shall be screwed, welded, flanged, grooved, or made with flexible joints. Type of joint for piping is as specified in Section 40_05_00.01 - Common Work Results for General Piping pipe schedule or as indicated on the Drawings.
 - b. 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.
 - c. Unless otherwise indicated on the Drawings or as specified in Section 40_05_00.01 - Common Work Results for General Piping pipe schedule, pipe joints shall be as follows:
 - 1) Pipe smaller than 2 inches in nominal diameter shall have screwed joints, welded joints, unions, or flexible couplings.
 - 2) Pipe 2 inches to 4 inches in nominal diameter shall have screwed joints, flanged joints, welded joints, or joints made with flexible couplings.
 - 3) Pipe larger than 4 inches in nominal diameter shall have flanged joints, welded joints, or joints made with flexible couplings.
 - 2. Flanged joints:
 - a. Flanges shall come together at the proper orientation with no air gaps between the flanges after the gaskets are in place.
 - b. Secure welding neck flanges with full penetration butt welds without backing rings.
 - c. Secure slip-on flanges with both internal and external welds.
 - d. 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.
 - 3. Grooved joints:
 - a. Assemble in accordance with manufacturer's published instructions.
 - b. Support grooved joint pipe in accordance with manufacturer's recommendations. In addition, provide at least 1 support between consecutive couplings.
 - 4. Screwed joints:
 - a. Perform threading with clean, sharp dies.
 - 1) Wavy, rough, or otherwise defective pipe threads are not acceptable.

- b. Make screwed joints tight and clean with an application of Teflon™ tape or paste compound applied to the male threads only, except as follows:
 - 1) Make up liquid and liquefied petroleum gas lines, with litharge and glycerin.
 - c. Provide railroad type unions with bronze-to-iron seat. Galvanized where used with galvanized pipe.
 - 1) Flanged joints may be used instead of unions.
 - 5. Welded joints:
 - a. Field welded joints: Electric arc welded in accordance with AWWA C206.
 - b. Welder's qualification: Qualified in accordance with AWWA C206.
 - 1) Welders' testing shall be at the Contractor's expense, including cost of test nipples, welding rods, and equipment.
 - c. Do not weld galvanized pipe.

3.02 DEFECTS IN COATINGS EXCEPT CEMENT MORTAR AND TAPE WRAP

- A. Owner and 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 CEMENT MORTAR

- A. Lining:
 - 1. Field applied interior joint lining:
 - a. Field applied lining shall be of the same density, smoothness, and thickness as shop applied lining.
 - b. After the backfill has been completed to final grade, fill interior joint recess with tightly packed cement mortar.
 - 1) Trowel flush with the interior surface with no indentation or projection of the mortar exceeding 1/16-inch.
 - 2) Remove excess cement mortar.

3.04 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.

3.05 FIELD COAT

- A. Aboveground steel pipe as specified in Section 09_96_01 - High-Performance Coatings.

3.06 FIELD QUALITY CONTROL

- A. Field test fabricated steel manifolds with the pipe to which they connect.
- B. Weld testing:
 - 1. Liquid penetrant testing:
 - a. As soon as possible after welding of pipeline joints, fillet welds shall be tested by the liquid penetrant inspection procedure in accordance with ASTM E165 under Method "B" and "Leak Testing".
 - b. Chip out defects, rework, and retest.
 - 1) Upon retest, the repaired area shall show no leaks or other defects.

END OF SECTION

SECTION 40_05_31.01
PLASTIC PIPING AND TUBING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Plastic pipe, tubing, and fittings for systems that are not plumbing systems.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
1. B16.12 - Cast Iron Threaded Drainage Fittings.
- B. ASTM International (ASTM):
1. D1248 - Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable.
 2. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
 3. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
 4. D1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.
 5. D2241 - Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated (SDR Series).
 6. D2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
 7. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
 8. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
 9. D2513 - Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings.
 10. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
 11. D2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
 12. D2855 - Standard Practice for 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.
 13. D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
 14. D3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
 15. D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
 16. D3350 - Standard Specification for Polyethylene Plastic Pipes and Fittings Materials.

17. D4101 - Standard Specification for Polypropylene Injection and Extrusion Materials.
 18. F438 - Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
 19. F439 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
 20. F441 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
 21. F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
 22. F493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
 23. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.
 24. F679 - Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
 25. F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
- C. American Water Works Association (AWWA):
1. C900 - Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inches to 12 Inches, for Water Transmission Distribution.
- D. NSF International (NSF).
- E. Plastics Pipe Institute (PPI):
1. TR 31 - Underground Installation of Polyolefin Piping.

1.03 ABBREVIATIONS

- A. ABS: Acrylonitrile-butadiene-styrene.
- B. CPVC: Chlorinated polyvinyl chloride.
- C. DR: Dimension ratio.
- D. DWV: Drain, waste, and vent.
- E. HDPE: High-density polyethylene.
- F. ID: Inside diameter of piping or tubing.
- G. NPS: Nominal pipe size followed by the size designation.
- H. NS: Nominal size of piping or tubing.
- I. PE: Polyethylene.
- J. PP: Polypropylene.
- K. PVC: Polyvinyl chloride.

- L. SDR: Standard dimension ratio; the outside diameter divided by the pipe wall thickness.

1.04 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data: As specified in Section 40_05_00.01 - Common Work Results for General Piping.
- C. Shop Drawings:
 - 1. Describe materials, pipe, fittings, gaskets, and solvent cement.
 - 2. Installation instructions.

1.05 QUALITY ASSURANCE

- A. Plastic pipe in potable water applications: Provide pipe and tubing bearing NSF seal.
- B. Fusion machine technician qualifications: 1-year experience in the installation of similar PE piping systems from the same manufacturer.
- C. Mark plastic pipe with nominal size, type, class, schedule, or pressure rating, manufacturer and all markings required in accordance with ASTM and AWWA standards.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect piping materials from sunlight, scoring, and distortion.
- B. Do not allow surface temperatures on pipe and fittings to exceed 120 degrees Fahrenheit.
- C. Store and handle PE pipe and fittings as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
- B. Fittings: Same material as the pipe and of equal or greater pressure rating, except that fittings used in drain, waste, and vent piping systems need not be pressure rated.
- C. Unions 2-1/2 inches and smaller: Socket end screwed unions. Make unions 3 inches and larger of socket flanges with 1/8-inch full-face soft neoprene or EPDM gasket.

2.02 PVC PIPING, SCHEDULE TYPE

- A. Materials:
 - 1. PVC Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
 - a. Pipe and fittings: Extruded from Type I, Grade 1, Class 12454 material in accordance with ASTM D1784.
 - b. PVC Pipe: Schedule 80 unless otherwise indicated on the Pipe Schedule.
 - 2. Fittings:
 - a. Supplied by pipe manufacturer.
 - b. Pressure fittings: In accordance with ASTM D2466 or ASTM D2467.
 - c. DWV fittings: In accordance with ASTM D2665.
 - 3. Solvent cement: In accordance with ASTM D2564:
 - a. Chemical service: For CPVC or PVC pipe in chemical service, provide the following primer and cement, or equal:
 - 1) Primer: IPS Corp., Type P70.
 - 2) Cement: IPS Corp., Type 724 cement or another cement certified by the manufacturer for chemical service.

2.03 PVC PIPING, CLASS TYPE

- A. PVC pipe, Class Type: In accordance with ASTM D2241:
 - 1. Thermoplastic pipe materials designation code: PVC 1120, 1220, or 2120.
 - 2. PVC compound: Class 12454 in accordance with ASTM D1784.
 - 3. Standard dimension ratio: SDR not greater than 21.
- B. Fittings: Ductile iron with transition gasket sized to accommodate the outside pipe diameter.
- C. PVC pipe, Class Type: In accordance with AWWA C900:
 - 1. Pressure Class: as scheduled in Section 40_05_00.01 - Common Work Results for General Piping.
 - 2. Fittings: Cast or ductile iron fittings as specified in Section 40_05_19.01 - Ductile Iron Pipe: AWWA C151, sized for the dimensions of the pipe being used.
 - 3. Joint design: Push-on or mechanical joint type as identified in Piping Schedule.
 - 4. Gaskets: Neoprene or EPDM in accordance with ASTM D1869 or ASTM F477.

2.04 CPVC PIPING

- A. Materials:
 - 1. CPVC pipe: Schedule 40 or Schedule 80, as specified, in accordance with ASTM F441 and Appendix, CPVC 4120:
 - a. Pipe: Extruded from Type IV, Grade 1, Class 23447 material in accordance with ASTM D1784.
 - b. Manufacturers: One of the following or equal:
 - 1) Charlotte Pipe and Foundry Co.
 - 2) Eslon Thermoplastics, Inc.
 - 3) GF Harvel.

2. Fittings: In accordance with ASTM F438 or ASTM F439 for pressure fittings, as appropriate to the service and pressure requirement:
 - a. Fittings: Supplied by the pipe manufacturer.
 - b. Manufacturers: One of the following or equal:
 - 1) Colonial Engineering.
 - 2) Eslon Thermoplastics, Inc.
 - 3) Chemtrol.
 - 4) Spears Manufacturing Co.
3. Solvent cement: In accordance with ASTM F493:
 - a. For CPVC pipe in chemical service, utilize IPS Corp., Type 724 cement or another cement certified by the manufacturer for high strength hypochlorite service.

2.05 SOURCE QUALITY CONTROL

- A. PVC piping, Schedule Type:
 1. Mark pipe and fittings in accordance with ASTM D1785.
- B. PVC piping, Class Type:
 1. Hydrostatic proof testing in accordance with AWWA C900: Test pipe and integral bell to withstand, without failure, two times the pressure class of the pipe for a minimum of 5 seconds.
- C. CPVC piping:
 1. Mark pipe and fittings in accordance with ASTM F441.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General:
 1. Where not otherwise specified, install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
 2. Provide molded transition fittings for transitions from plastic to metal or IPS pipe. Do not thread plastic pipe.
 3. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
 4. Provide serrated nipples for transition from plastic pipe to rubber hose.
- B. Installation of PVC piping, Schedule Type:
 1. Solvent weld joints in accordance with ASTM D2855:
 - a. For PVC pipe in chemical service use IPS Corp., Type 724 cement in accordance with manufacturer's instructions.
 2. Install piping in accordance with manufacturer's published instructions.
- C. Installation of PVC piping, Class Type:
 1. Install piping in accordance with the Appendix of AWWA C900 complemented with manufacturer's published instructions.

- D. Installation of CPVC piping:
1. Clean dirt and moisture from pipe and fittings.
 2. Bevel pipe ends in accordance with manufacturer's instructions with chamfering tool or file. Remove burrs.
 3. Use solvent cement and primer formulated for CPVC:
 - a. For CPVC pipe in chemical service use IPS Corp., Type 724 cement in accordance with manufacturer's instructions.
 4. Use primer on pressure and non-pressure joints.
 5. Do not solvent weld joints when ambient temperatures are below 40 degrees Fahrenheit or above 90 degrees Fahrenheit unless solvent cements specially formulated for these conditions are utilized.

3.02 FIELD QUALITY CONTROL

- A. Leakage test for PVC piping, Class Type:
1. Polyvinyl chloride (PVC) piping, Class Type: Subject to visible leaks test and to pressure test with maximum leakage allowance, as specified in Section 40_05_00.09 - Piping Systems Testing.
 2. Pressure test with maximum leakage allowance: Perform test after backfilling:
 - a. Pressure: 125 pounds per square inch, gauge.
 - b. Maximum leakage allowance as follows, wherein the value for leakage is in gallons per 100 joints per hour:

NPS, Inches	1-1/2	2	2-1/2	3	4	6	8	10	12
Leakage	0.41	0.52	0.63	0.76	0.98	1.45	1.88	2.35	2.80

END OF SECTION

SECTION 40_05_51.01
COMMON WORK RESULTS FOR VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. 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. A480 - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
 - 3. A536 - Standard Specification for Ductile Iron Castings.
- C. NSF International (NSF):
 - 1. 61 - Drinking Water System Components - Health Effects.
- D. Society for Protective Coatings (SSPC):
 - 1. SP 7 - Brush-Off Blast Cleaning.
 - 2. SP 10 - Near-White Blast Cleaning.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Submit the following information for each valve:
 - a. 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, and model number.

- e. Certified drawings with description of component parts, dimensions, weights, and materials of construction.
 - f. Certifications of reference standard compliance:
 - 1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
 - g. Clearly mark Submittal information to show specific items, materials, and accessories or options being furnished.
 - h. Factory test data.
- C. Provide vendor operation and maintenance manual as specified in Section 01_78_24 - Operation and Maintenance Manuals.
- 1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inches in nominal size and larger, and non-manual valves. Include information on valve operators.
- D. Provide Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
- E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

1.04 QUALITY ASSURANCE

- A. Manufacturer qualifications:
 - 1. Valves manufactured by manufacturers whose valves have had successful operational experience in comparable service.

1.05 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 DESIGN AND PERFORMANCE CRITERIA

- 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 Pipe 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. Metallic valves:
 - a. 3 inches nominal size and larger: Flanged ends.
 - b. Less than 3 inches nominal size: Screwed ends.
 - 2. Plastic valves in plastic piping systems:
 - a. Up to 4 inches: Provide solvent or heat welded unions.

- b. 6 inches and larger: Provide solvent or heat-welded flanges.

2.02 MATERIALS

- A. Stainless steel: In accordance with ASTM A480, Type 316 or Type 304, UNS Alloy S31600 or S30400.
- B. Valve and operator bolts and nuts, not including flange bolts and nuts as specified in Section 40_05_00.01 - Common Work Results for General Piping:
 - 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: Not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts.
 - 1. UNS Alloy C83600 or C92200 unless specified otherwise.
- D. Cast iron valve bodies: In accordance with ASTM A126, Class 30 minimum.
- E. Ductile iron valve bodies: In accordance with ASTM A536, Grade 65-45-12 minimum, unless specified otherwise.

2.03 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 in accordance with NSF 61 for drinking water use.
 - b. Clean surfaces in accordance with SSPC-SP 7 or SSPC-SP 10, as recommended by the epoxy manufacturer.
 - c. Apply in accordance with the manufacturer's published instructions.
 - d. Lining thickness: 0.010 to 0.012 inch, except that:
 - 1) 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 the manufacturer of the epoxy used for lining.
2. High solids epoxy:
- a. Product equivalent to high solids epoxy EPX-M-1-PWS as specified in Section 09_96_01 - High-Performance Coatings.
 - 1) Certified in accordance with NSF 61 for drinking water use.
 - 2) Interior: Coat valve interior with the 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.
 - a) Manufacturer shall provide for approval, coating information sufficient to allow the Engineer to assess equivalence to the specified high solids epoxy EPX-M-1-PWS as specified in Section 09_96_01 - High-Performance Coatings.
 - b. Clean surfaces in accordance with SSPC-SP 7 or SSPC-SP 10, or as recommended by the 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 the coating manufacturer.
 - 1) Repair holidays and other irregularities and retest coating.
 - 2) Repeat procedure until holidays and other irregularities are corrected.

2.04 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 polyethylene wrap as specified for ductile iron piping in Section 40_05_19.01 - Ductile Iron Pipe: AWWA C151.
 - a. Ensure polyethylene wrapping does not affect operation of valve.

2.05 VALVE BOXES

- A. Provide cast-iron valve boxes at each buried valve to access valve and valve operators.
- B. Do not support boxes on valve, valve operator, or pipe.
- C. Boxes:
 1. 2-piece, fabricated of cast iron; provide cover, with asphalt varnish or enamel protective coating.
 2. Adjustable to grade, install centered around the upper portions of the valve and valve operator.

- D. Manufacturers: One of the following or equal:
 - 1. Neenah Foundry Co.
 - 2. Tyler Pipe Industries, Inc.

2.06 VALVE OPERATORS

- A. Valve operator "Open" direction: Open counterclockwise.
- B. Provide valves located below operating level or deck with extensions for key operation or floor stands and handwheels, as indicated on the Drawings.
- 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.
 - 1. 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. 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. Install the valves in accordance with the manufacturer's installation instructions.

- B. 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.
- C. Provide 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 the Contractor.
 - 2. Where such additional valves are required as a result of a substitution or change initiated by the Contractor.
- D. Valve and actuator orientation:
 - 1. Coordinate with the valve supplier final orientation of valve and actuator assembly based on the Contractor's selection of equipment manufacturers and the valve and piping arrangement as indicated on the Drawings.
 - a. Rotate valve and/or actuator mounting orientation as specified in this Section unless otherwise indicated on the Drawings.
 - 2. Install valves with their stems in vertical position above the pipe, except as follows:
 - a. Butterfly valves, gate valves aboveground, globe valves, ball valves, and angle valves may be installed with their stems in the horizontal position.
 - b. Install buried plug valves with geared operators with their stems in a horizontal position.
 - 3. 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 the 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 the manufacturer's coating system and as specified in Section 09_96_01 - 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 01_75_17 - 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 40_05_52

SPECIALTY VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Solenoid specialty valves.
- B. As specified in Section 40_05_51.01 - Common Work Results for Valves.

1.02 REFERENCES

- A. American Society of Civil Engineers (ASCE):
 - 1. 25 - Earthquake-Actuated Automatic Gas Shutoff Devices.
- B. American Society of Mechanical Engineers (ASME):
 - 1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.
- C. American Water Works Association (AWWA):
 - 1. C511 - Standard for Reduced Pressure-Principle Backflow-Prevention Assembly.
 - 2. C800 - Underground Service Line Valves & Fittings (Also Included: Collected Standards For Service Line Materials).
- D. ASTM International (ASTM):
 - 1. A48 - Standard Specification for Gray Iron Castings.
 - 2. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
 - 3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 4. A536 - Standard Specification for Ductile Iron Castings.
 - 5. B584 - Standard Specification for Copper Alloy Sand Castings for General Application.
- E. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data: As specified in Section 40_05_51.01 - Common Work Results for Valves.
- C. Commissioning submittals:
 - 1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

1.04 WARRANTY

- A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

2.02 SOLENOID VALVES

- A. 2-way solenoid valves:
 - 1. Manufacturers: One of the following or equal:
 - a. Automatic Switch Co., Series 8210.
 - 1) Contractor shall provide external bypass to solenoid valve. External bypass shall use pipe of same material and size as main line and include a ball valve for manual operation.
 - 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 Utility Water (UW2).
 - b. Temperature of fluid: 60 degrees Fahrenheit.
 - c. Piping test pressure: 100 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 40_05_51.01 - Common Work Results for Valves in accordance with manufacturer's published instructions.

3.02 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning and this Section.
- B. Manufacturer services:
 - 1. Provide certificates:
 - a. Manufacturer's Certificate of Installation and Functionality Compliance.

END OF SECTION

SECTION 40_05_57.13

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 (1,000 V Maximum).
- D. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).

1.03 SUBMITTALS

- A. Shop Drawings: Include Drawings and product data with associated gate or valve as an integrated unit.

1.04 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.

1.05 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. Cylinder actuators, motorized actuators, and portable gate actuators are specified in Section 40_05_57.24 - 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: On manually actuated valves where indicated on the Drawings:
 - a. Heavy-duty, industrial grade, oiltight, with not less than 2 auxiliary contacts.
 - b. Rating: 10 amps, 120 volts alternating current.
 - c. Enclosure: NEMA Type 4X with stainless steel levers and arms. Provide switch with NEMA Type 7 enclosure when switch is located within areas with NEC Class I, Division 1; or Class I, 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. 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 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 DAF-45:
 - a. A41 - Clear anodic coating.
 - b. C22 - Medium matte finish.
- D. Gate stem covers: Concentric with stem.
- E. Position indicators:
- 1. For 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.
 - 2. Waterman Valves, LLC.
- B. Coating: As specified in Section 09_96_01 - 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-pound 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-pound 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 Valves, LLC.
- B. 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.
 - 2. Waterman Valves, LLC.
- B. 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.
 - 2. Waterman Valves, LLC.
- B. 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 05_05_24 - 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. Provide geared actuators for the 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. Provide handwheel actuators for valves mounted 6 feet or less above floors.
- C. Provide chain wheel actuators for valves mounted more than 6 feet to centerline above floors.

END OF SECTION

SECTION 40_05_57.24
ELECTRIC ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Electric motor-driven actuators for valves and gates.
- B. Equipment tag numbers:
 - 1. As scheduled.

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. International Organization for Standardization (ISO):
 - 1. 12944 - Paints and Varnishes.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_00 - Product Requirements.
- B. Provide a complete list/schedule of actuators being provided with their associated tag names, as indicated on the 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. Remote control station components (If applicable).
 - 4. Environmental ratings, including NEMA enclosure rating and submergence capabilities.
 - 5. Gear ratios for both manual and motorized actuation.
 - 6. Opening and closing directions.
 - 7. Electric motor data.
 - 8. Allowable starts per hour.
 - 9. List of included options and accessories.

10. Full travel times.
 11. Gearbox data, including gear ratio, and gearbox efficiency.
- D. Shop Drawings:
1. Wiring diagrams:
 - a. Include options and expansion cards furnished with each actuator.
 2. Dimensioned drawings of each valve and actuator combination.
 3. Dimensioned drawings of each valve gearbox.
- E. Calculations:
1. Operating torque.
 2. Maximum torque calculations for seating and unseating.
 3. Maximum operating torque at starting and normal operation.
- F. Installation instructions:
1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 2. Provide manufacturer's installation instructions.
- G. Quality Control Submittals:
1. Manufacturer's representative qualifications.
 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 3. Manufacturer's Certificate of Installation as specified in Section 01_75_17 - Commissioning.
 4. Manufacturer's Certificate of Functional Compliance as specified in Section 01_75_17 - Commissioning.
- H. Owner Training Submittals:
1. As specified in Section 01_75_17 - Commissioning.
- I. Operation and maintenance manuals:
1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 2. Include a list of configurable parameters and the final values for each.
 3. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_00 - Product Requirements, Section 46_05_10 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.05 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.06 MAINTENANCE

- A. As specified in Section 01_60_00 - 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).
 - f. Encoder.
 - g. Control module.
- C. Setting tool:
 - 1. If required for setting or configuring the actuator, provide a handheld setting tool.
 - a. Furnish 1 setting tool for every 10 actuators.
 - b. Capable of communicating with PC-based configuration software and transferring the following in either direction between the computer and programmer and setting tool, and between the setting tool and actuator.
 - c. Actuator configurations:
 - 1) Capable of storing up to 10 different configurations.
 - d. Diagnostic data:
 - Capable of storing 4 complete sets of diagnostic data.

1.07 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Lines 3 inches and smaller:
 - 1. The following, No or equal:
 - a. Rotork Controls Inc.
 - 1) ROMpak (Quarter-turn).
 - 2) CMA Range:
 - a) CMR - Multi-turn.
 - b) CMQ - Quarter-turn.
- B. Lines 4 inches and larger:
 - 1. The following, No or equal:
 - a. Rotork Controls Inc. IQ3 Range:
 - 1) IQ for multi-turn applications.
 - 2) IQT for quarter-turn applications.

2.02 MATERIALS

A. Enclosures:

1. Constructed of materials suitable for the environment where the actuator will be installed.
2. Stainless steel external fasteners.
3. 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.
4. Ratings
 - a. As scheduled and specified:
 - b. NEMA Type 6P: Double sealed and IP68 rated for prolonged submergence.
 - c. XP: Factory Mutual (FM) approved for Class I, Division 1 and Division 2 locations.

B. Coatings:

1. Material requirements:
 - a. Factory prime and coat with an ISO 12944 classification coating of C5M (Marine, offshore estuaries with high salinity) coating with 15 year durability.
 - b. Touch-up damaged coatings with manufacturer provided coating repair kit.
2. Application requirements:
 - a. Painting shall commence within 4 hours of blast cleaning.
 - b. Each paint coat within the system is to be applied in accordance with the paint manufacturer's instructions.
 - c. Paint thickness shall be checked for each coat on each actuator.
3. Qualification requirements:
 - a. Operators shall be experienced and proficient in surface preparation and coating application techniques.
 - b. Personnel shall have relevant knowledge of health and safety hazard, use of protective equipment, coating materials, mixing and thinning coatings, coating pot life, surface requirements, etc.
 - c. Personnel carrying out inspection or verification shall be certified as NACE coating inspector or equivalent such as ICorr.

2.03 CHARACTERISTICS FOR ACTUATORS ON LINES 3 INCHES AND SMALLER

A. Actuators for valves 3 inches and smaller:

1. Complete and operable with all components and accessories required for operation.
2. Power supply:
 - a. Valve motion independent of power supply phase rotation.
 - b. As indicated on the Drawings.
3. Size actuator to move valves from full open to closed position within the time indicated in the Actuator Schedule:
 - a. If an operating time is not indicated on the Actuator Schedule, size the actuator to move valves at minimum 12 inches per minute under maximum load. Measure closure rate for valves at the maximum diameter of disc, plug, or ball.

4. For outdoor or vault installations, provide an integral anti-condensation heater when available as an option.
5. Control inputs:
 - a. Capable of using discrete dry contacts.
 - b. Controls the valve when local-stop-remote is in REMOTE.
 - c. Material: Type 316 stainless steel.
 - d. Provide the following inputs at the actuator:
 - 1) OPEN.
 - 2) CLOSE.
6. 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) REMOTE.
 - b. Output contacts rated for 5 amps, 120 VAC.
7. Analog input:
 - a. Provide a 4 to 20 analog input for analog modulating valves when indicated on the Drawings.
 - b. Modulate valve to maintain position based on analog input value.
 - c. Maximum input impedance 250 ohms.
8. Analog output:
 - a. Provide an isolated 4 to 20 mA analog output when indicated on the Drawings.
9. Components:
 - a. Motors:
 - 1) Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety.
 - 2) 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 minimum for open/close service.
 - b. Manual actuation:
 - 1) Handwheel for manual operation.
 - c. Gearing: Self-locking, high-alloy steel gears.
10. Communication options:
 - a. As specified in the Contract Documents.

2.04 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 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. Actuators shall incorporate 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 Actuator Schedule:
 1. If an operating time is not indicated on the 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. Configuration:
 - a. Provide a non-intrusive, non-contacting interface for configuring input and output settings, control values, ranges, torque switch settings, valve positions switch settings, and options.
 - 1) Configurable from a handheld configuring tool or input devices on the actuator.
 2. Local interface, integral to actuator:
 - a. Non-intrusive, non-contacting selector switches:
 - 1) LOCAL-STOP-REMOTE:
 - a) Motor actuator operation is prevented with the switch in STOP.
 - 2) OPEN-CLOSE:
 - a) Controls the valve when LOCAL-STOP-REMOTE is in LOCAL.
 - b) Spring return to center.
 - c) Configurable between maintained (actuator runs until end of travel, high torque, or a LOCAL-STOP-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) Numerical display showing actual valve or gate position in percent of travel.
 3. Remote hand station:
 - a. Pole mounted.
 - b. Configuration: Bluetooth configuration tool.
 - c. Power: Via attached actuator (24 VDC output).
 4. Control inputs:
 - a. Capable of using discrete 24 VDC.
 - b. Controls the valve when LOCAL-STOP-REMOTE is in REMOTE.
 - c. Isolated inputs capable of operating from external control voltage source or internal power supply:
 - 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).
 5. Status outputs:
 - a. Monitor relay output: Dry contact, normally closed, opens when actuator is not in REMOTE or in the event of any internal fault or alarm condition.

- b. 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-STOP-REMOTE in REMOTE position.
- c. Contacts and communications:
 - 1) As specified in the Contract Documents.
 - 2) Dry contacts rated for both 120 VAC and 24 VDC.
- d. Analog input:
 - 1) 4-20 mA analog input for analog modulating valves when indicated on the Drawings.
- e. Analog output:
 - 1) Isolated 4-20 mA analog output when indicated on the Drawings.
 - a) Loop power sourced from the actuator power supply.
 - b) Output proportional to process value(s) indicated on the Drawings.

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.
- 2. Data logging:
 - a. Store diagnostic data and reference data.
 - b. Time-stamped historical operating data, including number of operations.
 - c. Torque profiles showing actual torque at each valve position through the operating range
 - 1) Store reference data (recorded during commissioning) and data from last operation.
- 3. Provide display of logged data on the actuator, or provisions to download to a personal computer.

F. Components:

- 1. Motors:
 - a. Specifically designed for valve actuator service with high starting torque, totally enclosed non-ventilated construction.
 - b. Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety.
 - 1) Design requirements for rubber-seated AWWA butterfly valves:
 - a) Design actuators for maximum gate or valve operating torque, in accordance with and using safety factors required in AWWA C504 and AWWA C542.
 - (1) 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.
 - (2) 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.

- 2) Design requirements for slide gates, gate valves, knife gate valves, globe valves, and diaphragm valves:
 - a) Design valves and actuators for maximum operating torque in accordance with and using safety factors required in AWWA C542.
 - b) Design for the maximum torque and thrust running load over the full cycle.
 - c) Maximum torque or thrust rating: 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.
 - c. Capable of being removed and replaced without draining the actuator gear case.
 - d. Motor bearings shall be amply proportioned of the anti-friction type and permanently lubricated.
 - e. Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius.
 - 1) 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).
 - 2) 60 starts per hour for open/close service or 1,200 starts per hour for modulating service.
 - f. Provide the following motor protection features:
 - 1) Jammed valve (no valve motion detected through a time delay).
 - 2) High motor temperature (sensed by an embedded thermostats).
 - 3) High torque.
 - 4) Single phasing protection.
- G. Position sensing:
1. Electronic and adjustable using a solid-state encoder wheel.
 - a. Mechanical limit switches and potentiometers are not acceptable.
 2. Capable of retaining position and monitoring valve or gate motion when valve is manually actuated and when main power is not present.
 3. Valve range and position switch outputs field adjustable.
- H. Torque sensing:
1. Torque shutdown setting: 40 percent to 100 percent rated torque:
 - a. Adjustable in 1 percent increments.
 2. Torque display: 0 to 100 percent-rated torque.
 3. Capable of interrupting control circuits during both opening and closing and when valve torque overload occurs.
 4. Electrical or electronic torque sensing.
 5. Independent of variations in frequency, voltage, or temperature.
 6. Actuator shall store actual operational torque curves for retrieval by plant maintenance staff.
 7. Provide a temporary inhibit of the torque sensing system during unseating or during starting in mid-travel against high inertia loads.
 8. Provide visible verification of torque switch status without any housing disassembly.

- I. 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.
 - 3) Provide Type 316 stainless steel.
 - 2. Declutch lever: Padlockable, capable of mechanically disengaging motor and related gearing and freeing hand wheel for manual operation.
- J. Gearing: Hardened alloy steel spur or helical gears and self-locking, alloy bronze worm gear set.
 - 1. Accurately cut to ensure minimum backlash.
- K. Bearings:
 - 1. Anti-friction bearing with caged balls or rollers throughout.
 - 2. Sealed-for-life type thrust bearings housed in a separate thrust base.
- L. 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.
- M. 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.

2.05 ACCESSORIES

- A. Software:
 - 1. Furnish PC-based diagnostic and configuration software to display diagnostic data and configure actuators.
 - 2. Provide software communications to the valve actuator and handheld setting tool using Bluetooth wireless communications.
 - a. Provide accessories and drivers required for operation and communications with a standard personal computer running Microsoft Windows.
- B. Termination module cover:
 - 1. For actuators on a valve network, provide a means to keep the valve network in service, in the event where the actuator must be removed.
 - 2. Provide sunshades for outdoor installations of remote control stations that use an LCD or similar screen. Regular pushbutton, sector switches, and pilot light control stations will not require a sunshade.

2.06 SOURCE QUALITY CONTROL

- A. 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. Furnish test reports and the Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 INSTALLATION

- A. As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- B. Install the equipment in accordance with the manufacturer's instructions.
- C. Position visual indicators so that they are most easily visible.
- D. Installation Verification:
 - 1. Furnish Manufacturer's Certificate of Installation Verification.

3.02 FIELD QUALITY CONTROL

- A. As specified in Section 01_75_17 - Commissioning, Section 46_05_94 - Mechanical Equipment Testing, and this Section.
- B. 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 40_80_01 - Commissioning for Instrumentation and Controls.
 - 3. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.03 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.
 - 1. Number of sessions:
 - a. Operations: 1.
 - b. Maintenance: 1.

3.04 ACTUATOR SCHEDULE

- A. Provide actuators indicated on the Drawings:
 - 1. Major process actuators are listed in the Actuator Schedule shown in Attachment A - Actuator Schedule.
 - a. Attachment A - Actuator Schedule does not include all number and types of actuators required for the Project.

END OF SECTION

ATTACHMENT A - ACTUATOR SCHEDULE

ACTUATOR SCHEDULE

Item	Reference DWG	Type	Size	Duty	NEMA Rating	Voltage/Phase/Hz	Notes	Service	Controls
Gravity Thickener Valve No. 1	65-VAL930A	PV	6"	STD	4X	480/3/60 Hz	1	O/C	D
Gravity Thickener Valve No. 2	65-VAL930B	PV	6"	STD	4X	480/3/60 Hz	1	O/C	D
Sludge Day Tank Cell 1 Isolation Valve	65-VAL940A	PV	6"	STD	4X	480/3/60 Hz	1	O/C	D
Sludge Day Tank Cell 2 Isolation Valve	65-VAL940B	PV	6"	STD	4X	480/3/60 Hz	1	O/C	D
<u>Notes:</u> (1) Provide actuators with remote control station. (2) New motorized actuator to be installed on existing equipment. Field verify characteristics prior to sizing motor actuator. <u>Abbreviations:</u> Type: BFV = Butterfly Valve. BV = Ball Valve. PV = Plug Valve. SG = Slide Gate. NEMA Rating: 4X for general locations. 6P for vaults and possible submergence. XP for Class I, Division 1 and Division 2 locations. Controls: A = Analog. D = Discrete. DP = Profibus DP. E-IP = Ethernet/IP. Duty: MD = Modulating duty (~1,200 starts/hr). MOD = Modulating. STD = Standard service (0-60 starts/hr) duty. Service: CTRL = Control. O/C = Open/Close. E-TCP = Ethernet TCP or TCP/IP. FF = Foundation Fieldbus H1. MB = Modbus RTU (RS-485). NET = Manufacturer's proprietary network. PA = Profibus PA.									

SECTION 40_05_62

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.
 - 2. A536 - Standard Specification for Ductile Iron Castings.

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures and Section 40_05_51.01 - Common Work Results for Valves.
- B. Product data: As specified in Section 01_60_00 - Product Requirements.
- C. Shop Drawings: Installation arrangement of major component assemblies.
- D. Calculations.
- E. Vendor operation and maintenance manual as specified in Section 01_78_24 - Operation and Maintenance Data.
- F. Commissioning Submittals:
 - 1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning:
 - a. Interior coating.
 - 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

1.04 WARRANTY

- A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_00 - Product Requirements and Section 40_05_51.01 - Common Work Results for Valves.

2.02 NON-LUBRICATED PLUG VALVES, FULL PORT (PV05)

- A. Manufacturers: One of the following or equal:
 - 1. Clow Valve.
 - 2. DeZurik, PEF.
 - 3. Milliken, 601F/600F.
 - 4. Val-Matic
- 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.
 - a. Grooved end body valves:
 - 1) Usage: Plug valves with grooved ends may be used in piping systems specified in the Pipe Schedule to have grooved end joints and as indicated on the Drawings.
 - 2) Grooved end joint design: In accordance with AWWA C606.
- C. Materials:
 - 1. Body and plug: ASTM A126, Class B, cast-iron , with plug face of neoprene, Buna N, or EPDM material suitable for the intended service as specified under the "Design" article 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 40_05_51.01 - Common Work Results for Valves.
- B. Field applied coating of valve exterior:
 - 1. Match color and be compatible with the manufacturer's coating system and as specified in Section 09_96_01 - 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 01_60_00 - Product Requirements.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install valves as specified in Section 40_05_51.01 - Common Work Results for Valves and the manufacturer's instructions.
 - 1. Unless otherwise 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. Furnish Manufacturer's Certificate of Installation Verification.
- B. Valves requiring lubrication: Lubricate and fill extended lubricant pipes with lubricant suitable for service intended.

3.02 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning and this Section.
- B. Functional Testing:
 - 1. Tests: Witnessed.
 - 2. Conduct pressure and leak test as specified in Section 40_05_51.01 - Common Work Results for Valves.
 - 3. Furnish Manufacturer's Certificate of Functional Compliance.

END OF SECTION

SECTION 40_05_63

BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Ball valves.
- B. As specified in Section 40_05_51.01 - 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 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data: As specified in Section 40_05_51.01 - 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 01_75_17 - Commissioning.

1.04 WARRANTY

- A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- 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.

2.02 METAL BODY BALL VALVES – FULL PORT (BAV00)

- A. Metal body ball valves, less than 6-inch size:
 - 1. Manufacturers: One of the following, or equal:
 - a. Conbraco Industries, Inc., Apollo Valves.
 - b. Flow-Tek, Inc.
 - c. Metso Automation/Jamesbury.
 - d. NIBCO, Inc.
 - 2. General:
 - a. Type: Non-lubricated, full port and capable of sealing in either direction.
 - b. End connections:
 - 1) Threaded or solder ends for sizes 3-inch and smaller.
 - 2) Class 150 flanged for sizes larger than 3 inches.
 - a) Flanges: In accordance with ASME B16.1 standards.
 - c. Stem packing: Manually adjustable while valve is under pressure.
 - d. Shafts:
 - 1) Rigidly connected to the ball by a positive means.
 - a) Design connection to transmit torque equivalent to at least 75 percent of the torsional strength of the shaft.
 - e. Handles: Stainless steel latch lock handle with vinyl grip and stainless steel nut designed to open and close the valve under operating conditions.
 - f. Temperature limits: Suitable for operation between minus 20 and 350 degrees Fahrenheit.
 - 3. Materials:
 - a. Valves in copper lines: Bronze body.
 - b. Valves in steel and ductile iron piping: Ductile iron or cast steel body.
 - c. Valves in stainless steel piping: Stainless steel body, material type to match piping material as specified in Section 40_05_00.01 - Common Work Results for General Piping.
 - d. Ball: Type 304 or 316 stainless steel, Type 316 in digester gas applications.
 - e. Seats: PTFE.
 - f. Stem seals: PTFE or Viton™.
 - g. Bearings: Self-lubricated, corrosion resistant material that will not contaminate potable water.
 - h. Valves for combustible fluid applications (digester gas, natural gas, fuel oil, etc.) must be of fire safe design.

4. Venting requirements:
 - a. Metal ball valves for hydrogen peroxide service:
 - 1) Provide valve with factory drilled 0.125-inch hole in the upstream side of the ball.
 - 2) Provide an engraved Type 316 stainless steel tag permanently attached to the valve stem stating, "One side of ball drilled for hydrogen peroxide service".

2.03 PLASTIC BODY BALL VALVES – FULL PORT (BAV40)

- 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.
 - a. For sodium hypochlorite service, provide model TB-Z. Model TBH-Z shall not be used.
 5. IPEX USA, LLC
 6. Plast-O-Matic Valves, Inc.
- B. General:
 1. Type: Non-lubricated and capable of sealing in either flow direction.
 2. End connections:
 - a. 4 inches and smaller size: Socket end true unions for solvent welded connection to adjacent piping.
 - b. 6-inch size: Socket end true unions with attached flanges for flanged connection to adjacent piping.
 3. All valves shall have integral ISO 5211 mounting pad for actuator installation.
 4. All valves shall have integral plate for lock-out/tag-out.
 5. Stem: Double o-ring seal with shear point above seal.
 6. Pressure rating: Suitable for the test pressure and maximum temperature of the corresponding piping system listed in the Piping Schedule.
- C. Materials:
 1. Body and ball:
 - a. PVC piping systems: PVC.
 - b. CPVC piping systems: CPVC.
 - c. HDPE piping systems: PVC.
 2. Seats: PTFE (Teflon™).
 3. O-rings: Match gasket material of corresponding piping system listed in the Piping Schedule.
- D. Limit switches, when indicated on the Drawings:
 1. Mechanical cam type with watertight enclosure and suited for remote indication of valve open-close status.
 2. Mount on valve actuator.
 3. Contacts: 120-volt alternating current, 20 amperes at 75 to 100 percent power factor and 24-volt direct current, 5 amperes minimum.

- E. Valve actuator:
 - 1. Valves shall be quarter turn operated with valve seat adjustability.
 - 2. Manually operated valves: Lever.
Electric motor operated valves, when indicated on the Drawings: Provide electric motor operator as specified in Section 40_05_57.24 - Electric Actuators.
- F. Venting requirements:
 - 1. PVC and CPVC ball valves for hypochlorite service:
 - a. Provide valve with factory drilled 0.125-inch hole in the upstream side of the ball.
 - b. Provide an engraved plastic tag permanently attached to the valve stem stating, "One side of ball drilled for hypochlorite service".
 - c. Provide an arrow inscribed on the valve body to indicate direction of flow.

PART 3 EXECUTION

3.01 INSTALLATION

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

3.02 COMMISSIONING

- A. As specified in Section 01_75_17 - 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 40_05_00.09 - Piping Systems Testing.

END OF SECTION

SECTION 40_61_00

COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Process control and instrumentation systems requirements for common components including installation, including, but not limited to, the following:
 - a. Hardware.
 - b. Software.
 - c. Programming.
 - d. Testing.
 - e. Commissioning.
 - 2. Loop drawings:
 - a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and 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. Owner and Engineer are not responsible for providing detailed loop diagrams for Contractor-furnished equipment.
 - 3. Requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in Technical Sections, including packaged mechanical systems, local control panels (LCPs), vendor control panels (VCPs), etc.
- B. Contract Drawings:
 - 1. Schematic diagrams:
 - a. Use schematic diagrams in conjunction with the descriptive operating sequence in the Technical Sections to furnish a coordinated and fully functional control system.
 - b. Schematic diagrams show control function only.
 - 1) Incorporate other necessary functions for proper operation and protection of the system.
 - c. Controls are indicated on the Drawings as de-energized.
 - d. Add relays, where required, to provide 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.
 - e. Mount devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated on the Drawings.

C. System description:

1. New design in existing system (brown field):
 - a. All tags with "65-" both in the field, in the PLC, HMI, and SCADA programs. There are partial duplicate tags between the new design and the existing equipment; including but not limited to 932 and 942.
 - 1) The Engineer needs to be made aware of any tagging conflicts and by a participant in resolving those conflicts.
 - b. Refer to all electrical and instrumentation drawings for more detailed information.
 - c. There is a new inline grinder that will have a vendor control panel, that panel will have 120VAC discrete signals hardwired back to the new PLC-910 in PCM-910.
 - d. Signal wire for automated valves, instruments, and power sources will be wired back to the PCM-910 and interface with PLC-910. All discrete signals are 120VAC and all analog signals are 4-20mA.
 - e. There will be a duplex sump pump that will have a vendor control panel, that panel will have discrete signals hardwired back to the new PLC-910 in PCM-910.
 - f. There are four progressive cavity pumps all powered by their own individual VFDs. All four VFDs will have signals hardwired back to the new PCM-910 to interface with PLC-910. Each pump will have a local control panel with pilot devices.
 - g. Each progressive cavity pump will have seal water and therefore seal water low flow alarm and hardwired interlock. Each pump will also have discharge high pressure alarm and hardwired interlock.
 - h. There are two sludge day tanks each with a mixer powered by a motor starter. The motor starter has 120VAC discrete signals hardwired back to the new PCM-910 to interface with PLC-910. Each tank also has a radar level transmitter wired to PCM-910 and connects to PLC-910.
 - i. PLC-910 in the new PCM-910 will be Allen Bradley ControlLogix and will connect to the existing PLC Ethernet/IP network via an ethernet switch located in VCP-900 (Operator Panel) located in the Dewatering building at VCP-900. The ethernet switch in VCP-900 will need to be field verified.
 - j. The existing SCADA system will need to be modified for the data from/to PLC-910. Modifications should have the same "look and feel" as the existing system..

1.02 REFERENCES

A. Abbreviations:

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. ECP: Electronic circuit protector.
6. ES: Ethernet switch.
7. FAT: Factory acceptance test, also known as Source Test.

8. HART: Highway addressable remote transducer.
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. 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.
11. I/O: Input/Output.
12. 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.
13. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
14. IP: Internet protocol or ingress protection.
15. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
16. 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.
17. 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.
18. 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.
19. 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.
20. P&ID: Process and instrumentation diagram.
21. PC: Personal computer.
22. 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.
23. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
24. 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.
25. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.
 26. PLC: Programmable logic controller.
 27. PS: Power supply.
 28. RIO: Remote I/O device for the PLC consisting of remote I/O racks or remote I/O blocks.
 29. 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.
 30. 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.
 31. SELV: Safety extra-low voltage.
 32. SFP: Small form-factor pluggable.
 33. SPDT: Single-pole, double-throw.
 34. SPST: Single-pole, single-throw.
 35. UPS: Uninterruptible power supply.
 36. 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.
 37. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

B. Standards:

1. American Petroleum Institute (API):
 - a. RP 550 - Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5-Oxygen Analyzers.
 - b. RP 551 - Process Measurement Instrumentation.
2. International Organization for Standardization (ISO):
 - a. 9001 - Quality Management Systems - Requirements.
3. International Society of Automation (ISA):
 - a. 5.1 - Instrumentation Symbols and Identification.
 - b. 5.4 - Instrument Loop Diagrams.
 - c. 20 - Instrument Forms Plus Pro-Combo-Enterprise Version (Microsoft SQL Server Express Database Software based).
4. National Electrical Manufacturers Association (NEMA).
5. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
6. National Institute of Standards and Technology (NIST).
7. Underwriters Laboratories, Inc. (UL):
 - a. 508 - Standard of Safety for Industrial Control Equipment.
 - b. 508A - Standard of Safety for Industrial Control Panels.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. 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.
 2. 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.
 3. Digital bus: A communication network, such as PROFIBUS, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.
 4. Instrument: A measurement device that includes a sensor for taking the measurement and one or both of the following:
 - a. A local display.
 - b. A device for communicating the measurement to a remote location such as a PLC or DCS.
 5. Modifications: Changing, extending, interfacing to, removing, or altering an existing circuit.
 6. 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.
 7. 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.
 8. 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.
 9. Programmer: Responsible for PLC programming and SCADA/HMI software configuration.
 10. RS-485: Also known as TIA-485 or EIA-485. Is a standard defining the electrical characteristics of drivers and receivers for use in serial communications system. Electrical signaling is balanced, and multipoint systems are supported, can be used with data rates up to 10 Mbit/s or at lower speeds distances up to 1,000 meters (4,000 feet).
 11. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.

1.04 DELEGATED DESIGN

- A. Requirements for Delegated Design are specified in the Technical Sections.

1.05 SUBMITTALS

A. General:

1. Adhere to the wiring numbering scheme as specified in Section 26_05_53 - Identification for Electrical Systems throughout the Project:
 - a. Uniquely number each wire.
 - b. Wire numbers must appear on equipment drawings.
2. 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 specified in this Section and indicated on the Drawings exclusively throughout Shop Drawings, datasheets, and similar Submittals.
 - b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, Supplier's, or Subcontractor's standard methods with those specified in this Section and indicated on the Drawings.

B. Specific Submittal requirements:

1. Control panel drawings:
 - a. General requirements:
 - 1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for items provided under section 40_67_01 - Control Systems: Panels, Enclosures, and Panel Components.
 - 2) Use equipment and instrument tags as depicted on the P&IDs for all Submittals.
 - 3) Nameplates and wire labeling:
 - a) Nameplate legend, including text, letter size, materials, and colors.
 - b) As specified in Section 26_05_53 - Identification for Electrical Systems or as indicated on the Drawings.
 - 4) Structural requirements:
 - a) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project Site seismic criteria.
 - b) Weight.
 - 5) Clearly show modifications to existing circuits:
 - a) Show existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
 - b. Required for materials and equipment listed in this and other Technical Sections.
 - c. Front, side, rear, internal, external elevations, and top and bottom views, showing all dimensions and all to scale.
 - 1) Locations of conduit entrances and access plates.
 - 2) Component layout and identification.
 - 3) Complete and detailed bills of materials:
 - a) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
 - b) Include all items within an enclosure.
 - 4) Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium-voltage power cables.
 - 5) Complete grounding requirements for each system component, including any requirements for PLCs, process LANs, and control system equipment.

- 6) PLC rack and card layout:
 - a) Provide a count of current I/O allocation.
 - b) Future I/O allocation.
 - c) Quantity of spares provided.
 - 7) NEMA rating.
 - 8) Material and finish.
2. Schematics and wiring diagrams:
- a. General requirements:
 - 1) Submit panel wiring diagrams for every panel that contains wiring.
 - 2) Use equipment and instrument tags as depicted on the P&IDs for all Submittals.
 - 3) Nameplates and wire labeling:
 - a) As specified in Section 26_05_53 - Identification for Electrical Systems or as indicated on the Drawings.
 - 4) Clearly show modifications to existing circuits:
 - a) Show existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
 - b. Include the following information:
 - 1) Name of panel.
 - 2) Wiring sizes and types.
 - 3) Terminal strip numbers.
 - 4) Terminal identification for device and field connections.
 - 5) Wire tags and labels.
 - 6) Functional name and manufacturer's designation for items to which wiring are connected.
 - 7) Set points for relays and control or alarm contact settings.
 - c. Incorporate equipment manufacturer's Shop Drawing information into the schematic diagrams in order to document the entire control system.
3. Loop drawings:
- a. Submit loop drawings after an accepted Commissioning Test Reports Submittal as specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.
 - 1) Engineer recommends submitting a sample/template loop drawing for review prior to this Submittal.
 - b. General requirements:
 - 1) Submit loop drawings for every analog, discrete, fieldbus signal, vendor-supplied equipment packages, and control panels.
 - a) Includes monitoring, alarming, interlocks, and control devices.
 - 2) Use equipment and instrument tags as depicted on the P&IDs for all Submittals.
 - 3) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
 - 4) Provide drawings for every instrumentation loop system:
 - a) Furnish a separate drawing sheet for each system or loop diagram.
 - 5) Nameplates and wire labeling:
 - a) As specified in Section 26_05_53 - Identification for Electrical Systems or as indicated on the Drawings.

- 6) Clearly show modifications to existing circuits:
 - a) Show existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
- 7) Provide loop drawings in the format indicated in the Contract Drawings.
- c. Provide a complete index in the front of each bound volume:
 - 1) Index the loop drawings by systems or process areas.
- d. 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 power feeds to the loops and instrumentation.
 - 5) Terminal assignments associated with every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
 - 6) Show VCP, instrument panel, conduit, junction box, equipment and PCS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
 - 7) Cables required for communication requirements.
4. PLC I/O list:
 - a. A complete listing of the PCS system point I/O database:
 - 1) Include for each data point relevant parameters such as range, contact orientation, limits, incremental limits, I/O hardware address, and PLC assignment.
 - 2) Organize on a site-by-site basis and separate by point type.
 - 3) In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
 - 4) Upon completion of the Work, update I/O lists to indicate the final as-built configuration of the systems:
 - a) Organize as-built I/O list on a site-by-site basis, separated by equipment and point type.
5. Control descriptions:
 - a. For each control loop, provide programming logic in the form of a written functional description indicating the operation of the equipment, signals, and controls based on the requirements specified in Section 40_61_15 - Control Strategies, Section 40_61_16.10 - Specific Control Strategies, and as shown on the P&IDs:
 - 1) Start from the specific control strategies provided in the Specifications.
 - a) Maintain same organization and format, and expand/edit the specific control strategies as needed.
 - b) Functional descriptions shall be modified to reflect the actual programming to be implemented in the PLCs.
 - 2) Include each function depicted or described in the Contract Documents.
 - 3) Include within the control description content:
 - a) Specific requirements.
 - b) Common requirements that pertain in general to all loops.
 - c) Listing ranges, setpoints, timers, values, counter values, etc.

- d) Manual keyboard entries.
 - e) Entry codes.
 - f) System responses.
 - g) Modes:
 - (1) Startup.
 - (2) Routine and normal operation.
 - (3) Regulation and control.
 - (4) Shutdown under specified modes of operation.
 - (5) Emergency operating shutdown.
6. Instrument datasheets:
- a. Submit instrument information under each instrument's section and not all in gathered together in one submittal.
 - b. Datasheets provided with the instrument specifications are preliminary and are not complete but are provided to assist with the completion of final instrument datasheets. Additional datasheets may be required.
 - c. Furnish fully completed datasheets for each instrument and component according to ISA-20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.
 - d. Format: Microsoft Word or Microsoft Excel.
 - 1) Features and options that are furnished.
 - e. Provide completed datasheet as specified in the Technical Sections and for each control system component.
7. Instrument installation drawings:
- a. Provide instrument installation, mounting, and anchoring details for components and assemblies, including access requirements and conduit connection or entry details.
 - b. Each installation shall be identified by the equipment or instrument by tag number.
 - c. Provide certification by the instrument manufacturer that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable.
 - d. Provide, at a minimum, the following contents for each detail:
 - 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 components.

- 12) Clearances required for instrument servicing.
 - 13) List itemizing manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.
8. Product data:
 - a. Provide a technical brochure or bulletin (cutsheet) for each instrument or equipment on the Project, labeled with equipment and instrument tags as depicted on the P&IDs.
 - 1) Submit with the corresponding datasheets.
 - 2) Organization: Index product data in the Submittal by systems or loops.
 - b. Engineering data:
 - 1) Test data and performance curves, when applicable.
 - c. Manufacturer's technical reference manuals.
 9. Quality Control Submittals:
 - a. As specified in Section 01_75_17 - Commissioning.
 - b. Manufacturer representative qualifications.
 - c. Manufacturer certificates.
 - d. Test Plans.
 - e. Test Reports.
 10. Owner Training Submittals.
 - a. As specified in Section 01_75_17 - Commissioning.
 11. Operation and maintenance manuals:
 - a. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - b. Organize the operation and maintenance manuals for each process in the following manner:
 - 1) Section A - Process and Instrumentation Diagrams.
 - 2) Section B - Control Panel Drawings.
 - 3) Section C - Schematics and Wiring Diagrams.
 - 4) Section D - Loop Drawings.
 - 5) Section E - Network Diagrams.
 - 6) Section F - PLC I/O List.
 - 7) Section G - Control Descriptions.
 - 8) Section H - Instrument Datasheets.
 - 9) Section I - Instrument Installation Drawings.
 - 10) Section J - Product Data.
 - 11) Section K - Sizing Calculations.
 - 12) Section L - Test Results.
 - 13) Section M - Operational Manual.
 - 14) Section N - Spare Parts List.
 12. 1.09 Meeting Minutes.
 - a. Include date and time of meeting.
 - b. Attendees of the meeting.
 - c. Content discussed and shared in the meeting as it related to the meetings required in 1.09.
 - d. Action list with assigned responsibility.

1.06 QUALITY ASSURANCE

- A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.

- B. Provide equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.
- C. ICSC must have their own operating UL listed panel fabrication facility.
 - 1. Panels must be fabricated at this facility and meet UL 508/508A requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Upon receipt of instruments in the field:
 - 1. Outside of the package: Prominently display tag number identification.
 - 2. On each instrument: Provide a nameplate as specified in this Section.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.
- B. Area classifications:
 - 1. Furnish enclosures that match the area classifications as specified in Section 26_05_00 - Common Work Results for Electrical.

1.09 ADMINISTRATIVE REQUIREMENTS

- A. Conduct the following meetings as specified in Section 01_31_19 - Project Meetings.
- B. Project PCIS overview conference:
 - 1. Contractor leads the meeting.
 - 2. Timing:
 - a. Prior to start of ICSC and programmer work.
 - 3. Attendees:
 - a. Carollo I&C Engineer or representative approved by the Carollo Project Manager, Owner, ICSC, and programmer.
 - b. Contractor.
 - c. Electrical subcontractor.
 - d. Manufacturers/Vendors furnishing major pieces of equipment that have VCPs.
 - 4. Agenda:
 - a. Meeting purpose:
 - 1) Review the entire Project, equipment, control philosophy, schedules, and Submittal requirements.
 - b. Review entire Project.
 - c. Review equipment lists.
 - d. Review control philosophy.
 - e. Review schedules.
 - f. Review Submittal requirements.
 - g. Safety and security.
 - h. Action items.
 - i. Next meeting.

C. System configuration meetings:

1. Preliminary meeting:
 - a. Contractor leads the meeting.
 - b. Timing:
 - 1) Before configuration work begins.
 - c. Attendees:
 - 1) Carollo I&C Engineer or representative approved by the Carollo Project Manager, Owner, and programmer.
 - d. Agenda:
 - 1) Meeting purpose:
 - a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
 - 2) Review the programmer provided examples of displays, display symbols, reports, etc., to show the capabilities of the system software.
 - 3) Safety and security.
 - 4) Action items.
 - 5) Next meeting.
2. Pre-submittal review meeting:
 - a. Contractor leads the meeting.
 - b. Timing:
 - 1) Before producing any Submittals.
 - c. Attendees:
 - 1) Carollo I&C Engineer or representative approved by the Carollo Project Manager, Owner, and programmer.
 - d. Agenda:
 - 1) Meeting purpose:
 - a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
 - b) Review an informal hardcopy of developed HMI screens for review by the Engineer.
 - 2) Review the system configuration.
 - 3) Review the HMI system database.
 - 4) Review the control schemes.
 - 5) Review the displays.
 - 6) Review the report formats.
 - 7) Review an informal hardcopy of developed HMI screens.
 - 8) Review the Submittal schedule.
 - 9) Safety and security.
 - 10) Action items.
 - 11) Next meeting.

D. Control logic meetings:

1. Preliminary meeting:
 - a. Contractor leads the meeting.
 - b. Timing:
 - 1) Before configuration work is begun on any PLCs programmed by the Contractor (including those provided through Subcontractors and Suppliers).

- c. Attendees:
 - 1) Owner, Carollo I&C Engineer or representative approved by the Carollo Project Manager, and programmer.
 - 2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.
 - d. Agenda:
 - 1) Meeting purpose:
 - a) Discuss overall control logic.
 - 2) Review list of each PLC and other programmable devices that will interface to the rest of the control system, including make, model, and a description of the interface.
 - 3) Review contact information for each individual responsible for programming each said PLC and other programmable device.
 - 4) Review schedule of Submittals that will contain HMI/LOI interface information.
 - 5) Safety and security.
 - 6) Action items.
 - 7) Next meeting.
2. Pre-submittal review meeting:
- a. Contractor leads the meeting.
 - b. Timing:
 - 1) Before producing any Submittals.
 - c. Attendees:
 - 1) Carollo I&C Engineer or representative approved by the Carollo Project Manager, Owner, and programmer.
 - d. Agenda:
 - 1) Meeting purpose:
 - a) Coordinate Submittals.
 - 2) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
 - 3) Review an informal hardcopy of developed HMI screens for review by the Engineer to determine that requirements are being sufficiently met.
 - 4) Review the Submittal schedule.
 - 5) Safety and security.
 - 6) Action items.
 - 7) Next meeting.
3. Final review meeting:
- a. Contractor leads the meeting.
 - b. Timing:
 - 1) After HMI/LOI interface Submittals have been submitted.
 - c. Attendees:
 - 1) Owner, Carollo I&C Engineer or representative approved by the Carollo Project Manager, and programmer.
 - 2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.
 - d. Agenda:
 - 1) Meeting purpose:
 - a) Discuss HMI/LOI interface Submittals and requirements.

- 2) Review minimum programming requirements:
 - a) PLC to PLC global data mapping.
 - b) PLCs to HMI tags mapping.
 - c) Communication methods.
 - 3) Review advanced requirements, as applicable:
 - a) Tag naming conventions.
 - b) LOI screen colors and navigation.
 - c) Interlock and permissive definitions.
 - d) Alarms: Clearing, formats, colors, and status.
 - e) Standard code blocks for common control functionality.
 - 4) Safety and security.
 - 5) Action items.
 - 6) Next meeting.
4. Additional requirements as specified in the following:
 - a. Section 40_61_15 - Control Strategies.
 - b. Section 40_61_16.10 - Specific Control Strategies.
 - c. Section 40_64_01 - Control Systems: Programmable Logic Controllers.
- E. Centrifuge Vendor Pre-commissioning meeting:
1. ICSC, through the Contractor, shall schedule the meeting.
 2. Owner and Carollo I&C Engineer or representative approved by the Carollo Project Manager shall attend this meetings.
 3. Topics shall include:
 - a. Scope of project.
 - b. The changes to the process.
 - c. Changes that the Centrifuge vendor will need to make to their PLC logic.
 - d. Changes to the information passed between the plant PLC and the Centrifuge PLC via the network.
 - e. Testing procedure(s).
 - f. Commissioning activities.
- F. Operator interface graphics generation meetings:
1. ICSC, through the Contractor, shall schedule the operator interface graphics meetings.
 2. Owner and Carollo I&C Engineer or representative approved by the Carollo Project Manager shall attend these meetings.
 3. Topics shall include graphics for:
 - a. HMI graphics.
 - b. Data acquisition and graphics display system.
 4. Graphics Meeting No. 1: Held in conjunction with the preliminary meeting as specified above:
 - a. ICSC shall chair and develop an agenda 3 weeks in advance of the meeting, which shall address the basic criteria to be adhered to in the configuration and development of graphic displays:
 - 1) At this meeting, the ICSC shall distribute sample display formats for illustration purposes.
 - 2) As a minimum, this meeting shall address the following issues:
 - a) In-plant and remote site areas and conventions for identifying tag names and descriptors.
 - b) Designation of groups within each plant area along with tag names and descriptors.

- c) Assignment of individual control loops and inputs to specific groups.
- d) Organization of the systems universal display hierarchy.
- e) Paging schemes to be used to enable the movement from one display to another.
- f) An itemization of the type of display to be used at each level in the graphic hierarchy, i.e., pre-formatted displays, templates, custom graphics, etc.
- g) Color convention to be employed on graphics for the annotation of various status information, differentiation between alarms based on alarm priority, background colors, static field colors, and dynamic field colors.
- h) Utilization of blinking and conditional text.
- i) Definition of graphic symbolism to be used on the Project. This listing shall include, but not be limited to, symbols to be used for process instrumentation, process equipment, piping, vessels, and valves:
 - (1) Symbolism must be specific as opposed to generic in that shapes must define both function and type, i.e., specific symbols for each valve design, each pump design, each type of flowmeter, etc.
 - (2) If the ICSC's library of shapes does not adequately describe plant or field conditions, the ICSC shall develop additional shapes to meet the plant or field requirements.
 - (3) Shapes and symbols used on the P&IDs shall be used as a guideline.
- j) Definition of display select commands that enable the operator to move within the display hierarchy.
- k) Utilization of cursor movement commands which enable the operator to move within a display.
- l) Definition of control input commands which enable the operator to interact with face plates control stations and custom graphic displays to implement control functions.
- m) Definition of data input commands which enable the operator to enter numeric values into the control system.
- n) Definition of the utilization of "poke" points or fields that are dynamically sensitive to operator inputs to facilitate operator entry directly into graphic displays.
- o) A review of graphic generation procedures.
- b. Subsequent to the adjournment of Graphics Meeting No. 1, the ICSC shall prepare and formalize a document titled "Graphics Criteria" which shall contain detailed meeting minutes and a definition of graphic guidelines to be adhered to:
 - 1) This report shall be supplemented by graphic examples which illustrate the incorporation and application of each graphic criteria.
 - 2) Report shall be submitted within 30 calendar days of the meeting's adjournment.
- 5. Ten additional displays shall be configured on line during the pre-commissioning test period.

- G. Alarming priority meetings:
1. ICSC, through the Contractor, shall schedule the alarming priority meetings.
 2. Owner and Carollo I&C Engineer or representative approved by the Carollo Project Manager shall attend these meetings.
 3. Alarming Priority Meeting No. 1: Held in conjunction with the preliminary meeting as specified above:
 - a. ICSC shall chair and develop an agenda 3 weeks in advance for a meeting, which shall address the basic criteria to be adhered to in the prioritization of alarms:
 - 1) At this meeting, the ICSC shall distribute a listing of plant alarms identified by tag names and descriptors.
 - 2) As a minimum, this meeting shall address the following issues:
 - a) Criteria for prioritizing alarms, including alarming priority levels (i.e., Priority 3 - alarm at PCS; Priority 2 - alarm at PCS and autodialer; Priority 1 - alarm at PCS, autodialer, and plant shutdown).
 - b) Alarm display banner basic criteria.
 - b. Subsequent to the adjournment of the Alarming Priority Meeting No. 1, the ICSC shall prepare and formalize a document titled "Alarm Criteria" which shall contain detailed meeting minutes and a definition of alarming guidelines to be adhered to:
 - 1) Report shall be submitted within 30 calendar days of the meeting's adjournment.

PART 2 PRODUCTS

2.01 GENERAL

- A. Furnish 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.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Non-conditioned spaces:
1. Provide additional temperature conditioning equipment to maintain 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.
- B. Outdoor installations:
1. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
 2. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified in the Sections for the equipment.

- C. This facility includes classified areas:
 - 1. As specified in Section 26_05_00 - Common Work Results for Electrical.
 - 2. Provide enclosures suitable for the area classification.
 - 3. Where suitable enclosures are not available, utilize other methods such as intrinsic safety barriers.
- D. 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.
- E. Furnish current version of software unless specifically noted in the Contract Documents.
 - 1. Use of an older version to maintain functionality of an existing system is acceptable with written permission from the Engineer.
 - 2. Equipment or software with limited support or end of life with the vendor is not acceptable.
- F. 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.
- G. 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.
- H. Terminal blocks:
 - 1. Schematics do not reflect the actual conductor routing. Add intermediate terminal in enclosures and equipment as needed based on the actual conductor routing.
- I. 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 mA 24 VDC, except as indicated.
 - c. Electrically or optically isolate 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 mA 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: 3 to 15 pounds per square inch gauge.
- 3. Discrete input signals: As indicated in the controller hardware specification.
- 4. Discrete output signals:
 - a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
 - b. Provide external terminal block mounted fuse with blown fuse indication for discrete outputs.
 - c. Provide interposing relays for discrete outputs for voltage and/or current compatibilities.
 - d. Provide interposing relays as required for functionality of the control circuit.
- 5. Signal performance and design criteria:
 - a. Stability:
 - 1) After controls have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.
 - b. Response:
 - 1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.
 - c. Agreement:
 - 1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
 - d. Repeatability:
 - 1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.
 - e. Sensitivity:
 - 1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.
 - f. Performance:
 - 1) Instruments and control devices shall perform in accordance with the manufacturers' specifications.

2.03 ACCESSORIES

- A. Provide flow conditioning devices or other required accessories as needed to meet the accuracy requirements in the Contract Documents.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. PCIS configurations are diagrammatic:
 - 1. Locations of equipment are approximate unless dimensioned.
 - 2. Where Project conditions require, make reasonable changes in locations and arrangements.
- B. Field instruments installation:
 - 1. 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 on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
 - b. Provide sun shields for field electronic instruments, panels, and enclosures located outdoors. Sun shields shall include standoffs to allow air gap between shield and equipment.
 - c. Orient LED, LCD, or other readout screens north to minimize sun glare and reduce potential of sun damage.
 - 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) As specified in Section 26_05_00 - 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 process connections are free of leaks.
- C. Cable and conductor termination:
 - 1. Terminate cables and conductors on terminal blocks.
 - 2. Terminal block enclosures:
 - a. Suitable for the area classification as specified in Section 26_05_00 - Common Work Results for Electrical.
- D. 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 mA DC loop with a 1/2-amp fuse between power supplies and receiver surge protectors.

3. Provide voltage surge protection for 4-wire transmitters and analyzers:
 - a. Protect both power source and signal loop.

3.04 RE-INSTALLATION

- A. 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.

3.05 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning.
- B. As specified in Section 40_80_01 – Commissioning for Instrumentation and Controls.

3.06 FIELD QUALITY CONTROL

- A. Functional Testing:
 1. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.
 2. Assist with troubleshooting and correcting instrumentation and control issues.

3.07 ADJUSTING

- A. Control valves:
 1. Stroke 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 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 Commissioning.

3.08 CLEANING

- A. Vacuum clean control panels and enclosures before process start-up and again after final completion of the Project.
- B. Clean panel surfaces.
- C. Return to new condition any scratches and/or defects.
- D. Wipe instrument faces and enclosures clean.

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

END OF SECTION

SECTION 40_61_15

CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Contractor-developed loop description submittal requirements.
 - 2. General programming requirements.
 - 3. Common control functions:
 - a. General control and monitoring functions to be provided throughout the PCS system.
 - 1) These requirements apply to all systems and supplement the specific loop descriptions in Section 40_61_16.10 - Specific Control Strategies, and information indicated on the Drawings.
 - 4. This is a brown field project and the SCADA system currently exists and is not being replaced the new PLC-910 program will need to communication with the existing SCADA system.
 - 5. The general and specific control strategies and programming requirements shall follow existing programming logic structure and methodologies to ensure consistency across the facility.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Clamp: Imposed upper and lower limits on setpoints to eliminate entries outside the allowable control parameters.
 - 2. Hardwired control: Control circuitry that does not utilize software to initiate functionality.
 - 3. Hardwired interlocks: A safety or protective feature that will interrupt equipment operation in all operating modes with no required operator intervention.
 - 4. Historize: To store data collected by a Supervisory Control and Data Acquisition system or Distributed Control system in a Historical Server or Historian for later use in trends and reports.
 - 5. Network link status: A proving register that allows the PCS to know if a PLC has lost communications with the PCS.
 - 6. Network time synch: Coordination of all PLCs in the system to one consistent time based on a server, GPS clock, or some other mechanism to set a global time.
 - 7. Software interlocks: A safety or protective feature interrupting equipment operation when the PLC has control.

8. Software permissive: A protective feature that will prevent a piece of equipment from starting. Will not stop the equipment once it's running.
9. Slew rate: Rate of change with respect to time.
10. Watchdog timer: Timers imposed to test components such as discrete I/O to verify the health of the card.

1.04 SUBMITTALS

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.05 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PROGRAMMING REQUIREMENTS

- A. General:
 1. All tags are to have the pre-fix 65.
 2. Use re-usable data types for variable names or aliases derived from tag and loop identification on the P&IDs for the equipment/instruments. For example:
 - a. PMP_931.Auto.
 - b. RNG_931.Running.
 - c. Fail_931.Failed.
 - d. PMP_932.Auto.
 - e. RNG_932.Running.
 - f. Fail_932.Failed.
 3. Use variable names or aliases derived from tag and loop identification on the P&IDs for all process values.
 - a. Submit names for Owner approval.
 - b. Unless otherwise noted, utilize a floating-point format for PLC algorithms and calculations.
 - c. Provide PLC logic to convert raw input values into engineering units in a floating-point format.
 4. Store all adjustable parameters in the PLC and configure them so that an operator with sufficient security access can change the parameters from the LOI or HMI. Update and display the current value at all locations, regardless of where the last change was made.
 5. Reusable PLC code blocks:
 - a. Develop and use new standard user defined function blocks (UDFBs) and user defined types (UDTs) where appropriate. One instance of each standard code block shall reside in each PLC and shall be referenced in main routines and subroutines.
 6. Documentation:
 - a. All control logic shall be annotated, including rungs, instructions, and tags.

- b. Each routine shall have a title and a detailed description in complete sentences of the control strategy represented by the control logic. Where parameters are passed to the routine, all parameters shall be defined in the routine description. Analog tag descriptions representing process variables shall include the engineering unit range of the analog variable.
 - c. Digital tag descriptions shall include the On and Off state labels.
 - d. Analog tag descriptions representing process variables shall include the engineering units' range of the analog variable.
 - e. Equations developed in the process logic shall be fully documented in the rung or routine description. This description should include a description of each constant and variable utilized in the equation, including engineering units.
- 7. Program slew rates for setpoints as needed to limit the effect of updated setpoints on the process:
 - a. Match the existing convention.
- 8. Setpoints:
 - a. Match the existing convention.
- 9. Store a copy of adjustable parameters and accumulated and integrated totals in PCS:
 - a. Match the existing convention.
- 10. Calculated values:
 - a. Match the existing convention.
- 11. Timers:
 - a. Match the existing convention.
- 12. Control Panel status:
 - a. Design the PLC system to function as a stand-alone unit that performs all of the control functions described in this Section completely independent from the functions of the PCS system PC-based operator interfaces:
 - 1) Failure of the PCS system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
 - b. Furnish a minimum of 1 screen that depicts the status of enclosures containing PLCs, communication equipment, UPS or I/O in the control system, including, but not limited to, the following:
 - 1) PLC cabinet over-temperatures from high temperature switch.
 - 2) Intrusion status on enclosures equipped with intrusion switches.
 - 3) AC power failure:
 - a) Monitor ahead of UPS.
 - 4) DC power supply failure:
 - a) For redundant power supplies, alarm when either power supply or the diode bridge fails.
 - 5) UPS failure signal.
 - 6) UPS low battery signal.
 - 7) Digital bus network coupler and or gateway failure signal.
 - 8) Ethernet switch failure signal.
- 13. Network link status:
 - a. Alarm on the loss of communications between any PLCs (vendor or plant).
 - b. Provide a HMI and/or LOI screen depicting communication pathways and graphically showing the loss.
 - c. Use produced/consume tags to monitor PLC to PLC communications.
 - d. Coordinate with all vendor PLCs so that they match the plant PLC monitoring methods.

14. PLC system communication status:
 - a. Furnish a minimum of 1 screen to display communication errors and status within the PCS:
 - 1) Communication between PCS and PLCs, PLC to PLC, PLC to RIO and PLC and or PCS to VCP.
 - 2) Network status:
 - a) Communication network cards.
 - 3) Display the status of each node and a summary of failures over the past 60 minutes.
 - b. Generate a communications alarm if a communication fault is detected or there is no response from a node for more than a user-specified time.
 - c. In the event of communications loss:
 - 1) Continue normal operation at each PLC.
 - 2) Where control parameters are received over a communications link:
 - a) If a link fails where process elements use the remote value for closed-loop control, hold operating status, speed, and position of the process elements at their last state before the communication alarm, unless other I/O local to that PLC indicates shutdown or override conditions:
 - (1) Ensure the operator can control the process using PCI\S MANUAL mode at the local LOI.
 - b) If a link fails where process elements use the remote value to determine setpoints, continue to operate using the last value received:
 - (1) Provide a manual override entry at the local LOI to allow an operator to enter a different value for any such remote signal.
 - (2) Generate an alarm whenever an override value is in use.

B. Common control functions:

1. Match the existing convention. The Engineer shall be notified of all conflicts between the existing convention and what is required in common control functions via submittal specified in 1.04.
2. Incorporate common control functions into control loops and devices and into the control programming, whether or not specifically shown in the specific control descriptions or elsewhere in the Contract Documents.
3. Alarms:
 - a. Indicate alarms at the LOI and HMI. Enable acknowledgement from either the HMI or the LOI.
 - b. Generate and include the following alarms for all analog or equivalent network signals.
 - 1) Low.
 - 2) Low-low.
 - 3) High.
 - 4) High-high.
 - 5) Out of range.
 - 6) Rate of change.
 - 7) Stale.
 - c. Indicate alarms at the LOI and HMI. Enable acknowledgement from either the HMI or the LOI.

- d. Generate high, high-high, low, and low-low level alarms where indicated:
 - 1) Provide an alarm reset deadband for each analog value to prevent excessive repeated alarms.
 - 2) Provide logic and timers to inhibit analog alarms based on process events. For example, inhibit low-flow alarms when a pump is stopped or has not been running long enough to establish flow.
- e. Flash alarm and fail conditions and their respective indicators on the PCS graphic screens and local indicating lights until the condition is acknowledged by the operator, even if the alarm condition is no longer present.
- f. Once an operator acknowledges the alarm, display alarm conditions in a steady state (not flashing) while the alarm condition is still present:
 - 1) Flash with a cycle rate of 1/2 second on and 1/2 second off.
- g. Once the alarm has been cleared and the operator has acknowledged the alarm or fail condition, turn the graphic alarm indicator off.
- h. For alarms that do not have inherent timers, provide an operator-adjustable proving timer to limit nuisance alarms, continuously adjustable from 0 seconds to 100 minutes. The initial setting of proving timers shall be 0 seconds:
 - 1) PLC shall start the timer when it first detects an alarm condition and only activate it after the timer has expired.
 - 2) If the alarm condition clears while the timer is running, the timer shall reset, and the alarm shall not be activated.
- i. Use interlocks and proving timers to prevent alarms from operating due to power loss, except for loss of power alarms.
- j. Furnish an alarm silence pushbutton at each PCM, LOI, or LCP with an audible alarm to signal the PLC to turn off the audible alarm until the next alarm occurs.
- k. Lamp test: Furnish lamp test pushbuttons at each control panel with more than 10 pilot lights that illuminate all pilot lights on the panel:
 - 1) May sequence through blocks of lights.
 - 2) Minimum on time for each lamp during lamp test 15 seconds.
- l. Horns and beacons:
 - 1) Where indicated in the Contract Documents:
 - a) Activate PCM horn and beacon on critical alarms and on other alarms as defined by the Facility Alarm Philosophy.
 - b) Deactivate PCM horn and beacon when PCM reset pushbutton is activated.
 - c) Silence PCM horn when PCM silence pushbutton is activated.
- 4. Where a reset is shown for counts, totals and times maintained in the PLC:
 - a. Provide a reset selection on the HMI screen that displays the value.
 - b. Provide a preset function on the HMI to allow an operator-entered value to become the accumulated total.
 - c. Limit access to the reset and preset functions to operators with suitable security levels.
 - d. Log the value before reset, including the operator, time, and reset date in the PCS archive.
 - e. Log the value before preset, preset value, operator, time, and date of preset in the PCS archive.

5. Count starts for each piece of equipment (off to on transitions of running status) in the PLC:
 - a. Display total starts on PCS screens and provide a reset function.
 - b. Calculate the number of starts for each day:
 - 1) Display current day and previous day starts on PCS displays.
 - 2) Do not reset daily start count when overall count is reset.
 - 3) Archive starts for each day through PCS.
 - c. Calculate the number of starts per hour. Alarm when the number of starts per hour exceeds the manufacturer limit.
6. Run time accumulation:
 - a. Integrate accumulated run time to the nearest 0.1 hour whenever the running status input indicates that the equipment is running:
 - b. Display total run time in hours on PCS screens.
 - c. Where indicated, calculate the total run time for each day:
 - 1) Display the current day and the previous day's run time on the HMI to the nearest 0.1 hour.
 - 2) Do not reset daily run time when overall time is reset.
 - 3) Archive run time for each day through PCS.
7. For all monitored analog values:
 - a. Convert values to engineering units in floating-point format within the PLC.
 - b. Maintain trends in PCS.
 - c. Flows and weights:
 - 1) Totalize flows in the PLC logic:
 - a) Where totalized flows are input to a discrete input, count input pulses and multiply by the volume per pulse.
 - b) Where no totalizer input is shown, integrate the analog input over time.
 - c) Display totals on the HMI and LOI.
 - d) Archive totals to the historical database through PCS.
 - d. Generate an alarm whenever an override value is in use.
 - e. Calculate hourly, daily, and monthly averages:
 - 1) Display averages on the HMI, and archive through PCS.
 - f. Calculate minimum and maximum values each day, and month:
 - 1) PLC or PCS may perform calculations.
 - 2) Display minima and maxima on the HMI, and archive through PCS.
8. Analog data processing:
 - a. Engineering unit conversion:
 - 1) Use engineering units for all analog point values. Convert analog inputs to engineering units.
 - b. Analog magnitude checking:
 - 1) Provide upper and lower limits to prevent operator-entered values (setpoints, etc.) from falling outside acceptable limits.
 - c. Analog value quality:
 - 1) Monitor analog values received at each PLC from analog inputs or communications from another PLC or RIO specific to critical analog values, and generate alarms for the following conditions:
 - a) Rate of change in excess of acceptable limit:
 - (1) Provide a separate rate limit for each value.
 - b) Stale value:
 - (1) For analog signals that come from analog inputs or calculations using analog inputs, which are expected to

- have some variation each time the input is read, alarm when there is no change in the value for 10 times the normal expected scan or communication update.
9. Analog device override (LOI and HMI):
 - a. Provide the following functions from the HMI and the local LOI all controlling analog input:
 - 1) An override value to be used in place of the analog input:
 - a) Enter in engineering units:
 - (1) Display the calibrated range in engineering units.
 - (2) Only allow entries within the calibrated range of the instrument.
 - b) When the analog input is enabled, track the analog input so that the override matches the analog input value when the input is initially disabled.
 - c) Maintain override status and value in the PLC.
 - d) Only allow access to override selections and settings to operators with sufficient security.
 - 2) An enable/disable selection:
 - a) When enabled, the value used by the PCS system is equal to the analog input value.
 - b) When disabled, the analog input is ignored, and the override value is used for all control and display functions.
 - c) Generate an alarm whenever an analog input is disabled.
 - d) Enter a value for the analog input from the PCS system to the PLC.
 - 3) Use the override value for all display and control functions instead of the actual analog input value.
 - b. Provide the following functions in the PLC, with selections and value entry from the HMI and/or LOI:
 - 1) An override value to be used in place of the normal output value:
 - a) Enter the percent of output span.
 - b) When the analog output is enabled, track the analog input so that the override matches the analog output value when the output is initially disabled.
 - 2) An enable/disable selection:
 - a) When enabled, the value sent to the output is the value determined by the PLC based on the control logic or operator-entered value in PCS MANUAL.
 - b) When disabled, the calculated PCS MANUAL values are ignored and the override value is sent to the output.
 - c) Generate an alarm whenever an analog output is disabled.
 10. I/O filtering and processing:
 - a. Analog input filtering:
 - 1) For each analog input, provide an adjustable first-order filter for the purpose of smoothing out spikes and other noise for analog transmitter input signals. By default, configure analog inputs with no filtering effect.
 - 2) Monitor analog input signal quality:
 - a) Over range: Input value is above the normal range (typically over 21 mA).

- b) Under range: Input value is below the normal range (typically under 3 mA, indicating a probable broken connection).
 - c) Generate alarms for over- or under-range inputs.
 - d) Do not use over- or under-range values for control or calculation purposes:
 - (1) Where a second instrument is provided to monitor the same condition (a redundant instrument or additional instruments furnished for averaging or different operating modes) and has a valid signal, use that input for control.
 - (2) Otherwise, hold all outputs affected by the signal at their last values before the signal went out of range.
 - 3) Digital input filtering (proving timer):
 - a) Provide an adjustable time delay function (0 to 10 seconds) on discrete input for de-bouncing.
 - b) By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.
11. Instrument scaling (HMI/LOI):
- a. Provide 1 or more maintenance screens to display ranges and trigger points for all field instruments:
 - 1) For analog instruments, use input scaling values in the PLC to determine minimum and maximum calibration points.
12. Levels:
- a. Level measurements:
 - 1) All level readouts displayed by the HMI, PLC, or SCADA shall be displayed in the actual level of the fluid or plant elevation, whichever the Owner desires.
 - b. Tank and vessel levels:
 - 1) Display as a level (typically in feet of liquid), volume (typically in gallons) and percentage of rated capacity (percent):
 - a) Some individual displays may only be level or volume when agreed to by the Owner and Engineer during screen review meetings.
 - 2) Monitor the rate of change of volume on tanks and vessels:
 - a) Establish the maximum withdraw rate at which the volume should decrease (all pumps or feeders operating at maximum output). Generate an alarm whenever the volume decreases faster than this rate.
 - b) Establish the maximum fill rate at which the volume should increase when filling.
 - (1) Generate an alarm whenever the volume increases faster than this rate.
 - (2) Verify tank and vessel levels are fluctuating to verify the validity of the IO register.
13. If it is determined the register is not active or failed in a manner that leaves a stagnant value generate an alarm.

14. PCS MANUAL-AUTO:
 - a. Where indicated, provide MANUAL-AUTO and START-STOP selections in the PCS, accessed from an LOI or HMI for operators with sufficient security, to provide the following operating modes:
 - 1) PCS AUTO: Normal, automatic control mode of the strategy allows complete PLC control in response to process conditions and programmed sequences.
 - 2) PCS MANUAL: Enables PCS manual control where control decisions are made by an operator through the PCS START-STOP, OPEN/CLOSE, or other selections as indicated.
 - 3) Program the PLC so that switching a strategy between AUTO and MANUAL (either direction) occurs with a smooth transition.
 - a) Keep running or position status unchanged when control is switched to MANUAL until a change is requested using the operator selections (START, STOP, OPEN, CLOSE).
 - b) Keep running and position status unchanged when control is switched to AUTO until the control logic determines a change is required.
15. Display the status of all operator selections (PCS MANUAL/AUTO, PCS START/STOP, etc.) on the PCS.
16. Interlocks:
 - a. Implement software interlocks as indicated to place equipment in a safe condition in response to impending hazardous process conditions. Apply software interlocks when equipment is operating in PCS AUTO or PCS MANUAL.
17. Permissives:
 - a. Implement software permissives where indicated to prevent equipment from starting in an unsafe condition.
 - b. Apply software permissives when equipment is operating in PCS AUTO or PCS MANUAL.
18. Process control algorithms:
 - a. Jog and hold:
 - 1) When the error between process variable and setpoint is beyond a setpoint deadband:
 - a) Jog valve or ramp speed in the required direction for a preset "Jog Time" or until the process variable reaches or passes the setpoint.
 - b) Then hold speed or position through a setpoint "Hold Time."
 - c) Continue alternating jog and hold until the error is less than the deadband.
 - 2) Provide operator access to jog time and hold time setpoints from the HMI.
 - b. PID algorithms:
 - 1) Provide a PID faceplate with the following displays and functions for each PID control algorithm:
 - a) Display Output, CV.
 - b) Display Setpoint, SP.
 - c) Display Process Variable, PV.
 - d) Allow for operator selection of automatic or manual control of the output.

- e) Under manual control of output, allow the operator to enter the desired output value.
 - f) Allow for input of the 3 proportional, integral, and derivative tuning parameters.
 - g) Configure PID loops to prevent reset windup when controlled equipment is operating in manual (local or PCS), or when the equipment has reached a physical limit.
 - h) When controlled equipment is being operated in remote PCS MANUAL, configure the PID function to track the process variable to provide a smooth transfer between manual and automatic modes.
 - i) Provide selectable slew rates with adjustable setpoints to allow the PID algorithm to slowly ramp to its final value to minimize system disturbance.
19. Equipment alternating and sequencing:
- a. Distribute number of starts and run time equally between identical equipment.
 - b. Where multiple pieces of equipment are used to control a single process variable, alternating of lead and lag equipment assignments is done as follows:
 - 1) Automatic lead/lag equipment selection:
 - a) Control system automatically selects the lead equipment and next lag equipment based on the lowest run time hours of the equipment.
 - b) When multiple equipment is running, the control system determines which equipment to stop next based on the running equipment with the highest run time hours.
 - c) A weighted run time factor can be assigned to each individual piece of equipment.
 - (1) Weighting factor is a percentage from 1 to 100 percent that is multiplied by the actual run time hours of the equipment to create a weighted run time hours of the equipment.
 - (2) Weighted run time hours of each piece of equipment are then used by the algorithms that select the equipment that will start or stop next.
 - (3) This is to allow for specific equipment to accrue more run time hours so that all pumps do not reach their maximum run time hours at approximately the same time.
 - (a) Display both the weighted and actual runtime hours on the PCS screen.
 - 2) Manual lead/lag selection:
 - a) Operator will assign the lead, "Next Lag" equipment through a selection matrix in the HMI.
 - b) When modifying this matrix, modifications shall not become active until an "ACCEPT ALL" software pushbutton is activated.
 - c) Provide a "CANCEL ALL" software pushbutton to clear all modification of the selection matrix and revert them to the last accepted changes.

20. Motor control:
- a. Monitor the device's LOCAL-OFF-REMOTE (LOR) switch (the hard-wired switch at the MCC, drive or equipment) to determine when the PLC has control of the associated equipment:
 - 1) Display current REMOTE status on the PCS screens.
 - b. Monitor the device's running status from the starter auxiliary or run status input:
 - 1) Display the current status (running or stopped) on the PCS screens.
 - 2) Use status to calculate total run time and daily run time, and to count total starts and daily starts.
 - 3) Provide a time stamp for each start.
 - 4) Provide software for motors 200 horsepower and greater to prevent exceeding the manufacturer's recommended maximum starts per hour.
 - c. When equipment control has been given to the PLC as reported by the LOCAL-OFF-REMOTE switch, allow selection of PCS AUTO or PCS MANUAL control modes based upon operator selection using the PCS screens.
 - d. Starting, stopping and running when the device LOR is in LOCAL:
 - 1) With the LOR switch in the LOCAL position, the motor is controlled by the START and STOP pushbuttons.
 - 2) With the LOR switch in the OFF position, the motor is prohibited from running.
 - 3) With the LOR switch in the REMOTE position, the motor is controlled remotely.
 - e. Starting, stopping, and running when the device LOR is in REMOTE:
 - 1) When the motor is expected to be running (PLC has issued a START or RUN due to process conditions or operator selection), LOR is in REMOTE, and the device is not reported to be running, start an operator adjustable "Control Activation" timer:
 - a) Provide "Control Activation" timers for each piece of controlled equipment:
 - (1) If the LOR and required running status do not change, and the PLC does not receive running status within the "Control Activation" time period:
 - (a) De-activate the output.
 - (b) Place the device in a "Failed" state.
 - (c) Generate a "Failed to Respond" alarm.
 - 2) When the motor is not expected to be running (PLC has issued a STOP or removed the RUN output), LOR is in REMOTE, and the device is reported to be running, start the "Control Activation" timer:
 - a) If the LOR and required stopped status do not change, and the PLC does not lose the running status within the "Control Activation" time period:
 - (1) Keep the RUN output off or the STOP output on.
 - (2) Place the device in a "Failed" state.
 - (3) Generate a "Failed to Respond" alarm.

- 3) Re-establish PLC control of a device in a “Failed” state only after one of the following:
 - a) An operator turns the device’s LOR switch out of REMOTE, and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).
 - b) An operator acknowledges the fault from the PCS.
- f. Where motor winding high-temperature switches or RTD temperature elements are shown, generate an alarm when a high temperature is sensed (contact opens or temperature above the high alarm setpoint), but do not stop the motor unless otherwise indicated.
- g. Motor equipped with current detection shall shut down and report a “failed” status for high current detection.
- h. Control 2-speed motors similar to other motors, except as listed below:
 - 1) Motor states are RUN-FAST, RUN-SLOW, and STOP.
 - 2) Start 2-speed motors in the RUN-SLOW state. If or when the high speed is required (RUN-FAST operator selection or process conditions), transition to RUN-FAST after a designated time.
 - 3) When transitioning from RUN-FAST to RUN-SLOW, remove the RUN-FAST output or issue a STOP, then wait for a “Fast to Slow” time delay before energizing the RUN-SLOW or START-SLOW output.
- i. Simultaneous starts:
- j. Duty-Standby selection:
 - 1) Start sequence shall be operator adjustable or automatically determined by elapsed runtime.
 - 2) For operator adjustable mode:
 - a) Operator shall enter the start sequence from a matrix of available equipment.
 - b) Operator shall be required to enter an equipment number into each start position.
 - c) With each entry, the current runtime of the entered equipment shall be displayed.
 - d) Once the operator has completed the entries, the “ACCEPT” button must be selected in order for logic to proceed.
 - e) Selecting the “CANCEL” button shall clear all entries, maintaining the previously entered valid sequence.
 - f) Submitted start sequences containing duplicate or invalid entries shall be automatically rejected.
 - 3) For elapsed runtime mode:
 - a) Lead and standby positions shall always be chosen by selecting the equipment with the least runtime for the DUTY position if it is available for service.
 - b) Equipment start positions shall alternate every 72 hours (operator adjustable).
 - c) Equipment with a status of “Not Ready” or “Out-of-Service” shall be automatically moved to the end of the start sequence.
- k. Equipment Out-of-Service:
 - 1) Control system shall have the facility to assign an “Out-of-Service” (OOS status) condition tag to equipment monitored by the control system.
 - a) During extended periods of maintenance and/or repair, an operator may make such an assignment to equipment so as to

suppress associated alarms and inhibit HMI/PLC control functions during the maintenance activities.

- I. Speed control:
 - 1) Modulate speed on VFD-driven motors using jog and hold, or PID control algorithms to maintain process conditions as described in the specific loop descriptions.
 - 2) Operate speed control within a pre-defined range:
 - a) Minimum speed as determined by equipment manufacturer. The higher of:
 - (1) Minimum motor speed to maintain adequate cooling for the type of load driven (constant or variable torque).
 - (2) Minimum equipment speed, such as minimum speed to deliver flow or to deliver minimum flow for equipment cooling or lubrication.
 - b) Maximum speed 100 percent (60 hertz) or as identified by the equipment manufacturer.
 - c) Scale analog signals to control speed at 0 to 100 percent of the operable speed range for the equipment.
 - 3) Where multiple equipment may operate together to maintain the same process condition, alternatively referred to as "Lead/Lag":
 - a) Start the first equipment at a preset starting speed.
 - b) When one or more of the equipment is running and the speed control algorithm reaches a preset "Start Next" speed value (initially 95 percent of speed range) through a preset time delay:
 - (1) Start the next available equipment at the preset starting speed.
 - (2) Ramp up the started equipment and ramp down the previously running equipment to the mid operating speed (adjustable in the PLC). Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with the new load running at the mid speed (for example if 1 pump is running and the second pump will be added, then the total flow of both pumps running at mid operating speed should be approximately the same as the flow of 1 pump at Start Next speed).
 - (3) Once both pieces of the equipment reach the mid-operating speed, resume the speed control algorithm for that equipment.
 - (4) Operate equipment at the same speed following the output of the speed control algorithm.
 - c) When two or more pieces of equipment are running, monitor for a "Stop Next" condition:
 - (1) Where the flow rate is monitored, use a preset "Stop Next" flow rate for each possible number and combination of equipment:
 - (a) Determine the initial "Stop Next" speed based on the flow that can be provided with one fewer piece of equipment running at a speed slightly below the "Start Next" speed.

- (2) When the “Stop Next” condition exists through a preset time delay:
 - (a) Ramp speed of running equipment, except for the equipment to be stopped up to a preset value based on the number of items running. Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with 1 fewer load running (typically slightly below the preset “Start Next” speed) while ramping speed of equipment to be stopped down to the preset minimum speed.
 - (b) Operate remaining equipment at the same speed following the output of the speed control algorithm. Stop the load once it reaches minimum speed.
- 21. Gate and valve control:
 - a. Monitor the device’s LOCAL-STOP-REMOTE (LSR) switch(es) (the integral switch in the actuator or hard-wired switch at the local control station):
 - 1) Display current REMOTE status on PCS screens.
 - b. Start an “Open Activation” timer whenever the device is expected to be open (PLC has issued an OPEN command in PCS AUTO, or OPEN was selected in PCS MANUAL):
 - 1) Initially set “Open Activation” time to twice the normal opening time.
 - 2) If the LSR position and open command do not change, and the PLC does not receive fully open status feedback within the “Open Activation” time period:
 - a) De-activate the open output.
 - b) Place the device in a “Failed” state.
 - c) Generate a “Failed to Open” alarm.
 - c. Start a “Close Activation” timer whenever the device is expected to be closed (PLC has issued a CLOSE command in PCS AUTO, or CLOSE was selected in PCS MANUAL):
 - 1) Initially set “Close Activation” time to twice the normal closing time.
 - 2) If the LSR position and close command do not change, and the PLC does not receive fully closed status feedback within the “Close Activation” time period:
 - a) De-activate the close output.
 - b) Place the device in a “Failed” state.
 - c) Generate a “Failed to Close” alarm.
 - d. Limit the number of open/close commands so that it does not exceed the manufacturer requirements.
 - e. For modulating valves (valves controlled from either a 4-20 mA signal or digital communications command) with position feedback, start a “Position Error” timer whenever the position feedback differs from the required position command by more than a setpoint error when the LSR is in REMOTE:
 - 1) For analog modulating devices, the error is determined by position feedback differing from position command by more than the setpoint error.

- 2) For discrete modulating devices, error is determined by feedback not changing in the correct direction or changing at less than a setpoint rate when the OPEN or CLOSE PLC output is active.
- 3) Initially, set the "Position Error" time to 60 seconds.
- 4) If the LSR position does not change, and the position error stays outside of the setpoint error through the "Position Error" time period:
 - a) Place the device in a "Failed" state.
 - b) Generate a "Position Fail" alarm.
- f. Provide separate time delay settings for each function and for each device.
- g. If the valve position inputs indicate an invalid state (i.e., valve open and closed at the same time), place the device in a "Failed" state and generate an "Invalid State" alarm.
- h. Re-establish PLC control of a device in a "Failed" state after one of the following:
 - 1) An operator turns the device's LSR switch out of REMOTE and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).
- i. For all alarm conditions, control other devices (as stopping pumps, etc.) as stated in the individual loop descriptions to make the system safe.
- j. For discrete modulating valves (valves positioned to intermediate positions to control process values through discrete OPEN and CLOSE outputs), count the number of actuations (OPEN or CLOSE commands) per hour in the PLC:
 - 1) Display count on the HMI.
22. Breaker status:
 - a. Display the following data to the extent it is available from the specified device:
 - 1) Open.
 - 2) Closed.
 - 3) Tripped.
 - 4) Ground fault.
 - 5) Settings.
 - 6) Racked out.
23. Power data:
 - a. Retrieve data from:
 - 1) Power quality meters (PQMs) at 480 V.
 - 2) Main breaker protective relays on 12.47 kV switchgear.
 - 3) Generator master control panel.
 - 4) Digital bus networks, as indicated.
 - 5) Where available, use EtherNet IP communications.
 - b. Display the following data (to the extent it is available) from the specified device.
 - 1) Current XXXX.X A:
 - a) A-Phase.
 - b) B-Phase.
 - c) C-Phase.
 - 2) Volts: XXXX.X V:
 - a) A-Phase.
 - b) B-Phase.
 - c) C-Phase.
 - 3) Reactive power: XXXX.X kVAR.
 - 4) Real power: XXXX.X kW.

- 5) Apparent power: XXXX.X kVA.
 - 6) Power factor: 0.XX.
 - 7) Energy: XXXXXXXX kW*hr.
 - 8) Demand peak: XXXX amp.
 - 9) Demand peak: XXXX kW.
 - c. For engine/generator system monitoring, also display percent of rated output.
24. Power supply and distribution displays power quality meters display:
- a. In addition to the power data listed above, display the following (where available) from PQMs, protective relays, and generator master control panel:
 - 1) Frequency: Hertz.
 - 2) THD (current and voltage): Up to 31st harmonic.
 - b. Calculate, indicate, historize, and trend data in a 12.47 kV meter table that lists measurements from the following protection relays:
 - 1) Protection Relay on 52-G1.
 - 2) Protection Relay on 52-G2.
 - 3) Protection Relay on 52-M1.
 - 4) Protection Relay on 52-M2.
 - 5) Protection Relay on 52-M3.
 - 6) Display calculated values for "Load At 12.47 kV", which sums the current, kW, and kW-hr values for all 5 protection relays.
 - 7) Display calculated values for "Load At 480 V", which sums the current, kW, and kW-hr values for all PQM meters.
 - 8) Display calculated values for "Transformer and Line Losses", which subtracts "Load at 480 V" from "Load At 12.47 kV" for current, kW, and kW-hr values for all PQM meters.
 - c. Display the data in a 480 V meter table that lists measurements from all power quality meters on the plant.
25. Calculate, indicate, historize, and trend plant-wide calculated values for kW by the following groups:
- a. Calculated values (summed from starter data for all equipment within the groups identified below):
 - 1) Demand peak: XXXX amp.
 - 2) Demand peak: XXXX kW.
 - 3) Electric Power Consumption, by Process Group (kW): XXXX kW.
 - 4) Electric Power Consumption, by Process Group (percent):
XX.XX percent (equals Electric Power Consumption, by Process Group (kW)/Sum of Electric Power Consumption on all 480 V Meters).
 - 5) Electric Energy Consumption, by Process Group (kW*hr):
XXXX kW*hr.
 - 6) Electric Energy Consumption, by Process Group (percent):
XX.XX percent (equals Electric Energy Consumption, by Process Group (kW)/Sum of Electric Energy Consumption on all 480 V Meters).
 - b. Display a Process Energy Consumption Table that lists the calculated values for each of the identified groups.
 - c. Display a Process Energy Pie Graph that portions wedges according to the values calculated in Electric Energy Consumption, by process group (5). Label wedges, (with numeric percentage), for groups to cover at least 90 percent of the Pie Graph. Remainder wedge of pie graph area can be labelled as "Other" (with numeric percentage).

3.02 TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 40_61_16.10

SPECIFIC CONTROL STRATEGIES - THICKENED SLUDGE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Loop descriptions for Thickened Sludge Processing. Prefix the I/O tags with "65-" in the PLC program and SCADA system or else there will end up being duplicate tag numbers to the existing equipment and I/O tags; for instance, loops 932 and 942.
 - 2. The contracted integrator and the centrifuge vendor will need to coordinate to determine the necessary changes required to the centrifuge VCP PLC program since the way the centrifuges are being supplied sludge is changing due to this project.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Abbreviations:
 - 1. HIM: Human Interface Module.
 - 2. HMI: Human Machine Interface.
 - 3. PLC: Programmable Logic Controller.
 - 4. SCADA: Supervisory Control and Data Acquisition.
 - 5. VCP: Vendor Control Panel.
 - 6. VFD: Variable Frequency Drive.
 - 7. All others are explained in the body below.
- C. Definitions:
 - 1. Loop description: Specific control requirements and functional descriptions for individual control loops.
 - 2. None.
- D. Setpoints:
 - 1. 65-LAL-981, Thickened Sludge Day Tank 1, ## inches.
 - 2. 65-LALL-981, Thickened Sludge Day Tank 1, ## inches.
 - 3. 65-LAL-982, Thickened Sludge Day Tank 2, ## inches.
 - 4. 65-LALL-982, Thickened Sludge Day Tank 2, ## inches.
 - 5. 65-LAL-921, Sludge Thickener THU-921, Copy for existing PLC program.
 - 6. 65-LALL-921, Sludge Thickener THU-921, Copy for existing PLC program.
 - 7. 65-LAL-922, Sludge Thickener THU-922, Copy for existing PLC program.
 - 8. 65-LALL-922, Sludge Thickener THU-922, Copy for existing PLC program.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Develop detailed loop descriptions based on the information in the Contract Documents:
 - 1. Submit loop descriptions with implemented modifications from this Section clearly marked.
 - 2. Remove all markings on final loop descriptions submitted with the applicable operation and maintenance manuals.

1.04 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GRAVITY THICKENER EFFLUENT VALVES & INLINE GRINDER

- A. General:
 - 1. References:
 - a. P&ID 65N01.
 - b. Section 40_05_57.24 – Electric Actuators
 - c. Section 46_24_23 – Inline Grinder
 - 2. Key equipment:
 - a. VALVE, 65-VAL-930A \ 65-FV-930A.
 - b. VALVE, 65-VAL -930B \ 65-FV-930B.
 - c. GRINDER, 65-GDR-930 \ 65-VCP-930.
 - 3. Abstract:
 - a. Thickened sludge from each existing gravity thickener (Typical of 2) flows out through a bottom hopper and into sludge lines which extend into the new Sludge Pump Station where electrically actuated thickened sludge control valves on each pipe is used to isolate sludge flow from each gravity thickener.
 - b. For normal operations, sludge is removed from only one thickener at a time. Downstream of the thickened sludge control valves the two pipes combine and flow through a relocated inline sludge grinder (existing in-line grinder located in the Dewatering Building will be relocated and installed inside the new Sludge Pump Station). Manual bypass piping is provided at the in-line grinder can be removed for maintenance without disrupting operations.
 - c. For normal operations, thickened sludge is pumped from the in-line grinder (or is bypass) to the new Sludge Day Tank (Cell 1 and/or Cell 2) by the Thickened Sludge Transfer Pumps.

- d. For Day Tank Bypass operations, thickened sludge is pumped from the in-line grinder (or is bypass) directly to existing centrifuges inside the Dewatering Building using Thickened Sludge Feed Pumps.
- e. The fluid level inside a Gravity Thickener from which thickened sludge is being removed is monitored and used to STOP downstream in-line grinder and pump equipment at a preset LOW LOW level to prevent equipment from running dry.

B. Hardwired controls:

- 1. Control Valves:
 - a. Pilot devices:
 - 1) Field:
 - a) LOCAL-OFF-REMOTE (LOR) selector switch.
 - b) OPEN-STOP-CLOSE (OSC) selector switch.
 - c) OPEN-CLOSE (O/C) position indicator.
 - 2) LCP:
 - a) None.
 - 3) Drive/starter enclosure:
 - a) None.
- 2. In-Line Grinder:
 - a. VCP:
 - 1) Provided with the existing in-line grinder installed inside the Dewatering Building.
 - a) LOCAL-OFF-REMOTE (LOR) selector switch. The grinder can be placed in LOCAL and STARTED or STOPPED, respectively.
 - b) OPEN-CLOSE (O/C) position indicator.
- 3. Interlocks:
 - a. Control Valves: None
 - b. In-Line Grinder:
 - 1) If the relocated grinder and vender control panel have a temperature switch the grinder shall shut down on high temperature.
- 4. LOCAL Indicators and alarms:
 - a. Field:
 - 1) Control Valves:
 - a) Valve actuator Integrated Fail indicator.
 - 2) In-Line Grinder:
 - a) Grinder integrated Fail indicator.
- 5. LCP:
 - a. Control Valves:
 - 1) None.
 - 2) Drive/starter enclosure:
 - a) None.
 - b. In-Line Grinder:
 - 1) VCP:
 - a) See the vendor provided documentation.

C. PCS controls:

- 1. PCS interlocks
 - a. The grinder shall only operate when a thickened sludge control valve is open and its associated thickener is not at a LOW LOW level and if a pump assigned to pull from a thickener is operating.

- b. A thickened sludge control valve shall close if its associated thickener is at a LOW LOW level.
 - 2. Auto (Remote) mode:
 - a. Control Valves:
 - 1) Valves can be controlled remotely when the valve L-O-R selector switch is placed in the REMOTE position.
 - 2) In PCS Auto, a thickened sludge control valve will open when a thickened sludge blowdown is initiated for its associated thickener and will close upon termination of the blowdown. Sludge blowdown operations are described later in this Section.
 - 3) The Operator can select DAY TANK BYPASS MODE:
 - a) There is no Auto control of these valves when in Day Tank Bypass Mode, but the Operator must have at least one thickener valve open.
 - b. In-Line Grinder
 - 1) When the inline grinder L-O-R selector switch is placed in the REMOTE position, it can be controlled REMOTELY manually.
 - 2) In PCS Auto, the grinder will turn on when a thickened sludge blowdown is initiated for either thickener and will turn off upon termination of the blowdown. Sludge blowdown operations are described later in this Section.
 - 3) The Operator can select DAY TANK BYPASS MODE:
 - a) When in DAY TANK BYPASS MODE, the grinder will run when any centrifuge feed pump is operating.
 - 3. Indicators and alarms:
 - a. Control Valves:
 - 1) Refer to Drawings and Section 40_61_15 - Control Strategies for indicators and alarms.
 - b. In-Line Grinder:
 - 1) Refer to Drawings and Section 40_61_15 - Control Strategies for indicators and alarms.
 - 2) Grinder L-O-R Selector Switch position
 - 3) Grinder ON/RUNNING
 - 4) Grinder FAIL.

3.02 THICKENED SLUDGE TRANSFER PUMPS

- A. General:
 - 1. References:
 - a. P&ID: 65N02.
 - b. Control Schematic: 06N02.
 - c. Section 43_23_57.10 – Progressing Cavity Pumps
 - 2. Key equipment:
 - a. Thickened Sludge Transfer Pump 1, 65-PMP-931.
 - b. Thickened Sludge Transfer Pump 2, 65-PMP-932.
 - c. Thickened Sludge Flow Meter, 65-FE/FIT-930.
 - 3. Abstract:
 - a. Under normal operations, intermittent sludge blowdown operations transfer thickened sludge from one thickener at a time to the Day Tank using the DUTY Thickened Sludge Transfer Pump. The automated

thickened sludge control valves control from which thickener sludge is removed.

- b. Thickened Sludge Transfer Pump 1 is dedicated to transfer service. Thickened Sludge Transfer Pump 2 can be used for either transfer service or as a backup pump for the Thickened Sludge Feed Pumps to feed a centrifuge (refer to Section 3.04 below). The operator selects which of these two pumps is the DUTY and must ensure that the manual valves in the field are properly positioned.
- c. For each thickener, there are operator adjustable TIMER ON, TIMER OFF and FLOW setpoints that define blowdown operations. These timers define the total volume of each blowdown and the cycle time between blowdowns.
- d. If a blowdown is in progress it delays the start of a second blowdown.
- e. The operator can select DAY TANK BYPASS MODE, which has no DUTY transfer pump and allows the thickeners to supply the feed pumps directly.
- f. Gravity thickener low fluid level will automatically STOP the DUTY thickened sludge transfer pumps under normal operations or the feed pumps under DAY TANK BYPASS MODE.

B. Hardwired controls:

- 1. Pilot devices:
 - a. Field:
 - 1) None.
 - b. LCP:
 - 1) LOCAL-OFF-REMOTE (LOR) selector switch.
 - 2) START pushbutton.
 - 3) STOP pushbutton.
 - 4) SPEED dial (potentiometer).
 - c. Drive/starter enclosure:
 - 1) VFD HIM only.
 - d. VCP:
 - 1) None.
- 2. Interlocks:
 - a. Drive/starter enclosure:
 - 1) Seal Water Low Flow.
 - a) Timer activated.
 - 2) Pump discharge High Pressure.
 - a) Timer activated.
 - 3) Pump Motor Winding High Temperatures (one per phase).
 - 4) Pump Stator High Temperature.
 - b. VCP:
 - 1) None.
- 3. Indicators and alarms:
 - a. Field:
 - 1) Thickened Sludge Transfer Pump 1 L-O-R selector switch position.
 - 2) Thickened Sludge Transfer Pump 2 L-O-R selector switch position.
 - 3) High discharge pressure indicator for each pump.
 - 4) Combined discharge flow indicating transmitter for both pumps.
 - b. LCP:
 - 1) Speed Potentiometer.

- c. Drive/starter enclosure:
 - 1) Running indicator.
 - 2) VFD Failed indicator.
 - d. VCP:
 - 1) None.
- C. VCP control: None.
- D. LOI control:
 - 1. See PCS Control below.
- E. PCS controls:
 - 1. PCS interlocks
 - a. The duty Thickened Sludge Transfer Pump shall only operate when a thickened sludge control valve is open and its associated thickener is not at a LOW LOW level.
 - b. The duty Thickened Sludge Transfer Pump shall shutdown if fluid level in Sludge Day Tank cells reaches HIGH HIGH setpoint.
 - 2. Auto (Remote) mode:
 - a. The operator selects the DUTY pump from either Thickened Sludge Transfer Pump 1 or 2.
 - 1) There will be no automatic switchover if the DUTY fails.
 - 2) If Pump 2 is selected as DUTY it cannot be assigned to a centrifuge for Thickened Sludge Feed Pump service.
 - 3) If DAY TANK BYPASS MODE is selected, there is no DUTY transfer pump and sludge removal from the thickeners will be performed by the Thickened Sludge Transfer Pump as detailed in Section 3.04.
 - b. The operator enters a TIMER ON, TIMER OFF and FLOW setpoints for each thickener.
 - c. For each thickener, upon expiration of the TIMER OFF, the PCS will open that thickeners thickened sludge control valve, start the TIMER ON, turn on the grinder and adjust the speed of the DUTY pump to maintain the FLOW setpoint as measured by FIT-930. It shall operate until the TIMER ON expires, at which point it will turn off the DUTY pump, turn off the grinder, and close the control valve.
 - d. If one thickeners TIMER OFF expires while another blowdown operation is in progress, the new thickener blowdown will be placed on hold. Upon expiration of the ON TIMER, blowdown operations will transfer to the new thickener in bumpless transition that opens the new thickener control valve before closing the old thickener control valve.
 - 3. Indicators and alarms:
 - a. Refer to Drawings and Section 40_61_15 - Control Strategies for indicators and alarms.
 - b. Additional indicators and alarms:
 - 1) None.

3.03 THICKENED SLUDGE DAY TANK CELLS

A. General:

1. References:
 - a. P&ID: 65N03.
 - b. Control Schematic: 06N03.
 - c. Section 46_41_34.01 – Vertical Shaft Flocculator Units
2. Key equipment:
 - a. Sludge Day Tank Mixer 1, MIX-981.
 - b. Sludge Day Tank Mixer 2, MIX-982.
 - c. VALVE, 67-VAL-940A \ 67-FV-940A.
 - d. VALVE, 67-VAL -940B \ 65-FV-940B.
3. Abstract:
 - a. The Sludge Day Tank stores thickened sludge from the thickeners in one or both cells. The configuration provides the following flexibility:
 - 1) Normal, single-cell operations: one cell both receives thickened sludge from the thickeners and supplies thickened sludge to the feed pumps so the other cell can be taken completely offline for cleaning.
 - 2) Normal, parallel operations: both cells operate in parallel, receiving sludge and supplying the feed pumps. In this mode, the tanks float off of each other via connected outlet piping.
 - 3) Normal, batch operations: one cell operates in fill mode receiving thickened sludge from the thickeners, while the other cell operates in drain mode supplying the feed pumps.
 - 4) DAY TANK BYPASS OPERATIONS: the Day Tank can be bypassed completely while the thickeners supply the feed pumps (refer to Section 3.04.
 - b. There is no automatic switchover between modes. The operator accomplishes this by positioning both manual and actuated valves and PCS selections.
 - c. The cell inlet valves are buried manual valves with no indication and their position does not impact PCS programming. The cell outlet valves are electrically actuated for operator convenience and to provide position status that the PCS uses in conjunction with the level indicator.

B. Hardwired controls:

1. Control Valves:
 - a. Pilot devices:
 - 1) Field:
 - a) LOCAL-OFF-REMOTE (LOR) selector switch.
 - b) OPEN-STOP-CLOSE (OSC) selector switch.
 - c) OPEN-CLOSE (O/C) position indicator.
 - 2) LCP:
 - a) None.
 - 3) Drive/starter enclosure:
 - a) None.

2. Mixers:
 - a. Pilot devices:
 - 1) Field:
 - a) None.
 - 2) LCP:
 - a) LOCAL-OFF-REMOTE (LOR) selector switch.
 - b) START pushbutton.
 - c) STOP pushbutton.
 - 3) Drive/starter enclosure:
 - a) None.
 - 4) VCP:
 - a) None.
3. Interlocks:
 - a. Control valves:
 - 1) None.
 - b. Mixer Drive/starter enclosure:
 - 1) Mixer Motor Temperature High Switch.
 - c. VCP:
 - 1) None.
4. Indicators and alarms:
 - a. Field:
 - 1) Control Valves:
 - a) Valve actuator Integrated Fail indicator.
 - 2) Mixers:
 - a) None
5. LCP:
 - a. Control valves:
 - 1) None.
 - b. Mixer Drive/starter enclosure:
 - 1) Running Indicator.
 - 2) Failed Indicator.
 - c. VCP:
 - 1) None.

C. VCP control: None.

D. LOI control:

1. See PCS Controls below.

E. PCS controls:

1. PCS interlocks
 - a. If the outlet valve of a cell is open, a LOW LOW level indicator from that cell will shutdown a feed pump.
 - b. The mixer will STOP at LOW LOW fluid level in each cell.
2. Auto (Remote) mode:
 - a. Mixers:
 - 1) The mixer in each Sludge Day Tank Cell automatically turns on when the level inside that cell is above the level LOW LOW setpoint. The mixer automatically shuts off when the level in that cell is below the LOW LOW level.

- b. Outlet valves
 - 1) There are no automatic control of these valves.
- 3. Indicators and alarms:
 - a. Refer to Drawings and Section 40_61_15 - Control Strategies for indicators and alarms.
 - b. Alarm If both Day Tank cells are open and there is a discrepancy between the two levels that exceeds an operator settable value.
 - c. Alarm if DAY TANK BYPASS MODE is selected and one of the Day Tank cell outlet valves are open.
 - d. Additional indicators and alarms:
 - 1) Daily Sludge Volume ADDED.
 - 2) Daily Sludge Volume REMOVED.

3.04 THICKENED SLUDGE FEED PUMPS

- A. General:
 - 1. References:
 - a. P&ID: 65N04
 - b. Control Schematic: 06N02.
 - 2. Key equipment:
 - a. Thickened Sludge Feed Pump 1, 65-PMP-941.
 - b. Thickened Sludge Feed Pump 2, 65-PMP-942.
 - c. Thickened Sludge Transfer Pump 2, 65-PMP-932.
 - d. Thickened Sludge Feed Flow Meter 1, 65-FE/FIT-921.
 - e. Thickened Sludge Feed Flow Meter 2, 65-FE/FIT-922.
 - f. Thickened Sludge Flow Meter, 65-FE/FIT-934.
 - 3. Abstract:
 - a. One Thickened Sludge Feed Pump supplies thickened sludge to one existing centrifuge located inside the existing dewatering building. Up to two DUTY centrifuges can operate simultaneously, requiring two DUTY feed pumps. The third centrifuge is a backup.
 - 1) The operator assigns a feed pump to each operating centrifuge and that feed pump is automatically controlled by the existing centrifuge PLC located inside the existing Dewatering Building.
 - 2) Any feed pump can supply any of the three existing centrifuges by properly positioning manual valves both inside the new Sludge Pump Station and inside the existing Dewatering Building on a new pipe header where the demolished sludge feed pumps were located. The operator must properly position all the manual valves to be consistent with the feed pump assignment.
 - 3) Thickened Sludge Feed Pumps 1 and 2 are the primary feed pumps and Thickened Sludge Transfer Pump 2 is a swing pump that can also be assigned to feed any one of the three centrifuges.
 - 4) Each feed pump, including Thickened Sludge Transfer Pump 2 when used as a feed pump, has a dedicated flow meter that can be used to control the pump.
 - b. For normal operations, the Day tank supplies the feed pumps. In DAY TANK BYPASS MODE, the thickeners supply the feed pumps through the inline grinder or its bypass.
 - c. The existing PLC located inside the Dewatering Building is currently programmed to control the three centrifuges together with the flow (speed)

of their dedicated feed pump and polymer feed. As part of this project, the Contractor will reprogram the existing PLC to operate a maximum of 2 units and to control each unit along with its assigned Thickened Sludge Feed Pump in the new Sludge Pump Station.

B. Hardwired controls:

1. Pilot devices:
 - a. Field:
 - 1) None.
 - b. LCP:
 - 1) LOCAL-OFF-REMOTE (LOR) selector switch.
 - 2) START pushbutton.
 - 3) STOP pushbutton.
 - 4) SPEED dial (potentiometer).
 - c. Drive/starter enclosure:
 - 1) VFD HIM only.
 - d. VCP:
 - 1) None.
2. Interlocks:
 - a. Drive/starter enclosure:
 - 1) Seal Water Low Flow.
 - a) Timer activated.
 - 2) Pump discharge High Pressure.
 - a) Timer activated.
 - 3) Pump Motor High Temperature.
 - 4) Stator HIGH temperature.
 - b. VCP:
 - 1) None.
3. Indicators and alarms:
 - a. Field:
 - 1) Thickened Sludge Feed Pump 1 L-O-R selector switch position.
 - 2) Thickened Sludge Feed Pump 2 L-O-R selector switch position.
 - 3) Thickened Sludge Feed Pump 1 Speed Potentiometer.
 - 4) Thickened Sludge Feed Pump 1 Speed Potentiometer.
 - 5) High discharge pressure indicator for each pump.
 - 6) Combined discharge flow indicating transmitter for each pump.
 - b. LCP:
 - 1) None.
 - c. Drive/starter enclosure:
 - 1) Running indicator
 - 2) VFD Failed indicator
 - d. VCP:
 - 1) None.

C. VCP control: None.

D. LOI control:

1. See PCS Control below.

- E. PCS controls:
1. PCS interlocks
 - a. If the outlet valve of a Day Tank cell is open, a LOW LOW level indicator from that cell will shutdown the feed pumps.
 - b. If in DAY TANK BYPASS MODE, a LOW LOW level indicator in a thickener with its control valve open will shutdown the feed pumps
 2. Auto (Remote) mode:
 - a. The operator assigns a Thickened Sludge Feed Pump or the Thickened Sludge Transfer Pump 2 to each operating centrifuge, up to two maximum.
 - b. The assigned feed pump is commanded to START by PLC-910 when PLC-910 receives the signal from the centrifuge PLC that it is ready for sludge. The assigned feed pump will be commanded to STOP by PLC-910 when the "Ready for Sludge" signal is removed.
 - c. PLC-910 will control the speed or flow of the assigned feed pump using the pump VFD. PLC-910 will get the commanded speed or flow from the centrifuge PLC via Ethernet communications. Each feed has a dedicated magnetic flow meter on its discharge that can be used as the process variable in a flow indicating control loop (FIC) the centrifuge programming requires it. PLC-910 will report back to the centrifuge PLC the instantaneous flow measured by the pump's FIT.
 3. Indicators and alarms:
 - a. Refer to Drawings and Section 40_61_15 - Control Strategies for indicators and alarms.
 - b. Additional indicators and alarms:
 - 1) Totalized daily Thickened Sludge pumped to centrifuges
 - 2) Thickened Sludge Feed Pump 1, Instantaneous/Daily Total Flow to centrifuges.
 - 3) Thickened Sludge Feed Pump 2, Instantaneous/Daily Total Flow to centrifuges.
 - 4) Thickened Sludge Transfer Pump 2, Instantaneous/Daily Total Flow to Centrifuges (when used as a Sludge Feed Pump).

3.05 OVERALL SCADA SCREEN OVERVIEW THAT SHOWS SETPOINTS, PUMP ASSIGNMENTS, ACTUATED VALVE POSITIONS AND MANUAL VALVE POSITIONS

- A. The PCS Programming shall include an overview SCADA screen that schematically shows all of the piping, equipment, actuated valves and manual valves from the thickeners to the centrifuges.
- B. The purpose of this screen is to assist the operator with plant operations and communication between shifts. It will rely on the operator input status of manual valves to be accurate.
- C. The screen shall include at a minimum:
1. Operator equipment assignments
 2. Operator mode selections.
 3. Equipment operating status and levels
 4. Valve position indication for actuated valves
 5. Operator input and display indicating positions of manual valves
 6. Directional arrows that show flow path.

3.06 SLUDGE PUMP STATION SUMP PUMP

- A. General:
 - 1. References:
 - a. P&ID: 65N05.
 - 2. Key equipment:
 - a. Sump Pump 1, PMP-981
 - b. Sump Pump 2, PMP-982.
 - c. Duplex Sump Pump Vendor Control Panel, VCP-980.
 - 3. Abstract:
 - a. The sump pump will pump out standing liquids from the sludge pump station to the recycled decant pump station.
- B. Hardwired controls:
 - 1. Pilot devices:
 - a. Field:
 - 1) None.
 - b. LCP:
 - 1) None.
 - c. Drive/starter enclosure:
 - 1) None.
 - d. VCP:
 - 1) See Vendor documentation.
 - 2. Interlocks:
 - a. Drive/starter enclosure:
 - 1) None.
 - b. VCP:
 - 1) See vendor documentation.
 - 3. Indicators and alarms:
 - a. Field:
 - 1) None.
 - b. LCP:
 - 1) None.
 - c. Drive/starter enclosure:
 - 1) None.
 - d. VCP:
 - 1) See vendor documentation
 - 2) At a minimum the VCP shall have:
 - a) RUNNING status.
 - b) FAULT Alarm.
 - c) LAH-980 Level Alarm High.
- C. VCP control:
 - 1. Manual mode:
 - a. See vendor documentation:
 - 1) Place control panel in manual (local) mode and operate the pumps using the vendor control panel user interface. The VCP will relay to PLC-910 the status of each pump, the VCP Auto mode status and the sump level high status based on switch position.

2. Auto mode:
 - a. See vendor documentation:
 - 1) When in Auto, the VCP will control the sump pump. The VCP will relay to PLC-910 the status of each pump, the VCP Auto mode status and the sump level high status based on switch position.
- D. LOI control:
 1. See PCS controls.
- E. PCS controls:
 1. Manual mode:
 - a. None.
 2. Auto mode:
 - a. None.
 3. Indicators and alarms:
 - a. Refer to Drawings and Section 40_61_15 - Control Strategies for indicators and alarms.
 - b. Additional indicators and alarms:
 - 1) None.

3.07 EXISTING GRAVITY THICKENERS

- A. General:
 1. References:
 - a. P&ID: 65N06.
 - b. P&ID: 65N07.
 2. Key equipment:
 - a. Gravity Thickener, THU-921
 - b. Gravity Thickener, THU-922
 3. Abstract:
 - a. The existing gravity thickeners, THU-921 and THU-922 are having their IO rerouted to the new PLC, PLC-910 in PCM-910. The logic currently used for both THU-921 and THU-922 should be copied and pasted into the new PLC-910 logic or rewritten in the PLC-910 logic. Each sludge thickener should operate just like it did before the relocation of IO.
- B. Hardwired controls:
 1. None.
- C. VCP controls:
 1. None.
- D. LOI controls:
 1. None.
- E. PCS controls:
 1. Same has before prior to the relocation of IO.

3.08 CENTRATE PUMP STATION

- A. General:
 - 1. References:
 - a. P&ID: 65N08.
 - 2. Key equipment:
 - a. Centrate Pump 1, CNPA-971
 - b. Centrate Pump 2, CNPA-972
 - 3. Abstract:
 - a. The centrate pumps, CNPA-971 and CNPA-972 are having their IO rerouted to the new PLC, PLC-910 in PCM-910. The logic currently used for both CNPA-971 and CNPA-972 should be copied and pasted into the new PLC-910 logic or rewritten in the PLC-910 logic. Each centrate pump should operate just like it did before the relocation of IO.
- B. Hardwired controls:
 - 1. None.
- C. VCP controls:
 - 1. Centrate pumps will need to be remapped from PLC-910.
- D. LOI controls:
 - 1. None.
- E. PCS controls:
 - 1. Same as before, prior to the relocation of IO.

3.09 RECYCLE DECANT PUMP STATION

- A. General:
 - 1. References:
 - a. P&ID: 65N09.
 - 2. Key equipment:
 - a. Recycle Decant Water Pump 1, RDP-991.
 - b. Recycle Decant Water Pump 2, RDP-992.
 - 3. Abstract:
 - a. The recycle decant water pumps, RDP-991 and RDP-992 are having their IO rerouted to the new PLC, PLC-910 in PCM-910. The logic currently used for both RDP-991 and RDP-992 should be copied and pasted into the new PLC-910 logic or rewritten in the PLC-910 logic. Each recycle decant water pump should operate just like it did before the relocation of IO.
- B. Hardwired controls:
 - 1. None.
- C. VCP controls:
 - 1. None.

- D. LOI controls:
 - 1. None.
- E. PCS controls:
 - 1. Same has before, prior to the relocation of IO.

3.10 UNDER DRAIN PUMP STATION

- A. General:
 - 1. References:
 - a. P&ID: 65N10.
 - 2. Key equipment:
 - a. Under Drain Pump 1, PMPA-1311.
 - b. Under Drain Pump 2, PMPB-1311.
 - 3. Abstract:
 - a. The Under Drain pumps, PMPA-1311 and PMPB-1311 are having their IO rerouted to the new PLC, PLC-910 in PCM-910. The logic currently used for both PMPA-1311 and PMPB-1311 should be copied and pasted into the new PLC-910 logic or rewritten in the PLC-910 logic. Each recycle decant water pump should operate just like it did before the relocation of IO.
- B. Hardwired controls:
 - 1. None.
- C. VCP controls:
 - 1. None.
- D. LOI controls:
 - 1. None.
- E. PCS controls:
 - 1. Same has before, prior to the relocation of IO.

3.11 TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 40_64_01

CONTROL SYSTEMS: PROGRAMMABLE LOGIC CONTROLLERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Programmable logic controller (PLC) based control systems hardware.
 - 2. Development software to be used with the specified PLC hardware.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Abbreviations:
 - 1. CPU: Central processing unit.
 - 2. I/O: Input/Output.
- C. Standards:
 - 1. Institute of Electrical and Electronics Engineers (IEEE).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Application software: Software that is programmed specifically for the Project.
 - 2. Development operating software: Software provided by the PLC manufacturer for use in programming the PLC.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. CPU:
 - a. Processor type.
 - b. Processor speed.
 - c. Memory.
 - d. Internal processor battery backup time.
 - 2. I/O modules:
 - a. Type.
 - b. Standard wiring diagram.
 - 3. Programming languages.
 - 4. Operating system requirements.

- C. Calculations:
 - 1. Calculations or documented estimate to verify that memory requirements of this Section are met, including spare requirements. If possible, use the PLC manufacturer's calculation or estimating worksheet.
 - 2. Calculations to verify that spare I/O requirements of this Section are met.
 - 3. Calculations to verify that PLC power supply requirements of this Section are met.
- D. Control logic:
 - 1. Fully annotated copy of programmed PLC logic.
 - 2. Cross-referenced index of PLC registers or points.
- E. Provide application software for the specific Project process requirements:
 - 1. Fully annotated copy of programmed PLC logic in its native format.
 - 2. Cross-referenced index of PLC registers or points.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide PLC hardware manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.10 MAINTENANCE

- A. Furnish the following:
 - 1. CPU: 1 spare for each type of CPU in the system.
 - 2. I/O cards: 1 spare for each type of I/O card in the system.
 - 3. Power supplies: 1 spare for each type of power supply in the system.
 - 4. Network/communications cards: 1 spare for each type of network or communications card in the system.
 - 5. Remote adapter: 1 spare for each type of remote adapter in the system.

- B. Installed spare requirements:
1. I/O points:
 - a. Provide total of 25 percent spare I/O capacity for each type of I/O at every PLC/RIO rack using the following calculation:
$$\left(1 - \frac{\text{UTILIZED IO POINT COUNT}}{\text{TOTAL IO POINT COUNT}}\right) * 100 = \% \text{SPARE}$$
 - b. Wire spare I/O points to field terminal blocks in the same enclosure the PLC/RIO resides in.
 2. PLC backplane capacity:
 - a. Provide 25 percent or 3 spare backplane slots, whichever is greater, in racks containing I/O.
 3. PLC memory:
 - a. Provide 50-percent spare program volatile memory.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide PLC hardware as indicated on the Drawings and as specified in this Section.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide PLC system components by a single manufacturer:
1. Third-party communication modules may be used only for communication or network media functions not provided by the PLC manufacturer.
- B. Use PLC manufacturer approved hardware, such as cable, mounting hardware, connectors, enclosures, racks, communication cable, splitters, terminators, and taps.
- C. PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects, and produced by manufacturers regularly engaged in the manufacture of these products.
- D. Wherever possible, use the same model of each PLC module type throughout the Project.

2.03 MANUFACTURERS

- A. The following, no equal:
1. Rockwell Automation:
 - a. ControlLogix 5580, 1756-L8 Series.
- B. PLC programming software system shall be manufactured by PLC hardware manufacturer:
1. Rockwell Software:
 - a. Studio 5000.

2.04 MANUFACTURED UNITS

- A. Programmable logic controller:
 - 1. Construction:
 - a. Furnish plug-in modular system.
 - b. Capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
 - 1) Temperature: 0 to 55 degrees Celsius.
 - 2) RFI: 80 to 1,000 MHz.
 - 3) Vibration: 10 to 500 hertz.
 - 4) Humidity: 0 to 95 percent.
 - c. Provide internal power supplies designed to protect against overvoltage and frequency distortion characteristics frequently encountered with the local power utility.
 - d. Design the PLC system to function as a standalone unit that performs all of the control functions described in this Section completely independent from the functions of the HMI system PC-based operator interfaces:
 - 1) Failure of the HMI system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
 - 2. CPU:
 - a. Configure each CPU so that it contains the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
 - b. Capable of interfacing with discrete inputs, analog inputs, discrete outputs, analog outputs, and communication cards to meet the specified requirements.
 - c. Capable of supporting and implementing closed-loop floating-point math and PID control that is directly integrated into the CPU control program.
 - 3. Memory:
 - a. Supply with sufficient memory to implement the specified control functions plus a reserve capacity as specified with the requirements of this Section:
 - 1) Reserve capacity:
 - a) Totally free from any system use.
 - 2) Programmed in a multi-mode configuration with multiple series or parallel contacts, function blocks, counters, timers, and arithmetic functions.
 - 4. Programming:
 - a. Provide a system where processors are programmed by:
 - 1) Portable laptop computer both locally and via the PLC control network.
 - 5. PLC power supply:
 - a. Input: 120 VAC.
 - b. Mounted in the PLC housing or as indicated on the Drawings.
 - c. Sized to power modules mounted in that housing, including an average module load for any empty housing slots, plus 50 percent above that total.
 - 6. PLC input/output, I/O modules:
 - a. General:
 - 1) Compatible with all PLCs being furnished under the Contract and by the same manufacturer as the PLCs.

- 2) Provide I/O modules that:
 - a) Isolate in accordance with IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.
 - b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
 - c) Accept dual-ended inputs.
 - 3) Use of common grounds between I/O points for modules that require individual isolation is not acceptable.
 - 4) Provide modules that are removable without having to disconnect wiring terminals:
 - a) Utilize a swing-arm or plug-in wiring connector.
 - 5) Provide at each PLC the I/O modules for the following:
 - a) Designated future I/O points contained in the I/O lists and/or shown on the P&IDs, control schematics, or described in the control strategies.
 - b) Installed spare capacity in accordance with the requirements of this Section.
 - c) Wire spares provided to the field terminal strip.
 - 6) Condition, filter, and check input signals for instrument limit conditions.
 - 7) Filter, scale, and linearize the raw signal into an engineering-units-based measurement.
 - 8) Alarm measurements for high, low, rate-of-change limits, and alarm trends.
 - 9) Provide external fuses mounted on the field connection terminal block for discrete input, discrete output, and analog input I/O points.
 - 10) When multiple cards of the same I/O type are provided and parallel equipment, instrumentation, or redundant processes exist, distribute I/O among cards to ensure that a single card failure will not render an entire process unavailable.
- b. Discrete input modules:
- 1) Defined as contact closure inputs from devices external to the input module.
 - 2) Provide inputs that are optically isolated from low-energy common-mode transients to 1,500 volts peak from users wiring or other I/O modules.
 - 3) Individually isolated inputs.
 - 4) With LEDs to indicate status of each discrete input.
 - 5) Input voltage: 120 VAC.
 - 6) Provide input module points that are individually fused with blown-fuse indicator lights, mounted external of the module on the output terminal strip:
 - a) Coordinate external fuse size with the protection located on the module so that the external fuse opens first under a fault condition.
- c. Discrete output modules:
- 1) Defined as contact closure outputs for ON/OFF operation of devices external to the output module:
 - a) Triac outputs may be used, with the permission of the Engineer. Care must be used in applying this type of module to ensure that the leakage current through the output device does not falsely signal or indicate an output condition.

- 2) Optically isolated from inductively generated, normal mode and low-energy common-mode transients to 1,500 volts peak.
- 3) LEDs to indicate status of each output point.
- 4) Output voltage: 120 VAC.
- d. Analog input modules: individually isolated:
 - 1) Signal type: Provide 4 to 20 mA for most applications; other levels are acceptable to interface to vendor control panels.
 - 2) Analog-to-digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
 - 3) Analog-to-digital conversion updated with each scan of the processor.
 - 4) Individually isolated each input.
 - 5) Coordinate the size of the external fuse with the protection located on the module, so that the external fuse opens first under a fault condition.
- e. Analog output modules:
 - 1) Signal type: Provide 4 to 20 mA for most applications; other levels are acceptable to interface to vendor control panels.
 - 2) Individual isolated output points each rated for loads of up to 1,000 ohms.
 - 3) HART analog input module:
 - a) Channels per module: 4 minimum.
 - b) Signal type: Each channel individually configurable for current (0 to 20 mA DC or 4 to 20 mA DC) or voltage (0 to 5 VDC, 0 to 10 VDC, or -10 to 10 VDC).
 - c) Each channel can individually have HART enabled or disabled.
 - d) Flash-upgradeable firmware.
 - e) Mounts in slot in PLC backplane.
 - f) Modules shall be configured using the specified PLC programming software.
7. Communications modules:
 - a. Remote I/O adapter module:
 - 1) For any PLC location requiring more than 1 housing to mount all of the I/O modules or that is identified as a RIO, provide the appropriate remote I/O adapter module for communication with the secondary housing(s).
 - 2) Install the RIO adapter module in the PLC backplane and the RIO backplane.
 - 3) Provide adapter modules that support all available types of I/O modules required.
 - 4) Provide network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
 - 5) Complete diagnostic LEDs.
 - b. Network communications modules:
 - 1) General:
 - a) Install communications modules in the PLC backplane.
 - 2) Ethernet:
 - a) Allen-Bradley ControlLogix - 1756-EN2T.
 - 3) Provide network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.

8. PLC backplane housing:
 - a. Mount the PLC power supply, CPU, communications module, and I/O modules in a suitable standard PLC backplane or housing.
 - b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
 - c. Provide a blank slot filler module for each spare slot.
- B. PLC programming software:
 1. Furnish operating software capable of monitoring and/or controlling the PLCs via the PLC data network:
 - a. Contain diagnostics to collect troubleshooting and performance data and display it in easy to understand graphs and tables.
 - b. Monitor devices at each drop on the PLC data network for proper communications.
 - c. Provide the ability to program PLCs on the PLC data network from the Engineer's console.
 2. PLC programming laptop/desktop operating system:
 - a. Microsoft Windows 11.
 3. Suitable for the PLCs specified above.
 4. For programming, monitoring, searching, and editing:
 - a. Usable both online, while connected to the PLC, and offline.
 - b. Operating software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical function blocks.
 - c. Capable of disabling/forcing inputs, outputs, and coils to simulate the elements of the ladder logic; forced elements shall be identifiable by means of color change.
 - d. Include a search capability to locate any address or element and its program location.
 - e. Display at the EC, PLC status information, such as faults and communication errors and amount of memory remaining.
 5. Support IEC-61131-3 compliant programming languages:
 6. Generate a PLC program printout, which is fully documented, through the PLC programming software:
 - a. Fully documented program listings include, as a minimum, appropriate rungs, address, and coils shown with comments to clarify to a reader what that segment of the program accomplishes on an individual line-by-line basis.
 - b. Include a sufficient embedded comment for every rung of the program explaining the control function accomplished in said rung.
 - c. Use a mnemonic associated with each contact, coil, etc., that describes its function.
 - d. Utilize the tag and loop identification as contained in the P&IDs:
 - 1) If additional internal coils, timers, etc., are used for a loop, they shall contain the loop number.
 - e. Provide a cross-reference report of program addresses.
 7. Software functions automatically without operator intervention, except as required to establish file names and similar information:
 - a. Furnish the operating system software that is the standard uncorrupted product of the PLC manufacturer with the following minimum functions:
 - 1) Respond to demands from a program request.

- 2) Dynamic allocation of the resources available in the PLC. These resources include main memory usage, computation time, peripheral usage, and I/O channel usage.
 - 3) Allotment of system resources based on task priority levels such that a logical allocation of resources and suitable response times are ensured.
 - 4) Queuing of requests in order of priority if one or more requested resources are unavailable.
 - 5) Resolution of contending requests for the same resource in accordance with priority.
 - 6) Service requests for execution of 1 program by another.
 - 7) Transfer data between programs as requested.
 - 8) Management of information transfers to and from peripheral devices.
 - 9) Control and recovery from program fault conditions.
 - 10) Diagnose and report real-time hardware device errors.
8. Program execution:
 - a. Application software - program execution scheduled on a priority basis:
 - 1) A multilevel priority interrupt structure is required.
 - 2) Enter into a list of pending programs a program interrupted by a higher priority program:
 - a) Resume its execution once it becomes the currently highest priority program.
 - 3) Schedule periodic programs.
 - 4) Base the allocation of resources to a time-scheduled program on its relative priority and the availability of resources.
 9. Start-up and restart:
 - a. Provide software that initializes and brings a PLC or any microprocessor-based hardware unit from an inactive condition to a state of operational readiness.
 - b. Initialization:
 - 1) Determination of system status before start-up of initializing operating system software and initializing application software.
 - 2) Loading of memory-resident software, initializing timers, counters, and queues, and initialization of dynamic database values.
 10. Shutdown:
 - a. Where possible, provide orderly shutdown capability for shutdowns resulting from equipment failure, including other PLC processor failures, primary power failure, or a manually entered shutdown command.
 - b. Upon loss of primary power, a high-priority hardware interrupt initiates software for an immediate, orderly shutdown.
 - c. Hardware is quickly and automatically commanded to a secure state in response to shutdown command or malfunction.
 - d. Alarm PLC failure at the operator interface level.
 11. Diagnostics:
 - a. Furnish diagnostic programs with the PLC software package to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures.
 - b. Use the manufacturer's standard diagnostic routines as much as possible.
 - c. Furnish diagnostic software and test programs for each significant component in the control system.

- d. As a minimum, provide diagnostic routines to test for power supply, central processing unit, memory, communications, and I/O bus failures.
- 12. Calendar/time program:
 - a. To update the second, minute, hour, day, month, and year and transfer accurate time and date information to system-level and application software.
 - b. Variations in the number of days in each month and in leap years must be handled automatically by the program.
 - c. Operator must be able to set or correct the time and date from any operator interface, only at the highest security level.
- 13. Algorithms:
 - a. Implementation of algorithms for the determinations of control actions and special calculations involving analog and discrete data.
 - b. Algorithms must be capable of outputting positional or incremental control outputs or providing the product of calculations.
 - c. Algorithms must include alarm checks where appropriate.
 - d. Provide, as a minimum, the following types of algorithms:
 - 1) Performs functions such as summing several variables, raising to a power, roots, dividing, multiplying, and subtracting.
 - 2) A switch algorithm, which reads the current and value from its input address and stores it as the value of its output address. 2 types of switches shall be accommodated: 2 outputs with 1 input and 1 output with 2 inputs.
 - 3) A 3-mode proportional-integral-derivative, PID, controller algorithm, with each of the 3 modes independently adjustable, supports both direct and reverse-acting modes.
 - 4) Lead, lag, dead time, and ratio compensators.
 - 5) Integration and totalization of analog process variables.
- 14. Furnish a comprehensive database for the analog inputs, calculated values, control modules, and outputs:
 - a. In addition, provide spare database points for future expansion.
- 15. One integrated database can be utilized for all types of analog points or separate databases for each type; in either case, the database for each point must include all specified aspects.
- 16. All portions of the database must be available for use by the display, report, and other specified software modules.
- 17. Data fields and functions specified below must be part of the point definition database at the operator interface. Provide the capability to define new database points through the point display specified below as well as modifying defined points through these displays. This point definition and modification must include all features and functions defined below. Analog database software must support the following functions and attributes:
 - a. Analog input signal types:
 - 1) Provide software at the remote terminal units (RTUs) and PLCs to read variable voltage/current signals and pulse duration/frequency type analog input signals.
 - b. Input accuracy:
 - 1) Inputs must be read with an accuracy of within 0.05-percent full-scale or better.
 - 2) Data conversion errors must be less than 0.05-percent full-scale.

- 3) Pulse accumulation error less than or equal to 1 count of actual input count at a scan rate of once per minute.
- 4) Maintain for a minimum of 1 year the system accuracy stated above without adjustments.
- c. Blocking:
 - 1) Provide mechanisms to inhibit or block the scanning and/or processing of any analog input through the operator interface.
 - 2) For any input so blocked, the operator may manually enter a value to be used as the input value.
- d. Filtering:
 - 1) For each analog input, provide a first order lag digital filter with an adjustable filter factor.
- e. Linearizing:
 - 1) Where analog inputs require square root extraction or other linearization, provide a mechanism to condition the filtered data before the process of scaling and zero suppression takes place.
- f. Calculated values:
 - 1) Provide means to allow for pseudo-inputs calculated by algebraic and/or Boolean expressions utilizing real inputs, other calculated values, constants, etc.
 - 2) These values must be handled the same as real inputs in terms of record-keeping, alarming, etc.
- g. Scaling and zero suppression:
 - 1) Provide a conversion program to convert input values into engineering units in a floating-point format.
- h. Alarms:
 - 1) Provide an alarm program to check analog variables against high-high, high, low, and low-low alarm limits.
 - 2) When an analog value exceeds a set limit, it must be reported as an alarm based on individually set priority level for each alarm point.
 - 3) Provide an adjustable hysteresis band in order to prevent excessive alarms when a variable is hovering around an alarm limit.
 - 4) Must be possible to inhibit alarms based on external events, e.g., lock-out low pump flow alarm when the pump is off.
- i. Averages:
 - 1) Provide a program to calculate and store hourly, daily, and monthly averages of analog variables.
 - 2) Continuously compute averages, i.e., the average for the current period to the present point in time must be stored in memory and available for use in displays, etc.
 - 3) Update hourly averages each minute or at the polling interval for the selected variable.
 - 4) Update daily averages at least once each hour and calculate using the results of the hourly averages.
 - 5) Update monthly averages at least once each day and calculate using the results of the daily averages.
 - 6) At the end of each averaging period, store the average values for the period on the hard disk for historical record-keeping and reset the present period average register to the present value of the variable.
 - 7) Active database must include the present period average and previous period average for each variable and averaging period.

- j. Totals:
 - 1) Provide a program to calculate and store hourly, daily, and monthly totalization of analog variables.
 - 2) Assign a scaling factor to each variable to convert to the appropriate units based on a 1-minute totalizing interval.
 - 3) Assign a separate factor for each totalizing interval.
 - 4) Variables for which totalization is inappropriate must have scaling factors of zero.
 - 5) At the end of each totalizing period, store the totalized values for the period on the hard disk for historical record-keeping and reset the present period totalization register to zero.
 - 6) Active database must include the present period total and previous period total for each variable and totalizing period.
- k. Engineering units:
 - 1) Provide software to allow the system and the operator to convert the measured analog variables to any desired engineering units.
 - 2) Operator must be able to view displays and generate reports of any measured variable in one or more engineering units, such as flow in gpm, mgd, cfs, and acre-feet per day.
 - 3) Pre-program the conversion of the engineering units, and, if not pre-programmed, the operator must be able to program new engineering unit conversions by using simple methods, e.g., multiplication of the database attributes by a constant.
 - 4) Programming method must be at a level and compatible with the specified training of the operator and the Owner's personnel.
 - 5) New conversions must not require the services of a special programmer and/or special, high-level, programming training.
- l. Control modules:
 - 1) For each control function configured, whether processed at the RTU, PLC, or operator interface, maintain a file of necessary data, including input values, setpoints, constants, intermediate calculated values, output value and limit clamps, etc.
 - 2) Input and output assignments, setpoints, and constants must be adjustable by the operator through the operator interface.
 - 3) Provide control algorithms for manual control with output values adjustable by the operator.
- m. Analog outputs:
 - 1) Analog outputs must be maintained as part of the database.
 - 2) These outputs must be adjustable manually by the operator through the operator interface or through automatic control algorithms.
- 18. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

C. General control functions:

- 1. Analog control functions:
 - a. PID, lead/lag, signal select, alarm, limit, delay, and time base.
 - b. Furnish the control system complete with a library of mathematical/calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR, and NXOR functions.

- c. Math utilities must be linkable to process data points or manual inputs via control block configuration.
 - d. By linking control blocks to data points, the math library must support system unit conversion and calculation requirements.
 - 2. Discrete control functions:
 - a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays, and time base.
 - 3. Control and status discrepancies:
 - a. Generate a discrepancy/fail alarm for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status:
 - 1) For example: System commands to start (call) and the pump fails to start (run status report back) within a predetermined operator-programmable time delay (time disagree), then a discrepancy (fail) alarm shall be generated.
 - b. Involuntary change in the device's status must also generate an alarm:
 - 1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.
 - c. Each command, status, and alarm must cause the color of the symbol to change.
 - d. Because many discrete final control elements have a cycle time in excess of the scan interval, provide each control output with an associated delay period selected to be longer than the operating period of the control element:
 - 1) Delay periods for each final control element must be adjustable at the operator interface.
 - 2) List time delays in the final documentation.
 - 4. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.
- D. Control configuration:
- 1. Provide software to allow control strategies to be developed and their operation initiated through the operator interface.
 - 2. Provide standardized control point displays for defining the control functions, including the function type, input/output addresses, setpoints, tuning constants, etc.
 - 3. Provide a mechanism to link separate control functions together into an integrated control strategy.
 - 4. Provide a mechanism to download operational/control setpoints developed at any operator interface to any PLC or RTU for operational implementation.
 - 5. Provide a mechanism to define and implement operational/control setpoints locally at the PLC or RTU and to upload them to the operator interface for operational record-keeping.
 - 6. Perform control configurations online at the operator interface; the PLC or RTU may be taken offline when being configured or downloaded.
- E. Remote inputs and outputs (RIOs):
- 1. Compatible with all PLCs being furnished under this Contract, shall be by the same manufacturer as the PLCs, and, as a minimum, include:
 - a. Power supply.
 - b. Rack.

- c. Backplane.
- d. Communications module.
- e. I/O modules.
- f. Enclosure.
- 2. Provide cables and software needed for a complete and operational RIO system as specified in the Contract Documents.
- 3. Provide a group of pre-assigned diagnostic registers to report RIO system faults to the driver PLC.
- 4. Control system must continue operation should a fault occur on a single RIO drop:
 - a. Upon clearing the fault, restart communications to that drop automatically.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Utilize personnel to accomplish or supervise the physical installation of all elements, components, accessories, or assemblies:
 - 1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.
- C. All components of the control system, including data network cables, are the installation responsibility of the ICSC unless specifically noted otherwise.
- D. Control system logic program shall reside at the PLC level.
- E. Use the tag and loop identifications found on the P&IDs for all tags used and/or assigned as part of the application software work provided by the ICSC.
- F. Program the PLC logic using the following language(s):
 - 1. Ladder Diagram.

3.03 TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.01 OWNER TRAINING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 40_64_21

CONTROL SYSTEMS: LOCAL OPERATOR INTERFACE (LOI)

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. LOI control systems hardware and software.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. Complete manufacturer's brochures for the following:
 - a. LOI hardware.
 - b. LOI programming software.
 - 2. Manufacturer's operation and installation instructions.
 - 3. Additional requirements:
 - a. Display type and size.
 - b. Operator input.
 - c. Processor type and speed.
 - d. Memory size.
 - e. Programming protocols.
 - f. Communication protocols.
 - g. Power requirements.
 - h. Operating temperature and humidity ranges.
 - i. NEMA ratings.
- C. Shop Drawings:
 - 1. System block diagram showing relationship and connections between devices. Include manufacturer and model.
 - 2. Mounting drawings with dimensions and elevations for each equipment location, including identification of all components, preparation and finish data, and nameplates.
 - a. Electrical connection diagrams.
 - b. Complete grounding requirements.
 - 3. Graphic screens:
 - a. Color printouts of each graphic screen and all control pop-ups.

- 4. Datasheets for each component together with a technical product brochure or bulletin:
 - a. Manufacturer's model number.
 - b. Project equipment tag.
- 5. Complete and detailed bills of materials identified by each cabinet. Include with each bill of material item the following:
 - a. Quantity.
 - b. Description.
 - c. Manufacturer.
 - d. Part numbers.
- D. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.
- E. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
- F. Record documents:
 - 1. Electrical connection diagrams revised to reflect any changes made in the field and submitted as record drawings.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the HMI equipment is compatible with the installed conditions.
- C. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.
- D. System compatibility:
 - 1. Software must be the standard operating software system designed specifically for use with the HMI hardware.
 - 2. Software must be furnished and developed by the manufacturer of the HMI hardware.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria:
 - 1. Provide HMI equipment suitable for the installed Site conditions, including, but not limited to, Site altitude, Site seismic conditions, humidity, and ambient temperatures.

1.07 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Provide system upgrades and maintenance fixes for a period of 2 years from Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide HMI hardware identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS

- A. The following, no equal:
 - 1. Rockwell Automation; Panelview Plus

2.04 MANUFACTURED UNITS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. All components of the control system, including data network cables, are the installation responsibility of the ICSC unless specifically noted otherwise.
- C. Provide panel support bracing if more than 25 percent of the area has been removed to allow for the mounting of the HMI.
- D. All tags used and/or assigned as part of the application programming work are to use the tag and loop identifications found on the P&IDs.

3.03 TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.01 OWNER TRAINING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 40_66_01

CONTROL SYSTEMS: NETWORK MATERIALS AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Materials and equipment used in process control and LAN networks, including:
 - a. Network switches.
 - b. Patch panels and other data network hardware.
 - c. Related accessories.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Standards:
 - 1. Electronic Industries Alliance (EIA):
 - a. 310-E - Cabinets, Racks, Panels, and Associated Equipment.
 - 2. Institute of Electrical and Electronics Engineers (IEEE):
 - a. 802.1X - Standard for Local and Metropolitan Area Networks—Port-Based Network Access Control.
 - b. 802.3 - Standard for Ethernet.
 - c. 802.11b - Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher Speed Physical Layer (PHY) Extension in the 2.4 GHz band.
 - 3. National Electrical Manufacturers Association (NEMA):
 - a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 4. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
 - 5. Telecommunications Industry Association (TIA):
 - a. 569 - Telecommunications Pathways and Spaces.
 - b. 607 - Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.
 - 6. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data:
 - 1. Include information on all network equipment.
 - 2. Manufacturer's operation and installation instructions.
- C. Shop Drawings:
 - 1. Complete set of drawings, including, but not limited to:
 - a. System block diagram showing relationship and connections between devices provided under this Contract, including connections to any existing equipment.
 - b. Include manufacturer and model information, and address settings.
 - c. Network riser diagram.
 - d. Network port diagram, which physically locates all ports within the facility, and identifies their patch panel and switch port.
 - e. Construction drawings for equipment cabinets, including dimensions, identification of components, preparation and finish data, and nameplates.
 - f. Electrical connection diagrams.
 - g. Complete grounding requirements.
 - 2. Furnish data sheets for each component together with a technical product brochure or bulletin:
 - a. Manufacturer's model number.
 - b. Project equipment tag.
 - 3. Complete and detailed bills of materials broken up by each cabinet. Each bill of material item will include the following:
 - a. Quantity.
 - b. Description.
 - c. Manufacturer.
 - d. Part numbers.
- D. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
- E. Calculations:
 - 1. Cooling calculations, including, but not limited to:
 - a. Highest expected ambient temperature for the enclosure's location.
 - b. Internal heat load.
 - c. Exposure to direct sunlight.
 - d. Dimensions of the enclosure in inches.
 - e. Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.
- F. Test reports:
 - 1. As specified in Section 26_05_20 - Fiber Optic Cable and Appurtenances and Section 40_80_01 - Commissioning for Instrumentation and Controls.

2. Signed test results as described in this Section.
 3. Test results shall include:
 - a. Narrative describing the test procedures followed.
 - b. Block diagram of test set up.
 - c. Manufacturer's information on test equipment used.
 - d. Detailed test results.
 - e. A narrative summarizing the results of the testing and identifying any further action required.
- G. Operating manuals:
1. Complete installation, operation, calibration, and testing manuals as specified in Section 01_75_17 - Commissioning.
- H. Record drawings:
1. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.
 2. Electrical connection diagrams shall be revised to reflect any changes made in the field and submitted as record drawings.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Vendor shall manufacture using low VOC-based materials to provide superior indoor air quality demonstrated by Greenguard certification.

2.03 MANUFACTURERS

- A. As listed below in the individual component paragraphs.

2.04 MANUFACTURED UNITS

- A. Ethernet switches:
1. Provided by the Owner.

- B. Routers:
 - 1. Provided by the Owner
- C. SFP transceivers:
 - 1. Provided by the Owner.
- D. Fiber Optic Connectors and Couplers
 - 1. Provide quantity of two (2) Corning 6 Port Duplex SC 62.5MM Panel.
- E. Wall Mount Fiber Enclosure
 - 1. Provide quantity of one (1) Corning 4 Panel Wall Mount Enclosure.

2.05 ACCESSORIES

- A. Provide duplex patch cords to connect the interface cards provided with the associated patch panels.
- B. Provide dust covers or plugs for unused ports.

PART 3 EXECUTION

3.01 PREPARATION

- A. Equipment support and anchoring to structures:
 - 1. As specified in Section 01_81_50 - Design Criteria, including, but not limited to:
 - a. Anchor bolt layout.
 - b. Equipment templates.
 - c. Anchor installation.

3.02 INSTALLATION

- A. Provide installation and configuration for the new and existing managed Ethernet switches. Provide configuration of the Ethernet switch network for a complete, functioning plant control system as indicated on the Drawings and as specified in this Section.
 - 1. Refer to SCADA block diagrams for new network connections.
 - 2. Provide configuration for managed Ethernet switches and other components, including, but not limited to, VLAN (virtual local area network), additional plant PLC communication cards, and separate managed Ethernet switches as required as indicated on the drawings, such that there is isolation of the following networks:
 - a. Remote I/O network: This includes the connections between the plant PLC and:
 - 1) Plant PLC expansion racks.
 - 2) Plant PLC remote I/O (RIO) racks.
 - b. Field network: This includes the connections between the PLC and:
 - 1) Field devices.
 - 2) LOI (Local Operator Interface).
 - 3) Vendor furnished Ethernet network components.

- 4) Valve actuator network: This includes the connections between the PLC and the valve master stations.
 - c. PLC network: This includes the connections between the plant PLCs and the I/O server(s).
 - 3. Process floor managed Ethernet switches for the process control network shall be configured and programmed for rapid fail over protection.
- B. Racks, if indicated on the drawings, shall be level and plumb.
- C. Work shall be performed in a professional and skillful manner.
- D. Cable management:
 - 1. Cables and equipment shall be installed in strict conformance with the manufacturer's recommendations.
 - 2. Install cable using lubricant designed for cable pulling.
 - 3. Install hook-and-loop wrap on all cable bundles within the network rack/enclosure. Plastic tie-wraps are not acceptable.
 - 4. Install network cables without splices.
 - 5. Installed bend radius shall be a minimum of 10 times the cable diameter.
 - 6. Terminate pairs at the jack and patch panel.
 - 7. Route cables through cable management or other form of containment. No loose, unsupported cables are permitted to span across network equipment.
 - 8. Use corner strips to protect cables from edges inside ducts and to maintain bend radius requirements.
- E. Internal rack wiring:
 - 1. Cables shall be installed avoiding sharp bends.
 - 2. Provide enough working space inside rack or cabinets such that closing enclosure doors does not crush or compress cabling.
 - 3. Bundle cables together in groups of no more than 12.
 - 4. Route cables from both sides of the rack to patch panels. Do not bring all bundles from a single side.
 - 5. No cabling shall obstruct equipment ventilation.
 - 6. Individual pairs will be untwisted less than 1/2-inch at termination points.
 - 7. Ground enclosure and equipment in accordance with TIA-607.
 - a. Individually bond network equipment chassis to the rack's grounding busbar. Do not daisy-chain bonding conductors.
 - b. Size the bonding conductor in accordance with the network equipment manufacturer's recommendation or #10 AWG, whichever is larger.
- F. External rack wiring:
 - 1. Do not install fiber cables in non-continuous cable supports such as cable ladders or wire baskets without radius cable supports or solid bottoms.
 - 2. Maintain cable separation in accordance with TIA-569.
 - a. Install cables a minimum of 40 inches away from electrical motors and transformers.
 - b. Install cables a minimum of 12 inches away from fluorescent lighting.
- G. Cables and terminations shall be labeled with cable designations as specified in Section 26_05_53 - Identification for Electrical Systems.

- H. Each data port shall be individually labeled with its patch panel/switch port ID:
 - 1. Labeling must be printed. No handwritten labels will be allowed.
- I. At the completion of the wiring installation, provide the following documentation:
 - 1. A plan-view of the premise(s) showing the jack numbering scheme.
 - 2. A printed certification report for the entire wiring installation showing compliance with TIA specifications for data cable.
 - 3. Reports such as those generated by Fluke DSP cable certification equipment meet this requirement.
- J. Managed Ethernet switches:
 - 1. Configure switches to prevent broadcast storms.
 - 2. Installations shall employ IGMP snooping to limit multicast messaging.

3.03 TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 OWNER TRAINING (NOT USED)

3.05 FIELD QUALITY CONTROL (NOT USED)

3.06 ADJUSTING

- A. Perform firmware installations, configuration, and other set up, as required, to place the network into proper operation.

END OF SECTION

SECTION 40_67_01

CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS

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1.01 SUMMARY

A. Section includes:

1. Design, fabrication and assembly of instrumentation enclosures, control panels and components provided under this Contract, including, but not limited to:
 - a. Custom built instrumentation and control panels, including enclosures for hand stations controllers, low voltage power distribution and marshalling panels.
 - b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs).
 - c. Control components.
 - d. Control panel installation.

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Standards:

1. Institute of Electrical and Electronics Engineers (IEEE):
 - a. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1,000 V and less) AC Power Circuits.
 - b. 802.3af - Standard for Information Technology Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.
 - c. 802.3at - Standard for Information Technology -- Local and Metropolitan area networks -- Specific requirements -- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements.
2. International Electrotechnical Commission (IEC):
 - a. 61643-11 - Low-Voltage Surge Protective Devices - Part 11: Surge Protective Devices Connected to Low-Voltage Power Systems - Requirements and test methods.
 - b. 61643-21 - Low-Voltage Surge Protective Devices - Part 21: Surge Protective Devices Connected to Telecommunications and Signaling Networks - Performance Requirements and Testing Methods.
3. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
4. Underwriters Laboratories Inc. (UL):
 - a. 248-14 - Low-Voltage Fuses - Part 14: Supplemental Fuses.
 - b. 497B - Standard for Protectors for Data Communications and Fire-Alarm Circuits.
 - c. 508 - Standard for Industrial Control Equipment.
 - d. 508A - Standard for Industrial Control Panel.
 - e. 698A - Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations.

- f. 913 - Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations.
- g. 1077 - Standard for Supplementary Protectors for Use in Electrical Equipment.
- h. 1283 - Standard for Electromagnetic Interference Filters.
- i. 1310 - Standard for Class 2 Power Units.
- j. 1449 - Standard for Surge Protective Devices.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. The term “panel” in this Section is interchangeable with the term “enclosure.”

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.05 SUBMITTALS

- A. Provide Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide a control panel hardware Submittal for each control panel/enclosure being provided on this Project, including, but not limited to:
 - 1. Product data:
 - a. Enclosure construction details and NEMA type.
 - b. Manufacturer’s literature and specification datasheets for each type of equipment to be installed within or on the panel or enclosure.
 - 2. Shop Drawings:
 - a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
 - 1) Provide draft for review and approval by the Engineer. Engineer has the authority to substantially alter initial panel layouts.
 - b. Complete nameplate engraving schedule.
 - c. Structural details of fabricated panels.
 - 3. Calculations:
 - a. Cooling calculations, including, but not limited to:
 - 1) Highest expected ambient temperature for the enclosure’s location.
 - 2) Internal heat load.
 - 3) Exposure to direct sunlight.
 - 4) Dimensions of the enclosure in inches.
 - 5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

- C. Delegated Design Submittals:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria:
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
 - c. For wall mounted equipment weighing 125 pounds or more.

1.06 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Assemble panels, enclosures, and rack systems along with internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
 - 1. Provide components and equipment with UL 508 listing.
 - 2. Control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the Contract Documents cannot be reasonably modified to meet the requirements for UL 508A labeling:
 - a. Non-listed, complex, and unique equipment may be evaluated and approved by a third-party testing agency, with prior approval by the Owner. Provide report documenting the testing standard, specification, method of testing, and that the equipment and materials meet appropriate designated standards or have been tested and found suitable for use in a specified manner.
 - 3. Provide fuses for equipment that is not UL or UR listed.
 - 4. Install intrinsically safe circuits and equipment in accordance with UL 698A.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide control panels identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Panel dimensions:
 - 1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer's non-certified information. It is the responsibility of the Contractor or manufacturer to design and size panels:
 - a. Size panels to provide space for equipment, wiring, terminations, and other items in the panel, including 20 percent of the total back panel area shall remain empty.
 - b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
 - c. Maximum panel depth: 32 inches, unless otherwise indicated.
- B. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in Section 01_81_50 - Design Criteria and as indicated on the Drawings.
- C. Non-conditioned spaces and outdoor installations:
 - 1. Provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.
- D. As listed below in the individual component paragraphs.
 - 1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer's specified operating ranges.

2.03 EXISTING PRODUCTS

- A. Provide labor and materials for complete modifications to existing panels as required.

2.04 MATERIALS

- A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
 - 1. Enclosures shall have the following properties:
 - a. NEMA Type 1: Steel.
 - b. NEMA Type 4: Steel with gasketed door, raintight.
 - c. NEMA Type 4X: Type 316 stainless steel (unless Type 304 is indicated on the Drawings).
 - d. NEMA Type 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.

- e. NEMA Type 12: Steel with gasketed door, dusttight.
 - f. NEMA Type 7: Cast aluminum.
- B. Bolting material:
- 1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts, and washers, with unified coarse (UNC) threads.
 - 2. Carriage bolts for attaching end plates.
 - 3. Other bolted joints shall have S.A.E. standard lock washers.

2.05 MANUFACTURED UNITS

- A. Panels/enclosures:
- 1. Manufacturers: One of the following or equal:
 - a. nVent/Hoffman.
 - b. Rittal.
 - c. Saginaw Control & Engineering.
 - 2. Panel assembly:
 - a. General guidelines for panel fabrication include:
 - 1) Continuous welds ground smooth.
 - 2) Exposed surfaces free of burrs and sharp edges.
 - 3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
 - b. Construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	14	14
Up to 57	12	12
57 to 69	12	10
69 to 82	12, except 10 on back	10
82 or more	10	10

- 1) Use heavier sheet metal to meet seismic requirements at the Project Site or when required due to equipment requirements.
- c. For Rittal or engineer-approved equal free-standing modular enclosure, construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	16	14
Up to 57	14	13
57 or more	16	11

- d. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.
- e. Provide stiffeners for back mounting or C folded back panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.
- f. Door construction:
 - 1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
 - 2) Sufficient width to permit door opening without interference with rear projection of flush-mounted instruments.
 - 3) Heavy-gauge stainless steel hinges.
 - 4) For NEMA Type 12, Type 4, and Type 4X, provide oil-resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
 - 5) Gasket installed to seal against roll lip on the enclosure opening.
- g. Latches:
 - 1) For panels, provide each door with an oil tight 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods shall be connected to a common door handle, hold doors securely, and form a compressed seal between door and gasket, at the top, side, and bottom.
 - a) Provide padlock for each enclosure with padlock provisions.
 - b) Provide 2 keys per panel.
 - c) All locks keyed alike.
 - 2) For Rittal or engineer-approved equal free-standing modular enclosure, provide each door with a 4-point latching mechanism, if available, or a 2-point latching mechanism if a 4-point is not available.
 - 3) For cabinets not available with 3-point latching hardware, provide multiple clips and padlock hasps.
- h. Panel cut-outs:
 - 1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
 - 2) Allow a minimum of 3-inch envelope around displays, controllers, and monitors.
 - 3) Reinforce around cut-outs with steel angles or flat bars for the following:
 - a) Large panel cutouts; for example, openings for local operator interfaces.
 - b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.
- 3. In addition to the requirements specified above, the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
 - a. Minimum 16-gauge, Type 304 stainless steel.
 - b. Captive stainless steel cover screws threaded into sealed wells.
 - c. Inside finish: White polyester powder coating.
 - d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
 - e. NEMA Type 4X powder-coated stainless steel enclosures are not an acceptable substitute for stainless steel unless indicated on the Drawings.

4. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
 - a. Enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
 - b. Door hardware: Stainless steel.
 - c. Provide factory installed rain canopy and sun shield for enclosures with operator interface panels.
 - d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.
- B. Arrangement of components:
 1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
 2. Arrange panel instruments and control devices in a logical configuration, associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
 3. Mount internal control components on an internal back panel. Devices may be mounted on the side panel only by special permission from the Engineer.
 4. Control panel mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.
- C. Overcurrent protection:
 1. Main overcurrent device:
 - a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange-mounted disconnect handle operating a molded-case circuit breaker and provide a control power transformer for 120-VAC circuits:
 - 1) Door-mounted disconnect handles are not acceptable.
 - 2) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
 - 3) Provide means to defeat the interlock.
 - 4) Lockable in the off position.
 - b. Control panels supplied with 120 VAC:
 - 1) Provide an internal breaker with the line side terminals covered by a barrier.
 - 2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
 - 3) Provide a nameplate prominently positioned on the control panel stating "CAUTION Risk of Electric Shock - UPS equipment outputs remain energized with main disconnect in off position" for any panel containing a UPS.
 2. Provide circuit breakers as specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
 3. Selection and ratings of protective devices:
 - a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
 - b. Voltage rating: Not less than the voltage of the application.

- c. Select current rating and trip characteristics to be suitable for:
 - 1) Maximum normal operating current.
 - 2) Inrush characteristics.
 - 3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
- d. Circuit breakers, fuses, and motor overcurrent protection devices used for branch circuit protection must be UL 508A compliant.
 - 1) Circuit breakers listed under UL 1077 Standard for Supplementary Protectors that do not comply with UL 508A requirements are not acceptable.
 - 2) Miscellaneous, miniature, and micro fuses listed under UL 248 Part 14 that do not comply with UL 508A requirements are not acceptable.
 - 3) Manual motor controllers provided with an instantaneous-trip overcurrent mechanism listed under UL 508 that do not comply with UL 508A requirements are not acceptable.
- 4. Provide a separate protective device for each powered electrical device:
 - a. An individual circuit breaker for each 120-VAC instrument installed within its respective control panel and clearly identified for function.
 - b. An individual fuse for each PLC discrete output. Provide with individual blown fuse indication external of the I/O card:
 - 1) Size external fuse to open before any I/O-card-mounted fuses.
 - c. Individual discrete inputs shall use a 1/2-amp fuse.
 - 1) Discrete output:
 - a) Size external fuse to open before any I/O-card-mounted fuses.
 - 2) Analog loop powered from the control panel:
 - a) 0.25-amp fuse.
 - 3) Analog loop powered from the control panel:
 - a) 0.25-amp fuse.
 - d. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.
- 5. Fuses for analog and discrete control loops:
 - a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
 - 1) Label shall not cover or interfere with equipment manufacturer's instructions.
 - b. Provide fuses rated for the voltage and available short-circuit current at which they are applied.
 - c. Manufacturers: One of the following or equal:
 - 1) Bussmann.
 - 2) Ferraz Shawmut.
 - 3) Littelfuse.
- 6. Fuse holders:
 - a. Modular type:
 - 1) DIN rail mounting on 35-millimeter rail.
 - 2) Touch-safe design: Connection terminals to be protected against accidental touch.
 - 3) Incorporates blown-fuse indicator.
 - 4) Plug-in style fuse terminals and fuse plugs are not acceptable.
 - b. Provide nameplate identifying each fuse:
 - 1) As specified in Section 26_05_53 - Identification for Electrical Systems.

- c. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, 1492-FB Series B.
 - 2) Phoenix Contact, UT4-HESI Series.
- 7. Control circuit breakers:
 - a. DIN rail mounting on 35-millimeter rail.
 - b. Manual OPEN-CLOSE toggle switch.
 - c. Rated for 250 VAC.
 - d. Interrupting rating: 10 kA or available fault current at the line terminal, whichever is higher.
 - e. Current ratings: As required for the application.
 - f. Provide nameplate identifying each circuit breaker:
 - 1) As specified in Section 26_05_53 - Identification for Electrical Systems.
 - g. Manufacturers: One of the following or equal:
 - 1) ABB.
 - 2) Allen-Bradley.
 - 3) Phoenix Contact, TMC Series.
 - 4) Square D.
- 8. Electronic circuit protectors:
 - a. Used where a NEC Class 2 power circuit is required.
 - b. Confirms to NEC Class 2 according to UL 1310.
 - c. DIN rail mounting on 35-millimeter rail.
 - d. Power source:
 - 1) Operating voltage: 24 VDC.
 - 2) Output current ratings: As required for the application.
 - 3) Maximum output current: 4 A.
 - 4) Maximum nameplate rating: 100 VA.
 - e. LED for status indication.
 - f. Remote status contact.
 - g. When using multi-channel electronic circuit protectors, distribute devices such that a failure is limited to a single network or segment.
 - h. Provide nameplate identifying each circuit electronic circuit protector module:
 - 1) As specified in Section 26_05_53 - Identification for Electrical Systems.
 - i. Manufacturers: One of the following or equal:
 - 1) Single channel:
 - a) Allen-Bradley, 1694 series.
 - b) Phoenix Contact, PTCB E1 series.
 - 2) Multi-channel:
 - a) Phoenix Contact, CBMC series.
 - b) Puls PISA11 series.
- D. Conductors and cables:
 - 1. Power and control wiring:
 - a. Materials: Stranded, soft annealed copper.
 - b. Insulation: 600 VAC type MTW.
 - c. Minimum sizes:
 - 1) Primary power distribution: 12 AWG.
 - 2) Secondary power distribution: 14 AWG.
 - 3) Control: 16 AWG.

- d. Color:
 - 1) AC power (line and load): Black.
 - 2) AC power (neutral): White.
 - 3) AC control: Red.
 - 4) AC control: Orange for foreign voltages.
 - 5) DC power and control (ungrounded): Blue.
 - 6) DC power and control (grounded): White with Blue stripe.
 - 7) Ground: Green.
 - 2. Signal cables:
 - a. Materials: Stranded, soft annealed copper.
 - b. Insulation: 600 VAC, PVC outer jacket.
 - c. Minimum size: 18 AWG paired triad.
 - d. Overall aluminum shield (tape).
 - e. Copper drain wire.
 - f. Color:
 - 1) Two-conductor:
 - a) Positive (+): Black.
 - b) Negative (-): White and red.
 - 2) Three-conductor:
 - a) Positive (+): Black.
 - b) Negative (-): Red.
 - c) Signal: White.
 - g. Insulate the foil shielding and exposed drain wire for each signal cable with heat-shrink tubing.
- E. Conductor identification:
- 1. Identify each conductor and cable with unique wire numbers as specified in Section 26_05_53 - Identification for Electrical Systems.
 - 2. Readily identified without twisting the conductor.
- F. General wiring requirements:
- 1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
 - 2. Install components in accordance with the manufacturer's instructions included in the listing and labeling.
 - 3. Provide a nameplate on the cover of the control panel identifying sources of power supply and foreign voltages within the control panel.
 - 4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
 - 5. Provide power surge protection for control panels.
 - 6. Provide signal surge protection within control panels for each analog I/O, discrete I/O, and data line (Copper Ethernet, Coax, Fieldbus signals) that originates from outdoor devices.
 - 7. Provide non-metallic ducts for routing and organization of conductors and cables:
 - a. Provide wiring separation plan.
 - b. Size ducts for ultimate build-out of the panel, or for 20-percent spare, whichever is greater.

- c. Provide separate ducts for signal and low voltage wiring from power and 120 VAC control wiring:
 - 1) 120 VAC: Grey colored ducts.
 - 2) 24 VDC: White colored ducts.
 - 8. Cables shall be fastened with cable-mounting clamps or with cable ties supported by any of the following methods:
 - a. Screw-on cable tie mounts.
 - b. Hammer-on cable-tie mounting clips.
 - c. Fingers of the nonmetallic duct.
 - 9. Wire ties:
 - a. No wire ties inside wire duct.
 - b. Use Panduit cable tie installation tool, with tension control/cutoff.
 - c. Verify cut ends are cut flush filed smooth after installed.
 - 10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
 - 11. Support panel conductors where necessary to keep them in place.
 - 12. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
 - 13. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
 - a. Factory-applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
 - 14. Control panel shall be the source of power for 120 VAC devices interconnected with the control panel, including, but not limited to:
 - a. Solenoid valves.
 - b. Instruments both mounted in the control panel and remotely connected to the control panel.
- G. Provide power circuits for Contractor- and vendor-furnished PLC cabinets in accordance with the PLC and instrument power wiring diagrams indicated on the Drawings or as specified.
- H. Thermal management:
 - 1. Provide heating, cooling, and dehumidifying devices in order to maintain instrumentation and control devices to within a range as specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation.
 - 2. Air conditioner:
 - a. Provide solid-state cabinet coolers or air conditioning units on outdoor panels containing electronic components such as local operator interfaces, panel instruments, programmable logic controllers, or remote I/O.
 - b. Provide filters on intake and exhaust openings.
 - c. Increase panel sizes as needed to accommodate cooling units.
 - d. Closed-loop design.
 - e. Power supply: 120 VAC.
 - f. Manufacturers: One of the following or equal:
 - 1) ICEcube, Blade series or IECEx/ATEX for Zones 1 and 2.
 - 2) Kooltronic, Guardian DP Series.

3. Heating:
 - a. Provide panels located in areas that are not climate controlled with thermostatically controlled strip heaters, except where all of the following conditions apply:
 - 1) Panel is not supplied with 120 VAC power.
 - 2) There are no electronics or moisture-sensitive devices in the enclosure.
 - 3) Panel is smaller than 38 inches high.
4. Enclosure temperature sensor as indicated on the Drawings:
 - a. Provide wall mounted RTD transmitter (to measure internal cabinet temperature) in enclosures containing electrical components such as PLCs, RTUs, RIO, and VFDs.
 - b. Platinum RTD.
 - c. 4 to 20 mA DC output.
 - d. Sensor and electronic enclosure.
 - e. Accuracy: Within 2 degrees Fahrenheit.
 - f. Manufacturers: One of the following or equal:
 - 1) Omega, EWS Series.
 - 2) TCS Basys Controls, TS Series as indicated on the Drawings.
5. Enclosure temperature switch:
 - a. Provide wall-mounted bimetallic switch transmitter (to measure internal cabinet temperature in enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
 - b. Sensor and electronic enclosure.
 - c. Accuracy: Within 2 degrees Fahrenheit.
 - d. Single contact:
 - 1) Manufacturers: One of the following or equal:
 - a) nVent/Hoffman ATEMNC.
 - b) Pfannenbergl FLZ.
 - c) Rittal.
 - e. Dual contact:
 - 1) Manufacturers: One of the following or equal:
 - a) nVent/Hoffman ADLTEMP.
 - b) Rittal.
6. Status relays and discrete inputs for switches, power supplies, and fieldbus devices (if applicable):
 - a. Provide as indicated on the Drawings or as specified.
7. Fan ventilation:
 - a. Provide nVent/Hoffman or Rittal fan speed control:
 - 1) Provide 2 door/cabinet-mounted vent fans for every 72 inches of cabinet width.
 - 2) Provide finger-guard kit.
 - 3) Filter kit with 2 spare filters for each intake fan.
 - 4) Provide bezel and gasket kit.
 - 5) Automatically adjust fan speed depending on remote temperature sensor input.
 - 6) 120 VAC, 60 hertz.
 - 7) NEMA Type 5-15R cord connections.

- I. Pilot devices:
 - 1. General:
 - a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
 - b. Size:
 - 1) 30.5 millimeters.
 - c. Heavy duty.
 - d. Pushbuttons:
 - 1) Contacts rated:
 - a) NEMA Type A600.
 - 2) Furnish 1 spare normally open contact and normally closed contact with each switch.
 - 3) Equipment shutdown (ESD): Palm or mushroom-head type with self-latching feature. ESD device will remain in the actuated position until deliberately reset.
 - e. Selector switches:
 - 1) Contacts rated:
 - a) NEMA Type A600.
 - b) Knob type.
 - 2) Furnish 1 spare normally open contact and normally closed contact with each switch.
 - 3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
 - f. Pilot lights:
 - 1) Type:
 - a) LED for interior installations.
 - 2) Push to test.
 - 3) Lamp color:
 - a) On/Running/Start: Red.
 - b) Off/Stop: Green.
 - c) Power: White.
 - d) Alarm: Amber.
 - e) Status or normal condition: White.
 - f) Opened: Red.
 - g) Closed: Green.
 - h) Failure: Red.
 - 2. Indoor and outdoor areas:
 - a. NEMA Type 4/13.
 - b. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, Type 800T.
 - 2) General Electric, Type CR104P.
 - 3) IDEC, TWND Series.
 - 4) Schneider Electric, Class 9001, Type K.
 - 3. Corrosive areas:
 - a. NEMA Type 4X.
 - b. Corrosion resistant.
 - c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc.
 - d. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, Type 800H.
 - 2) Cutler Hammer, Type E34.

- 3) IDEC, TWND Series.
 - 4) Schneider Electric, Class 9001, Type SK.
- 4. Hazardous (classified) areas/Class I, Division 2:
 - a. NEMA Type 4X.
 - b. Corrosion resistant.
 - c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc:
 - 1) Contacts contained within a hermetically sealed chamber:
 - a) Pushbuttons.
 - b) Selector switches.
 - c) Push-to-test contacts on pilot lights.
 - 2) UL listed and labeled for Class I, Division 2 areas.
 - d. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, Type 800H.
 - e. Cutler Hammer, Type E34.
- J. Signal isolators and converters:
 - 1. Furnish signal isolators that provide complete isolation of input, output, and power input:
 - a. Minimum isolation level: 1.0 kilovolts AC/50 hertz for at least 1 minute.
 - b. Adjustable span and zero.
 - c. Accuracy: Within 1.0 percent of span.
 - d. Ambient temperature range: -4 degrees to 149 degrees Fahrenheit.
 - 2. Manufacturers: One of the following or equal:
 - a. Acromag, 1500, 600T, 800T, Flat Pack, or ACR Series.
 - b. Action Instruments, Q500 Series or Ultra SlimPak II.
 - c. AGM Electronics, Model TA-4000.
 - d. Moore Industries, MIT 4-Channel.
 - e. Phoenix Contact, Mini Analog Pro.
- K. Relays:
 - 1. General:
 - a. For all types of 120-VAC relays, provide surge protection across the coil of each relay.
 - b. For all types of 24-VDC relays, provide a free-wheeling diode across the coil of each relay.
 - c. For plug in type relays, provide a relay base from the same manufacturer as the relay manufacturer.
 - 2. Control:
 - a. Magnetic style.
 - b. For use as standard control relay for motor and starter relay logic.
 - c. NEMA ratings:
 - 1) 300 volts.
 - 2) 10 amps thermal continuous test current.
 - 3) 60 amps make.
 - 4) 6 amps break.
 - d. Plug-in type.
 - e. LED indication for energization status.
 - f. Coil voltages: As required for the application.
 - g. Minimum poles: DPDT.

- h. Touch-safe design: Connection terminals to be protected against accidental touch.
 - i. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
 - j. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
 - k. Relays with screw-type socket terminals.
 - l. Provide additional relays when the following occurs:
 - 1) Number or type of contacts shown exceeds the contact capacity of the specified relays.
 - 2) Higher contact rating is required in order to interface with starter circuits or other equipment.
 - m. DIN rail mounting on 35-millimeter rail.
 - n. Ice-cube-type relays with retainer clips to secure relay in socket.
 - o. Integrated label holder for device labeling.
 - p. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley: Type 700 HC.
 - 2) IDEC: R* Series (* = H, J, R, S, U).
 - 3) Potter and Brumfield: Type KRP or KUP.
 - 4) Square D: Type K.
3. Isolation:
- a. Electromechanical style.
 - b. For use as an interposing relay for PLC based discrete I/O signals.
 - c. NEMA ratings:
 - 1) Switching voltage: 250 volts AC/DC.
 - 2) Limiting current: 6 amps continuous.
 - 3) Interrupt: 1,500 volt-amperes.
 - d. Plug-in type.
 - e. LED indication for energization status.
 - f. Coil voltages: As required for the application.
 - g. Minimum poles: SPDT.
 - h. Touch-safe design: Connection terminals to be protected against accidental touch.
 - i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
 - j. Relays with screw-type socket terminals.
 - k. DIN rail mounting on 35-millimeter rail.
 - l. Integrated label holder for device labeling.
 - m. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, Type 700 HL TBR Series.
 - 2) Eaton, XR TBR Series.
 - 3) IDEC, RV8H Series.
 - 4) Phoenix Contact, PLC-INTERFACE Series.
4. Latching:
- a. Magnetic-latching control relays.
 - b. NEMA ratings:
 - 1) 300 volts.
 - 2) 5 amps continuous.
 - 3) 360 volt-amperes make.
 - 4) 320 volt-amperes break.
 - c. Plug-in type.
 - d. DIN rail mounting on 35-millimeter rail.

- e. Coil voltage: As required for the application.
 - f. Minimum contacts: DPDT; as required for the application. Plus 1 spare contact.
 - g. Touch-safe design: Connection terminals to be protected against accidental touch.
 - h. Clear cover for visual inspection.
 - i. Provide retainer clip to secure relay in socket.
 - j. Manufacturers: One of the following or equal:
 - 1) IDEC, RR2KP Series.
 - 2) Square D, 8501, Type K.
5. Time delay:
- a. Provide time-delay relays to control contact transition time.
 - b. Contact rating:
 - 1) 240 volts.
 - 2) 10 amps continuous.
 - 3) 3,600 volt-amperes make.
 - 4) 360 volt-amperes break.
 - c. Coil voltage: As required for the application.
 - d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off-delay:
 - 1) For off-delay, use true power-off time-delay relays. Where the required timing range exceeds capability of the off-delay relay use, signal off-delay where power loss will not cause undesirable operation or pneumatic time-delay relays.
 - e. Minimum contacts: DPDT.
 - f. Units include adjustable dial with graduated scale covering the time range in each case.
 - g. Minimum timing range: 0.1 second to 10 minutes, or as required for the application.
 - h. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, Type 700-HR.
 - 2) IDEC, RTE Series.
 - 3) Tyco Electronics, Agastat 7000 Series (pneumatic).

L. Terminal blocks:

- 1. DIN rail mounting on 35-millimeter rail.
- 2. Rated for 15 amps at 600 volts.
- 3. Screw terminal type.
- 4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
- 5. Finger-safe protection for terminals for conductors.
- 6. Construction: Polyamide insulation material capable of withstanding temperature extremes from -40 degrees to 221 degrees Fahrenheit.
- 7. Terminals: Plainly identified to correspond with markings on the diagrams:
 - a. Permanent machine-printed terminal identification.
- 8. Disconnect-type field signal conductor terminals with socket/screw for testing.
- 9. Identify terminals suitable for use with more than 1 conductor.
- 10. Position:
 - a. So that the internal and external wiring does not cross.
 - b. To provide unobstructed access to the terminals and their conductors.

11. Manufacturers: One of the following or equal:
 - a. Allen-Bradley, 1492 Series.
 - b. Phoenix Contact, UT4 Series.
- M. DIN rail grounding:
 1. Grounding terminal blocks used exclusively for bonding each DIN rail section to panel grounding busbar shall:
 - a. Mount to DIN rail via grounding foot with mounting screw.
 - b. Connect to the panel grounding busbar shall be via a green insulated conductor sized in accordance with NEC.
 - c. Not be used for grounding signal cable shields.
 2. Screw terminal type.
 3. DIN rail mounting on 35-millimeter rail.
 4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
 5. Finger-safe protection for terminals for conductors.
 6. Terminals: Plainly identified to correspond with markings on the diagrams:
 - a. Permanent machine-printed terminal identification.
 7. Manufacturers: One of the following or equal:
 - a. Allen-Bradley, 1492-JG Series.
 - b. Phoenix Contact, USKLG Series.
- N. Wire duct:
 1. Provide flame retardant plastic wiring duct, slotted with dust cover.
 2. Type:
 - a. Wide slot.
 - b. Narrow slot.
 - c. Round hole.
 3. Manufacturers: One of the following or equal:
 - a. ABB.
 - b. Iboco.
 - c. Panduit.
 - d. Phoenix Contact.
- O. DIN rail:
 1. Perforated steel.
 2. 35-mm width.
 3. 15-mm deep.
 4. Provide 2-inch offset using one of the following:
 - a. Offset brackets.
 - b. Preformed standoff DIN Rail Channel.
- P. Surge protection devices (SPD):
 1. 120 VAC control panel power SPD:
 - a. Provide SPD for panel 120 VAC power entrances:
 - 1) Non-faulting and non-interrupting design.
 - 2) Provide line to neutral and neutral to ground surge protection.
 - b. Provide surge protection at secondary of main circuit breaker:
 - 1) Surge protection is not required for 120 VAC circuits that are only used for panel lights and receptacles.

- 2) For panels receiving power at 480 VAC, provide surge protection on the 120 VAC control power transformer secondary.
 - c. DIN rail mounting.
 - d. Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:
 - 1) Gastight connections.
 - 2) Visual status indication of MOV status on the input and output circuits.
 - 3) Dry contact rated for remote status indication.
 - e. Approvals:
 - 1) Tested in accordance with IEC 61643-11.
 - 2) Tested in accordance with UL 1283.
 - 3) Tested in accordance with UL 1449.
 - 4) Surge protection minimum requirements: Withstand a minimum 10-kA test current of an 8/20 μ s waveform in accordance with IEEE C62.41.1 Category C Area.
 - f. Manufacturers: One of the following or equal:
 - 1) ASCO, Model 277.
 - 2) Phoenix Contact, Type SFP Filter.
 - 3) Rockwell, 4983-DC series.
 - 4) Sola HD, STFE Elite series.
2. 24 VDC control panel power SPD:
- a. Provide SPD for 24 VDC power circuits.
 - b. Provide surge protection at DC power supply output.
 - c. DIN rail mounting.
 - d. Attach wiring to the SPD by means of a screw-type cable clamping terminal block:
 - 1) Optical status indicator.
 - 2) Dry contact rated for remote status indication.
 - e. Approvals:
 - 1) Tested in accordance with IEC 61643-11.
 - f. Manufacturers: One of the following or equal:
 - 1) Field instruments that require auxiliary power:
 - a) Emerson, Model 265 (SLAC) series.
 - b) Phoenix Contact, Plugtrab PLT--SEC-T3-24-FM-UT.
 - 2) Loop powered field instruments:
 - a) Emerson/Edco, Model SS65-036-2.
3. Panel mounted control, signal, and data line SPD:
- a. General:
 - 1) This section applies to SPD located in a control panel, field panel, network junction box, or marshalling panel.
 - 2) Approvals:
 - a) Tested in accordance with IEC 61643-21.
 - b) Tested in accordance with UL 497B.
 - 3) SPD shall consist of 2 parts:
 - a) Base module:
 - (1) DIN rail mounting.
 - (a) Grounded to DIN rail via mounting rail foot.
 - b) Plug protection module:
 - (1) Replacing a plug shall not require the removal of any wires nor interrupt the signal.

- 4) Provide indirect shield ground style SPD unless otherwise noted.
- 5) Provide ability to locally identify and indicate SPD health.
- 6) SPD shall be provided with controller module with dry contact for remote status monitoring of SPD device health.
- 7) SPD modules shall be compatible with signal, communication bus type, data type, or control power being protected.
- 8) Provide dedicated SPD for each signal, communication bus type, or data line being protected.
- b. Manufacturers: One of the following or equal:
 - 1) Dehn, Blitzductor XTU Series.
 - 2) Phoenix Contact, Plugtrab PT-IQ Series.
- 4. Copper Ethernet SPD:
 - a. Protects network equipment from lightning or other surge events.
 - b. Suitable for Gigabit networks.
 - c. Shielded RJ-45 ports.
 - d. In accordance with PoE standards IEEE 802.3af and 802.3at.
 - e. Nominal discharge surge current: 10 kA.
 - f. Approvals:
 - 1) Tested in accordance with IEC 61643-21.
 - 2) Tested in accordance with UL 497B.
 - g. Manufacturers: One of the following or equal:
 - 1) Citel, MJ8-C6A.
 - 2) Eaton/MTL, ZoneBarrier High Energy Ethernet.
 - 3) Phoenix Contact, DT-LAN-CAT6+.
 - 4) Weidmuller, VDATA CAT6.
- 5. Field device mounted SPD:
 - a. Conduit entry mounting.
 - 1) Provide parallel or through wiring configurations as required by the application.
 - a) Use parallel wiring configuration if there is an available cable gland at the device.
 - b) Use through wiring configuration if there is no available cable gland at the device.
 - 2) Provide screw connections compatible with field device.
 - b. NEMA 4X stainless steel material housing.
 - c. Approvals:
 - 1) Tested in accordance with IEC 61643-21.
 - d. 4-wire field device:
 - 1) Module shall provide simultaneous protection of signal cable, communication bus, or data line, and power supply line.
 - a) Maximum continuous voltage:
 - (1) DC:
 - (a) Signal: 32 VDC.
 - (b) Power supply: 255 VDC.
 - (2) AC:
 - (a) Signal: 22.6 VAC.
 - (b) Power supply: 255 VAC.
 - 2) Manufacturers: The following; Engineer knows of no equal:
 - a) Endress+Hauser, HAW569-CB2C.

- e. 2-wire or 3-wire field device:
 - 1) Module shall provide protection for the signal cable, communication bus or data line.
 - 2) Manufacturers: One of the following or equal:
 - a) Eaton/MTL, TP Series.
 - b) Endress+Hauser, HAW569 Series.
 - c) Phoenix Contact, Surgetrab S-PT Series.

Q. Horns and beacons:

- 1. Beacons/horn combination units:
 - a. Manufacturers: One of the following or equal:
 - 1) Edwards, Multi-Status LED 108i with tone module.
 - 2) Federal Signals, AV1ST Strobe Combination Audible/Visual Signal.
 - b. LED Colors: Red, Green, and Amber.
 - c. Power: 120 VAC.
 - d. Provide accessories such as pipe mount flange, pipe extensions, corner mount brackets, or wall mount brackets as needed.
 - e. Horn rated 80 dB minimum at 10 feet.
- 2. Dedicated beacon unit:
 - a. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, 855 B *-* 10 Series.
 - 2) Edwards, 102 Series.
 - 3) Federal Signal Corp., Starfire Series.
- 3. Dedicated horn unit:
 - a. Electromechanical:
 - 1) Manufacturers: One of the following or equal:
 - a) Edwards, 878EX or 879EX Series.
 - b) Federal Signal, 350 or 31X Series.
 - b. Electronic:
 - 1) Manufacturers: One of the following or equal:
 - a) Allen-Bradley, 855H or 855XH Series.
 - b) Edwards, 5530M or 5533MD Series.
 - c) Federal Signal, 300GCX or 300X Series.
 - c. Rated for 80 dB minimum at 10 feet.

R. Power supplies:

- 1. Configure power supply system so that either the primary or backup supply can be removed, repaired or replaced, and returned to service without disrupting the system operation.
- 2. Convert 120 VAC to 24-volt DC or other DC voltages required or as required for the application.
- 3. Provide redundant backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.
- 4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure in either a 1+1 or N+1 configuration as required:
 - a. Provide automatic switchover upon module failure.
 - b. Alarm contacts monitored by the PLC.
- 5. Provide protective isolation between power supply units either by means of Diodes, Diode Modules, MOSFET Modules, or use power supplies with built in

redundancy. Power supplies with built in redundancy must actively isolate each power supply and be designed as such.

6. Sized to provide 40-percent excess rated capacity.
 7. UL 508 listed to allow full-rated output without de-rating.
 8. Provide fuse or short-circuit protection.
 9. Provide a minimum of 1 set of dry contacts for each power supply configured to change state on failure for monitoring and signaling purposes.
 10. Output regulation: Within 0.05 percent for a 10-percent line change or a 50-percent load change.
 11. Operating temperature range: 32 degrees to 140 degrees Fahrenheit.
 12. Touch-safe design: Connection terminals to be protected against accidental touch.
 13. DIN rail mounting on 35-millimeter rail:
 - a. Mount the power supply in the proper orientation as recommended by the manufacturer to ensure adequate thermal dispersion without derating the power supply.
 14. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
 15. Manufacturers: One of the following or equal:
 - a. Fully redundant:
 - 1) IDEC, PS5R Series:
 - 2) Phoenix Contact, Quint Power Supply with SFB technology.
 - a) Phoenix Contact, Quint.
 - 3) PULS.
 - 4) Sola.
 - b. Redundancy module:
 - 1) Phoenix Contact, O-ring redundancy module.
- S. Intrinsic safety barriers:
1. Transformer isolated barrier:
 - a. Containing a transformer to provide complete:
 - 1) Isolation between the safe and hazardous areas for loop-powered devices.
 - 2) 3-way isolation between the safe area, hazardous area, and power supply powered devices.
 - b. Resistor for current limitation.
 - c. Fuses for short-circuit protection.
 - d. Provide barriers with pluggable connectors that are coded for easy replacement.
 - e. Transmission error shall be less than or equal to 0.1 percent of full-scale.
 - f. DIN rail mounting on 35-millimeter rail.
 - g. Approvals:
 - 1) FM.
 - 2) UL 913.
 2. Types:
 - a. Switch isolators:
 - 1) Designed and approved for use with discrete inputs.
 - 2) Supply power: 20 to 30 VDC.
 - 3) Output to track input.
 - 4) LED in the cover to indicate the status of the input.
 - 5) Selector switch to change the logic of the input.

- 6) Input: Dry contact.
- 7) Output: SPDT relay.
- b. Transmitter and converters for use with 4- to 20-mA signals without Hart® communications capability:
 - 1) Designed and approved for use with 4- to 20-mA analog signals.
 - 2) Designed for powering 2- and/or 3-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
 - 3) Supply voltage: 20 to 30 VDC.
- c. Transmitter and converters for use with 4- to 20-mA signals with Hart® communications capability:
 - 1) Designed and approved for use with 4- to 20-mA analog signals.
 - 2) Designed for powering 2- and/or 3-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
 - 3) Transfer digital signals from the hazardous area to the safe area.
 - 4) Complete bi-directional communication between a smart transmitter located in the field and the suitable equipment located in the safe area.
 - 5) Supply voltage: 20 to 30 VDC.
- 3. Manufacturers: One of the following or equal:
 - a. Pepperl + Fuchs.
 - b. Phoenix Contact, MACX Series.

2.06 ACCESSORIES

- A. Provide panels with an inside protective pocket to hold the panel drawings. Ship panels with 1 copy of accepted Shop Drawings, including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.
- B. Provide floor stands or legs with a minimum height of 12 inches where needed or as indicated on the Drawings.
- C. Provide a folding shelf for enclosures that contain programmable controllers. Shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.
- D. Provide nameplate to each panel as indicated on the Drawings:
 - 1. As specified in Section 26_05_53 - Identification for Electrical Systems on internal and external instruments and devices.
 - 2. With the following markings that is plainly visible after installation:
 - a. Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
 - b. Supply voltage, phase, frequency, and full-load current.
 - c. Power source or circuit ID.
 - d. Short-circuit current rating of the panel based on one of the following:
 - 1) A listed and labeled assembly.
 - 2) Established utilizing an approved method.

- E. Provide a window kit where indicated on the Drawings or where a transmitter with display is mounted inside a control panel. Window shall meet the following requirements:
1. Safety plate glass.
 2. Secured by rubber locking seal.
 3. Allow full viewing of devices issuing visual process data or diagnostics.
- F. Lighting:
1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
 - a. Covered or guarded.
 - b. Provide On-Off door-activated switches where indicated on the Drawings.
 - c. 120-volt, single-phase, 15-amp style plug.
 - d. Provide 4,000 K, 900 lumens LED fixture.
 - 1) Provide additional fixtures for every 36 inches of width.
- G. Receptacles:
1. Provide 1 duplex receptacle located every 6 feet of enclosure width, spaced evenly along the back mounting panels.
 2. GFCI, 120-volt, single-phase, 15-amp style plug.
 3. Provide circuit breaker or fuse to limit receptacle draw to 5 amps.
- H. Grounding:
1. Provide the following:
 - a. Grounding strap between enclosure doors and the enclosure.
 - b. Equipment grounding conductor terminals.
 - c. Provide equipment grounding busbar with lugs for connection of equipment grounding wires.
 - d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding busbar.
 2. Identify equipment grounding conductor terminals with the word "GROUND," the letters "GND", the letter "G", or the color green.
 3. Signal cable shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
 4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
 5. Design so that removing a device does not interrupt the continuity of the equipment-grounding circuit.
 6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
 7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
 8. Unless otherwise noted, connect exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment-grounding circuit.
 9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.
 - a. Control panel ground lugs and ground bar shall be copper mechanical or compression connection type. Aluminum connectors or lugs are not acceptable for use with copper conductors.

- I. Sunshades:
 - 1. Where indicated, provide panel-mounted sunshades for outdoor installations.
 - 2. Provide thermally insulated standoff.
 - 3. Provide deburred cutouts for access to exterior panel accessories.
 - 4. Material of sunshade and mounting hardware shall match enclosure.

2.07 FINISHES

- A. Finishes:
 - 1. Metallic (non-stainless):
 - a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.
 - b. Scratches or blemishes shall be filled before finishing. 1 coat of zinc phosphate shall be applied according to the manufacturer's recommended dry-film thickness and allowed to dry before applying the finish coat.
 - c. Finish coat shall be a baked polyester-urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
 - d. Exterior of enclosures located outdoors shall be UV-resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
 - 2. Stainless steel:
 - a. Stainless enclosures shall be provided with a Number 4 brushed finish, not painted.
- B. Colors:
 - 1. Exterior color of panels mounted indoors shall be manufacturer's standard light gray.
 - 2. Exterior of panels mounted outdoors shall be manufacturer's standard white.
 - 3. Panel interiors shall be manufacturer's standard white.

PART 3 EXECUTION

3.01 PREPARATION

- A. Equipment support and anchoring to structures:
 - 1. As specified in Section 01_81_50 - Design Criteria, including, but not limited to:
 - a. Anchor bolt layout.
 - b. Equipment templates.
 - c. Anchor installation.

3.02 INSTALLATION

- A. Install enclosures so that their surfaces are plumb and level within 1/8 inch over the entire surface of the panel: Anchor securely to wall and structural supports at each corner, minimum. Direct attachment to drywall is not permitted.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details.

- C. Provide floor stand kits for wall-mounted enclosures larger than 48 inches high.
- D. Provide concrete housekeeping pads for freestanding enclosures.
 - 1. Refer to the structural typical details.
- E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
 - 1. Undercoat floor-mounted panels.
- F. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.
- G. Holes for field conduits, etc., shall be cut in the field. No additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miscut holes shall require that the entire enclosure be replaced.
- H. Protect wiring from sharp edges and corners.
- I. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the Conduit Schedule but shall be shown on the loop drawings prepared by the Contractor.
- J. Provide individually fused analog input module points with blown-fuse indicator lights, mounted external of the module on the output terminal strip.
- K. Side panels:
 - 1. Side panels shall be kept free of control equipment and devices. Any deviation must be sent to the Engineer in writing asking for a deviation.
- L. Doors:
 - 1. Provide snake-skin cable management sleeve or spiral wire-wrap on wires where they pass from the interior of the cabinet past the door hinge to door-mounted devices.

3.03 TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 40_67_26

CONTROL SYSTEMS: UNINTERRUPTIBLE POWER SUPPLIES 10 KVA AND BELOW

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Single-phase double conversion uninterruptible power supplies rated 10 kVA and below.

1.02 REFERENCES

- A. As specified in Section 26_05_00 - Common Work Results for Electrical and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Standards:
 - 1. Federal Communications Commission (FCC):
 - a. FCC Part 15:
 - 1) Class A.
 - 2) Class B.
 - b. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
 - 2. National Electrical Manufacturers Association (NEMA):
 - a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
 - 3. Underwriters Laboratories, Inc. (UL):
 - a. UL 1778 - Standard for Uninterruptible Power Supply Systems and Equipment.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Critical load: Load supplied by the UPS.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. Manufacturer and model number.
 - 2. Catalog data.
 - 3. Dimensions:
 - a. Height.
 - b. Width.

- c. Depth.
 - d. Weight.
 - 4. Ratings:
 - a. Input voltage.
 - b. Output voltage.
 - c. Input/output power factor.
 - d. Efficiency.
 - e. Harmonic distortion.
 - f. Runtime.
 - 5. Noise specifications.
 - 6. Heat dissipation.
 - 7. Warranties and maintenance contracts:
 - a. Documentation to demonstrate conformance to Specifications noted in this Section.
 - 8. Communications requirements such as software, cards, etc.
 - 9. Alarms and status available for remote monitoring and system health.
- C. Shop Drawings:
 - 1. Power distribution block diagrams.
 - 2. Front and rear views of equipment enclosures:
 - a. Front elevation, including control and indicating devices.
 - 3. Support points and weight of overall equipment.
 - 4. Schematic and control wiring diagrams, including, but not limited to:
 - a. Line and load terminals.
 - b. Alarm and status terminals.
 - c. Manual maintenance bypass switch terminals.
 - d. External battery or step-down/step-up transformers, if any.
 - e. External wiring requirements for communication signals.
 - 5. Switching and overcurrent protective devices.
- D. Calculations:
 - 1. Include derating for temperature and elevation as necessary.
 - 2. UPS sizing computation:
 - a. Apply safety factors as specified in this Section.
 - b. Provide itemized list of critical loads, including individual VA and watt ratings.
 - 3. Battery time calculation based on specified runtime for total load with the safety factor multiplied to it. Table/graph for back-up time calculation.
 - 4. Load calculation shall include power for all shown in the power distribution drawing, which includes, but is not limited to, PLC power supply, field instruments (120 VAC and 24 VDC), instrument power, Ethernet switches, and I/O modules. Refer to network drawings for additional information and notes.
 - 5. Total battery recharge time as a function of capacity utilized.
- E. Design data:
 - 1. Design mounting and anchorage for seismic design criteria specified in Section 01_81_50 - Design Criteria:
 - a. Provide seismic kits as required to meet design criteria.
- F. Record documents:
 - 1. Provide record drawings of installed unit(s), including layout and wiring.

- G. Manufacturer's field reports.
- H. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. System instruction manuals that describe troubleshooting, installation, operations, and safety procedures.
 - 3. Recommendations for maintenance procedures and intervals.
 - 4. Battery data/replacement information.
 - 5. Parts list.

1.05 QUALITY ASSURANCE

- A. Manufacturer qualifications:
 - 1. A minimum of 10 years' experience in the design, manufacture, and testing of solid-state UPS systems.
 - 2. ISO 9001 certified.
- B. Regulatory requirements for complete UPS system:
 - 1. UL listed in accordance with UL 1778.
 - 2. IEEE C62.41, Category B.
 - 3. FCC 15:
 - a. Greater than 2,000 VA - Class A.
 - b. Less than 2,000 VA - Class B.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. The following no equal:
 - a. APC Smart-UPS-1500VA
 - b. Provide a quantity of two (2) of the same type and size UPS and mount on the bottom of the control panel enclosure.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

1. Batteries:
 - a. UPS shall have capability for connection of external battery modules to extend total available run time. External batteries shall match the UPS in aesthetics and color.
 2. Mounting:
 - a. Secured at the bottom of the cabinet.
 3. Output connections:
 - a. Receptacles:
 - 1) Less than or equal to 3 kVA UPS:
 - a) Provide a minimum of four NEMA Type 5-15R or Type 5-20R receptacles.
 - b) Provide at least one NEMA Type L5-30R receptacle.
- B. Communications:
1. Relay outputs:
 - a. Provide low voltage signals for On Battery, Low Battery, Any Mode Shutdown, and Battery Mode Shutdown.
 - b. Connections on a terminal block on the rear panel.
 2. USB:
 - a. Provide a USB connection that is HID compliant for network connection.

2.04 ACCESSORIES

- A. External maintenance bypass:
1. Manufacturers: One of the following or equal:
 - a. Eaton, HotSwap MBP Series.
 - b. Vertiv, Liebert Micropod Series.
 2. Properties:
 - a. Provides isolation of the UPS for maintenance purposes.
 - b. Provide maintenance bypass from the same manufacturer as the UPS manufacturer.
 - c. UL 1778 listed.
 - d. Provide manufacturer's recommended mounting kit as required by the application.
 - e. Make-before-break design so that UPS can be isolated from the critical loads by placing these loads on source power without interruption of operation.
 - f. Utility and UPS status indications.
 - g. Rated to carry the full input current of the UPS.
 - h. Connections to match UPS connections and as indicated on the Drawings.
 - i. Supply necessary input/output cords and receptacles for connections with power source and UPS.
- B. External batteries:
1. Manufacturers: One of the following or equal:
 - a. APC
 2. Properties:
 - a. To provide extended runtime capabilities.
 - b. Provide batteries from the same manufacturer as the UPS manufacturer.

- c. UL listed.
- d. Housing shall match the appearance of the UPS.
- e. Provide manufacturer's recommended mounting kit as required by the application.
- f. Connections to match UPS connections and as indicated on the Drawings.
- g. Supply necessary cords and cables for connection to UPS.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

- A. Install equipment in accordance with the manufacturer's instructions.
- B. Do not utilize extension cords, adapters, or other electrical connectors for UPS input.

3.03 FIELD QUALITY CONTROL

- A. Perform inspections and test procedures before UPS startup:
 - 1. Inspect equipment for signs of damage.
 - 2. Verify installation as indicated on the Drawings and specified in the Specifications.
 - 3. Inspect cabinets for foreign objects.
 - 4. Verify neutral and ground conductors are properly sized and terminated.
 - 5. Inspect battery cases.
 - 6. Inspect batteries for proper polarity.
 - 7. Check power and control wiring for tightness.
 - 8. Check terminal connectors for tightness.
 - 9. Ensure connection and voltage of the battery string(s).

3.04 SCHEDULES

Tag	Minimum Runtime	Input Voltage/Connection	Safety Factor	Notes
UPS-910	15 minutes	120VAC	1.5	Applies to 1 unit, not both

END OF SECTION

SECTION 40_71_15

FLOW MEASUREMENT: MAGNETIC FLOWMETERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Full-body magnetic flowmeters.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Standards:
 - 1. International Organization for Standardization (ISO):
 - a. 9000 - Quality management systems - Fundamentals and vocabulary.
 - b. 17025 - General requirements for the competence of testing and calibration laboratories.
 - 2. National Institute of Standards and Technology (NIST).
 - 3. NSF International (NSF).

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Include sizing information from the manufacturer that includes:
 - 1. Chart of the measurement error from zero to maximum measured volumetric flow range indicated in datasheets.
 - 2. Indication of input parameters and their values used in the calculations.
- C. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications as specified in Section 01_75_17 - Commissioning.
- D. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - 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 required accessories are provided and are compatible with the process conditions and physical installation.
- C. Manufacture instrument facilities certified to the quality standards of ISO 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation and Servicing.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. 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.

2.03 MANUFACTURERS

- A. One of the following, no equal:
 - 1. Siemens
 - 2. Endress+Hauser:

2.04 MANUFACTURED UNITS

- A. As specified in this Section, including Attachment A - ISA Datasheet - Flow Measurement: Magnetic Flowmeters.

B. Magnetic flowmeter:

1. General:

- a. Magnetic flowmeters obtain the flow velocity by measuring the changes of induced voltage of the conductive fluid passing across a controlled magnetic field.
- b. Complete zero stability shall be an inherent characteristic of the flowmeter system.
- c. Include for each magnetic flow metering system:
 - 1) A metering tube with electrodes (sensor).
 - 2) Fully welded flanges that are rated for the full pressure class of the piping.
 - 3) Signal cable if remote mounted.
 - 4) Transmitter integral or remote as indicated on the Drawings.
 - 5) Flowmeter grounding rings.

2. Performance requirements:

- a. Accuracy:
 - 1) 0.25 percent of flow rate from 10 to 100 percent of full-scale for velocities ranging between 1.9 to 10 feet per second.
- b. Repeatability:
 - 1) 0.25 percent of rate.

3. Element:

a. Metering tube:

- 1) Constructed of Type 304 or 316 stainless steel (unless specifically noted otherwise in the instrument datasheet) with flanged connections to match with piping material.
 - a) Carbon steel cannot be used when coils are on the outside of the metering tube, it will not pass the magnetic field.
 - b) Coils that are embedded in the liner are not permitted.
- 2) Liner material in conformance with:
 - a) Manufacturer's recommendations for the intended service.
- 3) Electrodes type and material in conformance with:
 - a) Manufacturer's recommendations for the intended service.
 - b) Utilize a minimum of 2 self-cleaning electrodes.
- 4) As indicated in the datasheets.
- 5) Meter terminal housing NEMA Type 4X, unless installed in locations such as vaults that will experience submergence. In those applications NEMA 6P is required.
- 6) Meter coating consisting of epoxy painted finish.
- 7) Components:
 - a) 2 grounding rings:
 - (1) Which are in conformance with the manufacturer's bore and material recommendation for the meter's intended service.

4. Transmitter:

- a. Power supply:
 - 1) As indicated in the datasheets.
- b. Outputs:
 - 1) As indicated in the instrument datasheet.
- c. Microprocessor-based signal converter/transmitter.
- d. Utilize DC pulse technique to drive flux-producing coils.
- e. Contain a 6-digit display for flow rate, percent of span, and totalizer.
- f. Operator keypad interface.

- g. Integral zero return to provide consistent zero output signals in response to an external dry contact closure.
- h. Integral low flow cut-off zero return.
- i. Programmable parameters, including:
 - 1) Meter size.
 - 2) Full-scale flow rate.
 - 3) Magnetic field frequency.
 - 4) Time constant.
- j. Data retention for a minimum of 5 years without auxiliary main or battery power.
- k. Self-diagnostics and automatic data checking.
- l. Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
- m. Ambient operating temperature limits of -5 to 140 degrees Fahrenheit (-20 to 60 degrees Celsius).
- n. Enclosure:
 - 1) As indicated in the instrument datasheet.
- o. Ethernet/IP capable.

2.05 ACCESSORIES

- A. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.
- B. Provide sunshades for transmitters located outdoors.
- C. Provide galvanic isolation gaskets, nylon/Teflon™ flange bolt insulation bushings, and nylon washers on meters installed on pipes with cathodic protection.
- D. Electronic tester for calibration verification and diagnostics.
 - 1. Transmitter shall have continuous internal meter verification method comparing current meter system values to base line value.
 - 2. Should variance in readings be determined exceeding a preset limit the transmitter will provide an alarm condition via a configurable discrete output.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

- A. Factory calibrate each flow metering system at a facility that is traceable to the NIST.
 - 1. ISO 17025 accredited test facility with certified accuracy traceable to NIST.
 - 2. Suggestion, the calibration facility be traceable to international standards and ILAC, International Laboratory Accreditation Committee MRA, Mutual Recognition Agreement.
 - 3. This ensures worldwide accreditation of calibration laboratories.
- B. Evidence of accreditation shall originate from a national verification agency such as A2LA ILAC.
- C. FM approval certification or equal when installed in classified areas.

- D. A real-time computer-generated printout of the actual calibration date indication actual velocities and as read values of the flow tube.
 - 1. Flow calibration report of the manufacturers flow lab calibration procedure shall be shipped with the meter system.
 - 2. Minimum calibration shall be a 3 point calibration, including 1, 3, and 10 feet per second velocities for every meter and transmitter system. 2 points at 15 to 20 percent and 80 to 100 percent are statistically proven to be sufficient calibration points.
 - 3. Manufacturer shall archive calibration reports for future reference.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. For instruments located outdoors or where instrument elements and transmitters are separated by conduit located outside the building envelope, provide surge protection devices at the transmitters.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.
- B. Calibration verification:
 - 1. Verify factory calibration of instruments in accordance with the manufacturer's instructions.
 - a. Verify flow meter performance to the original manufacturer specifications.
 - 2. Verification shall be traceable to factory calibration using a third party, attested onboard system pursuant to ISO standards.
 - 3. Verification report in accordance with common quality systems such as ISO 9000 to prove the reliability of the meter-specified accuracy.
 - 4. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.
 - 1. Number of sessions:
 - a. Operations: 2, 1 hour each.
 - b. Maintenance: 2, 1 hour each.

3.05 SCHEDULES

- A. Instrument datasheets included in this Section.
- B. The provided information does not necessarily include all required instruments.

- C. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - FLOW MEASUREMENT: MAGNETIC FLOWMETERS

PROJECT INFORMATION

PLANT

CUSTOMER WEBER BASIN WATER
CONSERVANCY DISTRICT

PROJECT 203356

LOCATION

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

TAG 65-FIT-921 (65-FE-921)

MEASURING PRINCIPLE MAGNETIC

SPECIFICATION NUMBER 17302

PLC PLC-910

DRAWING NUMBER 65N04

POWER LOCATION PCM-910

SERVICE MAGNETIC FLOW METER

TYPICAL DETAIL(S) NF130, NF135

CONNECTION

LINE SIZE 4"

PROCESS CONNECTION ANSI 150

LINE MATERIAL SEE NOTE

PROCESS CONN. MATERIAL DUCTILE IRON

FLUID

FLUID THICKENED SLUDGE

PRESSURE 125 PSI

NOMINAL FLOW 150 GPM

TEMPERATURE 50 DEG F

FLOW RANGE 50-200 GPM

VISCOSITY 5% TOTAL SOLIDS

CONDUCTIVITY N/A

ELEMENT

ELEMENT TAG NO. 65-FE-921

PROCESS CONNECTION ANSI 150

ENCLOSURE CLASS NEMA 4X

LINER MATERIAL PFA

HAZARDOUS APPROVALS N/A

VACUUM POSSIBILITY NO

TUBE SIZE 4"

ELECTRODE TYPE FLUSH

TUBE MATERIAL STAINLESS STEEL

ELECTRODE MATERIAL 304 SST

TRANSMITTER

TRANSMITTER TAG NO. 65-FIT-921

HAZARDOUS APPROVALS N/A

MOUNTING REM

EMPTY PIPE DETECTION YES

ENCLOSURE CLASS NEMA 4X

BI DIRECTIONAL FLOW YES

POWER 120VAC-1P

PULSE OUTPUT YES

AMBIENT TEMPERATURE 70 DEG F

RELAY OPTIONS YES

OUTPUT 4-20 MA

POTTED ELECTRONICS NO

SURGE PROTECTION YES

CATHODIC PROT. LINE NO

NOTES

DUCTILE IRON W/ CEMENT MORTAR

PROJECT INFORMATION

PLANT

CUSTOMER WEBER BASIN WATER
CONSERVANCY DISTRICT

PROJECT 203356

LOCATION

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

TAG 65-FIT-922 (65-FE-922)

MEASURING PRINCIPLE MAGNETIC

SPECIFICATION NUMBER 17302

PLC PLC-910

DRAWING NUMBER 65N04

POWER LOCATION PCM-910

SERVICE MAGNETIC FLOW METER

TYPICAL DETAIL(S) NF130, NF135

CONNECTION

LINE SIZE 4"

PROCESS CONNECTION ANSI 150

LINE MATERIAL SEE NOTE

PROCESS CONN. MATERIAL DUCTILE IRON

FLUID

FLUID THICKENED SLUDGE

PRESSURE 125 PSI

NOMINAL FLOW 150 GPM

TEMPERATURE 50 DEG F

FLOW RANGE 50-200 GPM

VISCOSITY 5% TOTAL SOLIDS

CONDUCTIVITY N/A

ELEMENT

ELEMENT TAG NO. 65-FE-922

PROCESS CONNECTION ANSI 150

ENCLOSURE CLASS NEMA 4X

LINER MATERIAL PFA

HAZARDOUS APPROVALS N/A

VACUUM POSSIBILITY NO

TUBE SIZE 4"

ELECTRODE TYPE FLUSH

TUBE MATERIAL STAINLESS STEEL

ELECTRODE MATERIAL 304 SST

TRANSMITTER

TRANSMITTER TAG NO. 65-FIT-922

HAZARDOUS APPROVALS N/A

MOUNTING REM

EMPTY PIPE DETECTION YES

ENCLOSURE CLASS NEMA 4X

BI DIRECTIONAL FLOW YES

POWER 120VAC-1P

PULSE OUTPUT YES

AMBIENT TEMPERATURE 70 DEG F

RELAY OPTIONS YES

OUTPUT 4-20 MA

POTTED ELECTRONICS NO

SURGE PROTECTION YES

CATHODIC PROT. LINE NO

NOTES

DUCTILE IRON W/ CEMENT MORTAR

PROJECT INFORMATION

PLANT

CUSTOMER WEBER BASIN WATER
CONSERVANCY DISTRICT

PROJECT 203356

LOCATION

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

TAG 65-FIT-930 (65-FE-930)

MEASURING PRINCIPLE MAGNETIC

SPECIFICATION NUMBER 17302

PLC PLC-910

DRAWING NUMBER 65N02

POWER LOCATION PCM-910

SERVICE MAGNETIC FLOW METER

TYPICAL DETAIL(S) NF130, NF135

CONNECTION

LINE SIZE 3"

PROCESS CONNECTION ANSI 150

LINE MATERIAL SEE NOTE

PROCESS CONN. MATERIAL DUCTILE IRON

FLUID

FLUID THICKENED SLUDGE

PRESSURE 125 PSI

NOMINAL FLOW 150 GPM

TEMPERATURE 50 DEG F

FLOW RANGE 50-200 GPM

VISCOSITY 5% TOTAL SOLIDS

CONDUCTIVITY N/A

ELEMENT

ELEMENT TAG NO. 65-FE-930

PROCESS CONNECTION ANSI 150

ENCLOSURE CLASS NEMA 4X

LINER MATERIAL PFA

HAZARDOUS APPROVALS N/A

VACUUM POSSIBILITY NO

TUBE SIZE 4"

ELECTRODE TYPE FLUSH

TUBE MATERIAL STAINLESS STEEL

ELECTRODE MATERIAL 304 SST

TRANSMITTER

TRANSMITTER TAG NO. 65-FIT-930

HAZARDOUS APPROVALS N/A

MOUNTING REM

EMPTY PIPE DETECTION YES

ENCLOSURE CLASS NEMA 4X

BI DIRECTIONAL FLOW YES

POWER 120VAC-1P

PULSE OUTPUT YES

AMBIENT TEMPERATURE 70 DEG F

RELAY OPTIONS YES

OUTPUT 4-20 MA

POTTED ELECTRONICS NO

SURGE PROTECTION YES

CATHODIC PROT. LINE NO

NOTES

DUCTILE IRON W/ CEMENT MORTAR

PROJECT INFORMATION

PLANT

CUSTOMER WEBER BASIN WATER
CONSERVANCY DISTRICT

PROJECT 203356

LOCATION

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

TAG 65-FIT-934 (65-FE-934)

MEASURING PRINCIPLE MAGNETIC

SPECIFICATION NUMBER 17302

PLC PLC-910

DRAWING NUMBER 65N04

POWER LOCATION PCM-910

SERVICE MAGNETIC FLOW METER

TYPICAL DETAIL(S) NF130, NF135

CONNECTION

LINE SIZE 3"

PROCESS CONNECTION ANSI 150

LINE MATERIAL SEE NOTE

PROCESS CONN. MATERIAL DUCTILE IRON

FLUID

FLUID THICKENED SLUDGE

PRESSURE 125 PSI

NOMINAL FLOW 150 GPM

TEMPERATURE 50 DEG F

FLOW RANGE 50-200 GPM

VISCOSITY 5% TOTAL SOLIDS

CONDUCTIVITY N/A

ELEMENT

ELEMENT TAG NO. 65-FE-934

PROCESS CONNECTION ANSI 150

ENCLOSURE CLASS NEMA 4X

LINER MATERIAL PFA

HAZARDOUS APPROVALS N/A

VACUUM POSSIBILITY NO

TUBE SIZE 4"

ELECTRODE TYPE FLUSH

TUBE MATERIAL STAINLESS STEEL

ELECTRODE MATERIAL 304 SST

TRANSMITTER

TRANSMITTER TAG NO. 65-FIT-934

HAZARDOUS APPROVALS N/A

MOUNTING REM

EMPTY PIPE DETECTION YES

ENCLOSURE CLASS NEMA 4X

BI DIRECTIONAL FLOW YES

POWER 120VAC-1P

PULSE OUTPUT YES

AMBIENT TEMPERATURE 70 DEG F

RELAY OPTIONS YES

OUTPUT 4-20 MA

POTTED ELECTRONICS NO

SURGE PROTECTION YES

CATHODIC PROT. LINE NO

NOTES

DUCTILE IRON W/ CEMENT MORTAR

SECTION 40_71_43

FLOW MEASUREMENT: ROTAMETERS (VARIABLE AREA FLOWMETERS)

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Rotameters (variable area flowmeters).

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - 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 required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. 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.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. ABB.
 - 2. Brooks.
 - 3. King Instrument Co.

2.04 MANUFACTURED UNITS

- A. Rotameters:
 - 1. General:
 - a. Variable area type flowmeters with local flow indication.
 - b. Material construction:
 - 1) As indicated in the datasheet.
 - 2. Performance requirements:
 - a. Flow range:
 - 1) As specified in instrument datasheets or instrument index.
 - b. Accuracy:
 - 1) Glass tube: Within 2.0 percent of range.
 - 2) Metal tube: Within 5.0 percent of range.
 - 3) 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. Metal tube with magnetic follower:
 - 1) Type 316 stainless steel.
 - c. Turndown: 10 to 1.
 - d. Process temperature:
 - 1) As indicated in the datasheet.
 - e. Maximum process pressure:
 - 1) As indicated in the datasheet.
 - 2) Range:
 - a) As indicated in the datasheet.

- f. Float:
 - 1) Metal tube rotameters: Float with encapsulated magnet.
- 4. Components:
 - a. Seals: O-rings or packing glands fully compatible with process fluid.
 - b. Integral needle valve for flow control.
- 5. Scale:
 - a. Metal tube: Dial indicator with rotatable magnet coupled to magnet encapsulated in rotameter float.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 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

**ATTACHMENT A - ISA DATASHEET - FLOW MEASUREMENT:
ROTAMETERS (VARIABLE AREA FLOWMETERS)**

PROJECT INFORMATION

PLANT
PROJECT 203356

CUSTOMER WEBER BASIN WATER CONSERVANCY DISTRICT
LOCATION

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 65-FI-931	P&ID 65N02	SERVICE ROTAMETER	FLUID WATER MEASURING PRINCIPLE VARIABLE AREA FLOW LINE SIZE 1/2 INCH LINE MATERIAL 304 SST PROCESS CONN. MAT'L STEEL <i>Notes: SEAL WATER</i>	TYPICAL DETAILS [*] PRESSURE 100 PSI TEMPERATURE 50 DEG F PROCESS CONN. F-NPT	FLOW RANGE 0-10GPM VISCOSITY 1 SEAL MATERIAL EPDM TUBE MATERIAL 316 SST
TAG 65-FI-932	P&ID 65N02	SERVICE ROTAMETER	FLUID WATER MEASURING PRINCIPLE VARIABLE AREA FLOW LINE SIZE 1/2 INCH LINE MATERIAL 304 SST PROCESS CONN. MAT'L STEEL <i>Notes: SEAL WATER</i>	TYPICAL DETAILS [*] PRESSURE 100 PSI TEMPERATURE 50 DEG F PROCESS CONN. F-NPT	FLOW RANGE 0-10GPM VISCOSITY 1 SEAL MATERIAL EPDM TUBE MATERIAL 316 SST
TAG 65-FI-941	P&ID 65N04	SERVICE ROTAMETER	FLUID WATER MEASURING PRINCIPLE VARIABLE AREA FLOW LINE SIZE 1/2 INCH LINE MATERIAL 304 SST PROCESS CONN. MAT'L STEEL <i>Notes: SEAL WATER</i>	TYPICAL DETAILS [*] PRESSURE 100 PSI TEMPERATURE 50 DEG F PROCESS CONN. F-NPT	FLOW RANGE 0-10GPM VISCOSITY 1 SEAL MATERIAL EPDM TUBE MATERIAL 316 SST
TAG 65-FI-942	P&ID 65N04	SERVICE ROTAMETER	FLUID WATER MEASURING PRINCIPLE VARIABLE AREA FLOW LINE SIZE 1/2 INCH LINE MATERIAL 304 SST PROCESS CONN. MAT'L STEEL <i>Notes: SEAL WATER</i>	TYPICAL DETAILS [*] PRESSURE 100 PSI TEMPERATURE 50 DEG F PROCESS CONN. F-NPT	FLOW RANGE 0-10GPM VISCOSITY 1 SEAL MATERIAL EPDM TUBE MATERIAL 316 SST

SECTION 40_71_79

FLOW MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Thermal dispersion flow switches.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of calibration instruments.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - 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 required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments identified in the Contract Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. 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.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. Thermal dispersion type:
 - a. Fluid Components International LLC, FLT93.
 - b. Kayden.

2.04 MANUFACTURED UNITS

- A. As specified in this Section, including Attachment A - ISA Datasheet - Flow Measurement: Switches.
- B. Thermal dispersion type:
 - 1. General:
 - a. Instrument uses a heated probe and a reference probe.
 - 1) Deviation in the amount of heat measured by the reference probe deviates beyond the setpoint and adjustable relay closes.
 - 2) Switch:
 - a) Micro-processor based with continuous self-diagnostics, "Smart Heater" to prevent sensor failure, no mechanical jumpers or trim pots, and a 3-year warranty.

- 3) Seal water applications:
 - a) For clean water flow applications in line sizes 1 inch or smaller, provide in-line pre-assembled flow switch assembly with NPT process connections.
- 2. Performance requirements:
 - a. Accuracy:
 - 1) Liquids: Within 0.5 percent reading or within 0.04 fps.
 - b. Repeatability: Within 1 percent of setpoint range.
 - c. Response time: 0.5 to 2.5 seconds.
 - d. Adjustable bypass delay timer.
 - e. Adjustable range.
- 3. Switch characteristics:
 - a. Exposed parts: Powder coated aluminum housing.
 - b. Wetted parts:
 - 1) Materials as recommended by the manufacturer and approved by the Engineer.
 - c. Power supply:
 - 1) As indicated in the datasheets.
 - d. Operating temperature range:
 - 1) As indicated in the datasheets.
 - e. Enclosure:
 - 1) As indicated in the datasheets.

2.05 ACCESSORIES

- A. Provide sunshades for outdoor installations.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

- A. Factory calibrate each instrument with a minimum 3-point calibration or according to the manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration datasheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.
- B. Provide FM approval certification or equal when installed in classified areas.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 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

ATTACHMENT A - ISA DATASHEET - FLOW MEASUREMENT: SWITCHES

PROJECT INFORMATION

PLANT
PROJECT 203356

CUSTOMER WEBER BASIN WATER CONSERVANCY DISTRICT
LOCATION

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	FLUID	HAZARDOUS APP	POWER
65-FSL-931	65N02	THERMAL FLOW SWITCH	WATER	N/A	120VAC-1P
65-FE-931		MEASURING PRINCIPLE	THERMAL	ELEM. ENC. CLASS NEMA 4X	POWER LOCATION LOOP
		SET POINT	0-10GPM	SWITCH ENCL. CLASS NEMA 4X	OUTPUT RELAY
		PROCESS CONNECTION	M-NPT	PRESSURE N/A	RELAY FORM SPDT
		CONNECTION MATERIAL	304 SST	TEMPERATURE 50 DEG F	PLC [NOT FOUND ON P&ID]
		INSERTION LENGTH	5/16"	VISCOSITY 1	SURGE PROTECTION NO
		TYPICAL DETAILS	NF111		
TAG	P&ID	SERVICE	FLUID	HAZARDOUS APP	POWER
65-FSL-932	65N02	THERMAL FLOW SWITCH	WATER	N/A	120VAC-1P
65-FE-932		MEASURING PRINCIPLE	THERMAL	ELEM. ENC. CLASS NEMA 4X	POWER LOCATION LOOP
		SET POINT	0-10GPM	SWITCH ENCL. CLASS NEMA 4X	OUTPUT RELAY
		PROCESS CONNECTION	M-NPT	PRESSURE N/A	RELAY FORM SPDT
		CONNECTION MATERIAL	304 SST	TEMPERATURE 50 DEG F	PLC [NOT FOUND ON P&ID]
		INSERTION LENGTH	5/16"	VISCOSITY 1	SURGE PROTECTION NO
		TYPICAL DETAILS	NF111		
TAG	P&ID	SERVICE	FLUID	HAZARDOUS APP	POWER
65-FSL-941	65N04	THERMAL FLOW SWITCH	WATER	N/A	120VAC-1P
65-FE-941		MEASURING PRINCIPLE	THERMAL	ELEM. ENC. CLASS NEMA 4X	POWER LOCATION LOOP
		SET POINT	0-10GPM	SWITCH ENCL. CLASS NEMA 4X	OUTPUT RELAY
		PROCESS CONNECTION	M-NPT	PRESSURE N/A	RELAY FORM SPDT
		CONNECTION MATERIAL	304 SST	TEMPERATURE 50 DEG F	PLC [NOT FOUND ON P&ID]
		INSERTION LENGTH	5/16"	VISCOSITY 1	SURGE PROTECTION NO
		TYPICAL DETAILS	NF111		

Flow Switch

SPECIFICATION 17301

PROJECT INFORMATION

PLANT
PROJECT 203356

CUSTOMER WEBER BASIN WATER CONSERVANCY DISTRICT
LOCATION

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	HAZARDOUS APP	POWER
65-FSL-942	65N04	THERMAL FLOW SWITCH	N/A	120VAC-1P
65-FE-942		FLUID WATER		
		MEASURING PRINCIPLE THERMAL	ELEM. ENC. CLASS NEMA 4X	POWER LOCATION LOOP
		SET POINT 0-10GPM	SWITCH ENCL. CLASS NEMA 4X	OUTPUT RELAY
		PROCESS CONNECTION M-NPT	PRESSURE N/A	RELAY FORM SPDT
		CONNECTION MATERIAL 304 SST	TEMPERATURE 50 DEG F	PLC [NOT FOUND ON P&ID]
		INSERTION LENGTH 5/16"	VISCOSITY 1	SURGE PROTECTION NO
		TYPICAL DETAILS NF111		

SECTION 40_72_24

LEVEL MEASUREMENT: RADAR PULSE TIME OF FLIGHT (PTOF)

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Non-contact radar (PTOF) level instruments.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Abbreviations
 - 1. PTOF: Pulse Time of Flight.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications as specified in Section 01_75_17 - Commissioning.
- C. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.
- C. 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 required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. 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.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. Siemens.
 - 2. Ohmart Vega, VegaPuls.

2.04 MANUFACTURED UNITS

- A. Pulse Time of Flight:
 - 1. General:
 - a. Instrument emits radar pulses via a transmitter, with a frequency range of up to 80 GHz.
 - b. Pulses reflect from the surface being measured and are received back at the instrument via a sensor.
 - c. Instrument measures the pulse travel time between the transmitter, surface, and receiver to calculate the level.
 - d. Safety:
 - 1) Shall not generate frequency waves with power levels hazardous to humans.

2. Performance requirements:
 - a. Accuracy: Level:
 - 1) 0.25 inch.
3. Element:
 - a. Level element must conform to the process material compatibility as indicated in Attachment A - ISA Datasheet - Level Measurement: Radar Pulse Time of Flight (PTOF) or the Instrument Index.
 - b. Connections:
 - 1) Process: Antenna design shall be suitable for mounting in a nozzle as indicated in Attachment A - ISA Datasheet - Level Measurement: Radar Pulse Time of Flight (PTOF) or the Instrument Index.
 - 2) Design shall be such that product condensation on the antenna shall not affect the performance of the gauge. It shall be possible to choose between parabolic-, cone-, or rod-shaped antennas.
4. Transmitter:
 - a. Microprocessor-based signal converter/transmitter.
 - b. Power supply:
 - 1) As indicated in the datasheets.
 - c. Outputs:
 - 1) As indicated in the datasheets.
 - d. Backlit digital display for level or volume.
 - e. Self-diagnostics and automatic data checking.
 - f. Signal integrity:
 - 1) Immune to radio frequency and electromagnetic interference with field strength of 15 volts/meter or less over a frequency range of 50 Hz to 460 MHz.
 - 2) Able to ignore momentary level spikes or momentary loss of echo and indicate loss of echo condition on indicating transmitter unit.
 - g. Protected terminals and fuses in a separate compartment, which isolates field connection from electronics.
 - 1) Indication: Local - 5-digit display.
 - h. Enclosure:
 - 1) As indicated in the datasheets.
 - i. Electrical connection: 1/2-inch male NPT.

2.05 ACCESSORIES

- A. Software: Provide Windows based PC software for configuration and echo mapping.
- B. Provide sun shield for outdoor installations.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

- A. Factory calibrate each level transmitter at a facility that is traceable to NIST.
- B. Provide complete documentation covering the traceability of calibration instruments.
- C. FM approval certification or equal when installed in classified areas.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.
 - 1. Number of sessions:
 - a. Operations: 2 at 1 hour each.
 - b. Maintenance: 2 at 1 hour each.

3.05 ADJUSTING

- A. Verify factory calibration of 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 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

**ATTACHMENT A - ISA DATASHEET - LEVEL MEASUREMENT:
RADAR PULSE TIME OF FLIGHT (PTOF)**

PROJECT INFORMATION

PLANT

CUSTOMER WEBER BASIN WATER
CONSERVANCY DISTRICT

PROJECT 203356

LOCATION

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

TAG 67-LIT-981 (67-LE-981)

SPECIFICATION NUMBER 17208

MEASURING PRINCIPLE RADAR PTOF

DRAWING NUMBER 65N03

PLC PLC-910

SERVICE RADAR PTOF

TYPICAL DETAILS NL153

CONNECTION

PROCESS CONNECTION FLANGE MOUNT

FLUID

LEVEL RANGE 0-20FT

TEMPERATURE 50 DEG F

ELEMENT

ELEMENT TAG NO. 67-LE-981

ENCLOSURE CLASS NEMA 4X

ELEMENT HAZ. MATERIALS N/A

ELEMENT MATERIAL MFR. STD.

SUBMERGENCE DETECTION NO

TEMPERATURE COMP. NO

HEATED ELEMENT YES

TRANSMITTER

TRANSMITTER TAG NO. 67-LIT-981

HAZARDOUS APPROVALS N/A

MOUNTING INT

ENCLOSURE CLASS NEMA 4X

POWER [*]

OUTPUT 4-20 MA

AMBIENT TEMPERATURE 70 DEG F

MEASUREMENT APPL LEVEL

SURGE PROTECTION YES

NOTES

LOOP POWERED

PROJECT INFORMATION

PLANT

CUSTOMER WEBER BASIN WATER
CONSERVANCY DISTRICT

PROJECT 203356

LOCATION

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

TAG 67-LIT-982 (67-LE-982)

SPECIFICATION NUMBER 17208

MEASURING PRINCIPLE RADAR PTOF

DRAWING NUMBER 65N03

PLC PLC-910

SERVICE RADAR PTOF

TYPICAL DETAILS NL153

CONNECTION

PROCESS CONNECTION FLANGE MOUNT

FLUID

LEVEL RANGE 0-20FT

TEMPERATURE 50 DEG F

ELEMENT

ELEMENT TAG NO. 67-LE-982

ENCLOSURE CLASS NEMA 4X

ELEMENT HAZ. MATERIALS N/A

ELEMENT MATERIAL MFR. STD.

SUBMERGENCE DETECTION NO

TEMPERATURE COMP. NO

HEATED ELEMENT YES

TRANSMITTER

TRANSMITTER TAG NO. 67-LIT-982

HAZARDOUS APPROVALS N/A

MOUNTING INT

ENCLOSURE CLASS NEMA 4X

POWER [*]

OUTPUT 4-20 MA

AMBIENT TEMPERATURE 70 DEG F

MEASUREMENT APPL LEVEL

SURGE PROTECTION YES

NOTES

LOOP POWERED

SECTION 40_73_13

PRESSURE/VACUUM MEASUREMENT: GAUGES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pressure/vacuum gauges.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Standards:
 - 1. American Society of Mechanical Engineers (ASME):
 - a. B40.100 - Pressure Gauges and Gauge Attachments.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. Accessories.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - 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 required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments specified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. 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.

2.03 MANUFACTURERS

- A. One of the following or equal:
 - 1. Ametek U.S. Gauge.
 - 2. Ashcroft:
 - a. Maximum pressure greater than or equal to 10 pounds per square inch: Model 1279.
 - 1) If a stainless steel dial casing is required:
 - a) Model 1009.
 - 3. Wika, Model XSEL type 232.34.

2.04 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:
 - 1) As indicated in the datasheets.
4. Dial gauge:
 - a. Dial size: 4-1/2 inches.
 - b. Dial case material:
 - 1) As indicated in the datasheets.
 - 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 pressure gauges directly connected to diaphragm seals.
 - f. Provide gauge locks where possible.
 - g. Hermetically sealed.
 - h. Connection and mounting:
 - 1) Direct mounted and suitable for outdoor installation.
 - 2) 1/2-inch NPT.
 - 3) Connection material:
 - a) As indicated in the datasheets.
 - i. Pointer: Externally adjustable.

2.05 ACCESSORIES

- A. Pulsation dampeners and snubbers:
 1. As indicated in the datasheets.
 2. Provide with each pressure gauge installed on discharge of positive displacement type pump.
 3. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
 4. Mount integrally to the pressure gauge.
 5. Connection: 1/2-inch NPT.
 6. Provide diaphragm seals as specified in the Contract Documents and/or as indicated in the datasheets.
 7. Diaphragm seal and pressure gauge shall be assembled by the manufacturer and shipped as an assembly.
- B. Furnish instrument isolation as indicated in the datasheets and specified in Section 40_73_64 - Pressure/Vacuum Measurement: Instrument Valves:
 1. Mount isolation device integrally to the instrument.
 2. Isolation device and instrument shall be assembled by the manufacturer and shipped as an assembly.
- C. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

- A. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.
- B. Provide complete documentation covering the traceability of calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 ADJUSTING

- A. Verify factory calibration of 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.

3.05 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

ATTACHMENT A - ISA DATASHEET - PRESSURE/VACUUM MEASUREMENT: GAUGES

Pressure Gauge

SPECIFICATION 17404

PROJECT INFORMATION

PLANT
PROJECT 203356

CUSTOMER WEBER BASIN WATER CONSERVANCY DISTRICT
LOCATION

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 65-PI1-931	P&ID 65N02	SERVICE PRESSURE INDICATOR FLUID THICKENED SLUDGE TEMPERATURE 50 DEG F MEASURING PRINCIPLE DIRECT PRESSURE RANGE: 0-100 PSIG GAUGE RANGE 0-100 PSIG <i>Notes: PART OF PSH ASSY</i>	CONNECTION TYPE 1/2 IN NPT ISOLATION SEALS ANNULAR CASE MATERIAL PHENOLIC TYPICAL DETAILS [*] OPTIONS SNUBBER	BOTT. HOUSING MAT. 304L STAINLESS STEEL INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. TEFLON DIAL SIZE 4-1/2" AMBIENT TEMP 70 DEG F
TAG 65-PI1-932	P&ID 65N02	SERVICE PRESSURE INDICATOR FLUID THICKENED SLUDGE TEMPERATURE 50 DEG F MEASURING PRINCIPLE DIRECT PRESSURE RANGE: 0-100 PSIG GAUGE RANGE 0-100 PSIG <i>Notes: PART OF PSH ASSY</i>	CONNECTION TYPE 1/2 IN NPT ISOLATION SEALS ANNULAR CASE MATERIAL PHENOLIC TYPICAL DETAILS [*] OPTIONS SNUBBER	BOTT. HOUSING MAT. 304L STAINLESS STEEL INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. TEFLON DIAL SIZE 4-1/2" AMBIENT TEMP 70 DEG F
TAG 65-PI1-941	P&ID 65N04	SERVICE PRESSURE INDICATOR FLUID THICKENED SLUDGE TEMPERATURE 50 DEG F MEASURING PRINCIPLE DIRECT PRESSURE RANGE: 0-100 PSIG GAUGE RANGE 0-100 PSIG <i>Notes: PART OF PSH ASSY</i>	CONNECTION TYPE 1/2 IN NPT ISOLATION SEALS ANNULAR CASE MATERIAL PHENOLIC TYPICAL DETAILS [*] OPTIONS SNUBBER	BOTT. HOUSING MAT. 304L STAINLESS STEEL INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. TEFLON DIAL SIZE 4-1/2" AMBIENT TEMP 70 DEG F
TAG 65-PI1-942	P&ID 65N04	SERVICE PRESSURE INDICATOR FLUID THICKENED SLUDGE TEMPERATURE 50 DEG F MEASURING PRINCIPLE DIRECT PRESSURE RANGE: 0-100 PSIG GAUGE RANGE 0-100 PSIG <i>Notes: PART OF PSH ASSY</i>	CONNECTION TYPE 1/2 IN NPT ISOLATION SEALS ANNULAR CASE MATERIAL PHENOLIC TYPICAL DETAILS [*] OPTIONS SNUBBER	BOTT. HOUSING MAT. 304L STAINLESS STEEL INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. TEFLON DIAL SIZE 4-1/2" AMBIENT TEMP 70 DEG F

PROJECT INFORMATION

PLANT
PROJECT 203356

CUSTOMER WEBER BASIN WATER CONSERVANCY DISTRICT
LOCATION

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 65-PI2-931	P&ID 65N02	SERVICE PRESSURE INDICATOR FLUID WATER TEMPERATURE 50 DEG F MEASURING PRINCIPLE DIRECT PRESSURE RANGE: 10-70 PSIG GAUGE RANGE 0-100 PSI <i>Notes: SEAL WATER</i>	CONNECTION TYPE 1/4 IN NPT ISOLATION SEALS N/A CASE MATERIAL PHENOLIC TYPICAL DETAILS NP503 OPTIONS SNUBBER	BOTT. HOUSING MAT. 304L STAINLESS STEEL INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. N/A DIAL SIZE 4-1/2" AMBIENT TEMP 70 DEG F
TAG 65-PI2-932	P&ID 65N02	SERVICE PRESSURE INDICATOR FLUID WATER TEMPERATURE 50 DEG F MEASURING PRINCIPLE DIRECT PRESSURE RANGE: 10-70 PSIG GAUGE RANGE 0-100 PSI <i>Notes: SEAL WATER</i>	CONNECTION TYPE 1/4 IN NPT ISOLATION SEALS N/A CASE MATERIAL PHENOLIC TYPICAL DETAILS NP503 OPTIONS SNUBBER	BOTT. HOUSING MAT. 304L STAINLESS STEEL INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. N/A DIAL SIZE 4-1/2" AMBIENT TEMP 70 DEG F
TAG 65-PI2-941	P&ID 65N04	SERVICE PRESSURE INDICATOR FLUID WATER TEMPERATURE 50 DEG F MEASURING PRINCIPLE DIRECT PRESSURE RANGE: 10-70 PSIG GAUGE RANGE 0-100 PSI <i>Notes: SEAL WATER</i>	CONNECTION TYPE 1/4 IN NPT ISOLATION SEALS N/A CASE MATERIAL PHENOLIC TYPICAL DETAILS NP503 OPTIONS SNUBBER	BOTT. HOUSING MAT. 304L STAINLESS STEEL INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. N/A DIAL SIZE 4-1/2" AMBIENT TEMP 70 DEG F
TAG 65-PI2-942	P&ID 65N04	SERVICE PRESSURE INDICATOR FLUID WATER TEMPERATURE 50 DEG F MEASURING PRINCIPLE DIRECT PRESSURE RANGE: 10-70 PSIG GAUGE RANGE 0-100 PSI <i>Notes: SEAL WATER</i>	CONNECTION TYPE 1/4 IN NPT ISOLATION SEALS N/A CASE MATERIAL PHENOLIC TYPICAL DETAILS NP503 OPTIONS SNUBBER	BOTT. HOUSING MAT. 304L STAINLESS STEEL INSTRUMENT VALVES INSTRUMENT VALVE TREE DIAPHRAGM MAT. N/A DIAL SIZE 4-1/2" AMBIENT TEMP 70 DEG F

DATASECTION 40_73_36

PRESSURE/VACUUM MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pressure/vacuum switches.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. Accessories.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - 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 required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide instruments specified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. 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.

2.03 MANUFACTURERS

- A. Mechanical type pressure switch: One of the following or equal:
 - 1. ASCO, S-Series.
 - 2. Ashcroft, B Series.
 - 3. United Electric, Controls Series.
- B. Electronic type pressure switch: One of the following or equal:
 - 1. Ashcroft, N Series.
 - 2. United Electric, Series One.

2.04 MANUFACTURED UNITS

- A. As specified in this Section, including Attachment A - ISA Datasheet - Pressure/Vacuum Measurement: Switches.
- B. Mechanical type pressure switches:
 - 1. General:
 - a. Diaphragm or diaphragm-sealed piston type.
 - 2. Performance requirements:
 - a. Pressure range:
 - 1) As indicated in the datasheets.

- 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:
 - 1) As indicated in the datasheets.
 - e. Setpoint:
 - 1) As indicated in the datasheets.
 - 2) Switch shall activate at setpoint on increasing pressure for high-pressure alarm applications and on decreasing pressure for low-pressure alarm applications.
 - f. Deadband.
 - 1) As indicated in the datasheets.
 - g. Switch elements:
 - 1) As indicated in the datasheets.
 - 1) As indicated in the datasheets.
 - 2) Rated at 5 A, 125/250 VAC.
 - 1) Resets:
 - a) As indicated in the datasheets.
 - h. Enclosure: Epoxy coated:
 - 1) As indicated in the datasheets.
 - i. Switch mounting:
 - 1) As indicated in the datasheets.
- 4. Components:
 - a. Provide necessary hardware for pressure switch mounting.

2.05 ACCESSORIES

- A. Pulsation dampeners and snubbers:
 - 1. Provide with each pressure switch installed on discharge of positive displacement type pump.
 - 2. Materials: Stainless steel.
 - 3. Mount integrally to the pressure switch.
 - 4. Connection: 1/2-inch NPT.
- B. Provide diaphragm seals as specified in the datasheets or as indicated on the Drawings and as specified in Section 40_73_63 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals:
 - 1. Diaphragm seal and pressure switch shall be assembled by the manufacturer and shipped as an assembly.
- C. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

- A. Factory calibrate each instrument with a minimum 3-point calibration or according to the manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration datasheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.
- B. FM approval certification or equal when installed in classified areas.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.04 ADJUSTING

- A. Verify factory calibration of 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.

3.05 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

ATTACHMENT A - ISA DATASHEET - PRESSURE/VACUUM MEASUREMENT: SWITCHES

Pressure Switch

SPECIFICATION 17403

PROJECT INFORMATION

PLANT
PROJECT 203356

CUSTOMER WEBER BASIN WATER CONSERVANCY DISTRICT
LOCATION

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	HAZARDOUS APP	POWER [*]
65-PSH-931	65N02	FLUID THICKENED SLUDGE		N/A	
65-PE-931		FLUID TEMPERATURE 50 DEG F		ELEM. ENCL. CLASS NEMA 4X	POWER LOCATION LOOP
		MEASURING PRINCIPLE MECHANICAL		ELEMENT MATERIAL 304 SST	OUTPUT RELAY
		SET POINT 50 PSIG OPEN		SWITCH ENCL. CLASS NEMA 4X	RELAY FORM SPDT
		ADJUSTABLE RANGE 10 -75 PSIG		ENCL. MATERIAL 304 SST	PLC [NOT FOUND ON P&ID]
		TYPICAL DETAILS NP124		SURGE PROTECTION NO	MANUAL RESET NO
		CONN. MOUNTING BOTTOM		BOTT. HOUSING MAT. 304L STAINLESS S	SEAL TYPE ANNULAR
		CONNECTON TYPE M-NPT		INSTRUMENT VALVES N/A	DIAPHRAGM/WET MAT TEFLON
TAG	P&ID	SERVICE	PRESSURE SWITCH HIGH	HAZARDOUS APP	POWER [*]
65-PSH-932	65N02	FLUID THICKENED SLUDGE		N/A	
65-PE-932		FLUID TEMPERATURE 50 DEG F		ELEM. ENCL. CLASS NEMA 4X	POWER LOCATION LOOP
		MEASURING PRINCIPLE MECHANICAL		ELEMENT MATERIAL 304 SST	OUTPUT RELAY
		SET POINT 50 PSIG OPEN		SWITCH ENCL. CLASS NEMA 4X	RELAY FORM SPDT
		ADJUSTABLE RANGE 10 -50 PSIG		ENCL. MATERIAL 304 SST	PLC [NOT FOUND ON P&ID]
		TYPICAL DETAILS NP124		SURGE PROTECTION NO	MANUAL RESET NO
		CONN. MOUNTING BOTTOM		BOTT. HOUSING MAT. 304L STAINLESS S	SEAL TYPE ANNULAR
		CONNECTON TYPE M-NPT		INSTRUMENT VALVES N/A	DIAPHRAGM/WET MAT TEFLON
TAG	P&ID	SERVICE	PRESSURE SWITCH HIGH	HAZARDOUS APP	POWER [*]
65-PSH-941	65N04	FLUID THICKENED SLUDGE		N/A	
65-PE-941		FLUID TEMPERATURE 50 DEG F		ELEM. ENCL. CLASS NEMA 4X	POWER LOCATION LOOP
		MEASURING PRINCIPLE MECHANICAL		ELEMENT MATERIAL 304 SST	OUTPUT RELAY
		SET POINT 50 PSIG OPEN		SWITCH ENCL. CLASS NEMA 4X	RELAY FORM SPDT
		ADJUSTABLE RANGE 10 -75 PSIG		ENCL. MATERIAL 304 SST	PLC [NOT FOUND ON P&ID]
		TYPICAL DETAILS NP124		SURGE PROTECTION NO	MANUAL RESET NO
		CONN. MOUNTING BOTTOM		BOTT. HOUSING MAT. 304L STAINLESS S	SEAL TYPE ANNULAR
		CONNECTON TYPE M-NPT		INSTRUMENT VALVES N/A	DIAPHRAGM/WET MAT TEFLON

Pressure Switch

SPECIFICATION 17403

PROJECT INFORMATION

PLANT
PROJECT 203356

CUSTOMER WEBER BASIN WATER CONSERVANCY DISTRICT
LOCATION

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		
65-PSH-942	65N04		FLUID THICKENED SLUDGE	HAZARDOUS APP N/A	POWER [*]
65-PE-942			FLUID TEMPERATURE 50 DEG F	ELEM. ENCL. CLASS NEMA 4X	POWER LOCATION LOOP
			MEASURING PRINCIPLE MECHANICAL	ELEMENT MATERIAL 304 SST	OUTPUT RELAY
			SET POINT 50 PSIG OPEN	SWITCH ENCL. CLASS NEMA 4X	RELAY FORM SPDT
			ADJUSTABLE RANGE 10 -75 PSIG	ENCL. MATERIAL 304 SST	PLC [NOT FOUND ON P&ID]
			TYPICAL DETAILS NP124	SURGE PROTECTION NO	MANUAL RESET NO
			CONN. MOUNTING BOTTOM	BOTT. HOUSING MAT. 304L STAINLESS S	SEAL TYPE ANNULAR
			CONNECTON TYPE M-NPT	INSTRUMENT VALVES N/A	DIAPHRAGM/WET MAT TEFLON

SECTION 40_73_63

PRESSURE/VACUUM MEASUREMENT: DIAPHRAGM AND ANNULAR SEALS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Annular seals.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Standards:
 - 1. American National Standards Institute (ANSI).

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - 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.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - 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 required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Furnish a spare annular seal for every size provided in the Project.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide seals identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. 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.

2.03 MANUFACTURERS

- A. Annular seals:
 - 1. One of the following or equal:
 - a. Ashcroft, Wafer Isolation Ring.
 - b. Onyx Valve.

2.04 MANUFACTURED UNITS

- A. Annular seals:
 - 1. General:
 - a. Inside diameter of annular seal shall provide uninterrupted flow:
 - 1) There shall be no dead ends or crevices.
 - 2) Process flow shall be sufficient to make the annular seal self-cleaning.
 - b. Pressure sensing flexible cylinder shall measure pressure around the full inside circumference of the pipeline.

2. Requirements:
 - a. Pressure rating: Equivalent to the ANSI flanges.
 - b. Materials of construction:
 - 1) Inner flexible cylinder: Manufacturer's standard.
 - 2) Body:
 - a) As indicated in the instrument datasheets.
 - 3) Assembly flanges: To match adjacent piping.
 - 4) Fill fluid: Silicone oil.
 - c. Nominal pipe size: As indicated on the Drawings.
 - d. Process connection:
 - 1) As indicated in the instrument datasheets.
 - e. Instrument connection: 1/2-inch NPT.

2.05 ACCESSORIES

- A. Provide field fill kits.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation System.
- B. Coordinate the installation with trades to ensure that the mechanical system has 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.

3.03 CALIBRATION AND TESTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 40_73_64

PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Instrument valve tree.
 - 2. Valve manifolds.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
 - 1. Product data:
 - a. Instrument valve type.
 - b. Body material.
 - c. Size.
 - d. Options.
 - 2. Shop Drawings:
 - a. Mounting details for instrument valves.

1.04 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - 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 required accessories are provided and are compatible with the process conditions and physical installation.
- C. Provide valves manufactured at facilities certified to the quality standards of ISO 9001.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - 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.

1.06 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide valves and valve manifolds identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Provide valves and valve manifolds suitable for the installed Site conditions, including, but not limited to, material compatibility, process, and ambient temperatures.

2.03 MANUFACTURERS

- A. Instrument valve tree as indicated in the Contract Documents.
- B. Valve manifolds:
 - 1. One of the following or equal:
 - a. Anderson Greenwood.
 - b. Emerson, Rosemount.
 - c. Hex Valve.
 - d. Noshok.

2.04 MANUFACTURED UNITS

- A. Instrument valve tree as indicated in the Contract Documents.
- B. Valve manifolds:
 - 1. General:
 - a. Provide 2-valve, 3-valve, blowdown type 5-valve, or metering type 5-valve manifolds, as indicated in the datasheets.
 - b. Valve manifolds shall have 1-piece bonnet with a metal-to-metal seal to the valve body below the bonnet threads.
 - 2. Requirements:
 - a. Bonnet lock pin to prevent accidental loosening.
 - b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
 - d. Manifold valves shall have straight through portion for bi-directional flow and easy roddable cleaning.
 - e. Manifold valves shall allow for direct or remote instrument mounting.
 - f. Shall be able to withstand pressures up to 6,000 psi for soft seat valves and 10,000 psi for hard seat valves at maximum 200 degrees Fahrenheit.
 - g. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) O-ring: Teflon™.
 - h. 2-valve manifolds:
 - 1) 1 isolation valve and 1 drain/vent and calibration valve.
 - i. 3-valve manifolds:
 - 1) 2 isolation valves and 1 equalizing valve for differential pressure applications.
 - 2) Plugged vent connections used for vent/drain or calibration.
 - j. Blowdown 5-valve manifold:
 - 1) 2 isolation valves, 1 equalizing valve, 2 blowdown valves for differential pressure applications.
 - k. Metering 5-valve manifold:
 - 1) 2 isolation valves, 2 equalizing valves, 1 vent/drain and calibration valve for differential pressure applications.
- C. Level sensor isolation valves:
 - 1. General:
 - a. Valve shall provide process isolation from level diaphragm.
 - b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested, soft seat design with replaceable seat for soft seat valves.
 - 2. Requirements:
 - a. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) Flange diameter size: 3 inches.

2.05 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.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location and verify the valve will work properly when installed.

3.02 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of valves.

END OF SECTION

SECTION 40_80_01

COMMISSIONING FOR INSTRUMENTATION AND CONTROLS

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ATTACHMENT A - FACTORY ACCEPTANCE TEST - CONTROL PANELS

ATTACHMENT B - INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION

ATTACHMENT C - SWITCHES INSTALLATION AND CALIBRATION CHECKLIST

**ATTACHMENT D - TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND
CALIBRATION CHECKLIST**

ATTACHMENT E - CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Testing requirements that apply to process control and instrumentation systems for the entire Project.
 - 2. This project will require changes made to the Centrifuge, THU-921 and THU-922 PLC logic and interface with the Plant PLC network per the contract documents. Coordinate with the Owner and Centrifuge vendor to have the vendor on-site to make the necessary changes and commission those changes.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Standards:
 - 1. Telecommunications Industry Association (TIA).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Complete end-to-end testing (CEET) - Signals are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
 - 2. Loop validation tests - Signals are tested from the field device to the PLC.
 - 3. Permanent link: Fixed portion of cabling installed between an equipment outlet and its immediate distributor or between 2 distributors.
 - 4. Platform testing: Testing of the PLC and SCADA/HMI at the manufacturer's or programmer's shop to demonstrate the program's functionality based upon specified and designed control requirements.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. General:
 - 1. Reference additional detailed test Submittal scheduling and prerequisite requirements as specified in the sequencing article of Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- C. Overall test plan:
 - 1. Develop the PCIS system test Submittals in consultation and cooperation with applicable Subcontractors.
 - 2. Develop and submit an overall testing plan for the PCIS. Overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.

3. Describe the test phases as they apply specifically to this Project and each process system.
 4. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
 5. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
 6. Provide examples of proposed forms and checklists.
- D. Test procedures:
1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
 2. Provide a statement of test objectives for each test.
 3. Prepare specific procedures for each process system.
 4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
 5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
 6. Describe the expected role of the Engineer, as well as any requirements for assistance from the Owner's staff.
 7. Provide the forms and checklists to be used.
- E. Test forms:
1. Submit completed calibration forms, test forms, and checklists.
 - a. Test forms shall include the detailed test procedures or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
 - b. Every page of each test form shall include Project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
 - c. Sample test forms at the end of this Section show the minimum required content:
 - 1) Sample test forms have not been customized for this Project.
 - 2) Develop and submit test forms customized for the Project and meeting the specified test and Submittal requirements.
- F. FAT procedure additional minimal requirements:
1. Prepare and submit a FAT procedure which includes:
 - a. Control system testing block diagram.
 - b. Estimated test duration.
 - c. Details on the simulator construction, components, and operation.
- G. Testing binders:
1. Sub-system to be tested: Provide and submit a test binder containing test procedures and individual 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 test prerequisites, test personnel, and equipment.
 4. Include or list reference material and provide separately at the time of the test.
 5. Record test results and verify that all test requirements and conditions have been met.
- H. Furnish Commissioning Submittals listed below, as specified in this Section, and Section 01_75_17 - Commissioning:
1. Manufacturer's representative qualifications.
 2. Owner Training.
- I. Test reports:
1. At the conclusion of each test, submit a complete test report, including test results and certifications.
 2. Include completed test binders, forms, and checklists.
 3. Submission, review, and acceptance of each test report is required before the start of the sub-system.

1.05 QUALITY ASSURANCE

- A. Test personnel:
1. Furnish qualified technical personnel to perform calibration, testing, and verification. Test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

- A. Installation supervision:
1. Provide as specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.03 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning.
- B. Testing and training phase:
1. Source Testing:
 - a. Manufacturer services: Provide as specified in the table below.

Section Number	Section Title	Source Testing (Witnessed or Non-Witnessed)
40_61_15 - Control Strategies	Control Strategies	Non-Witnessed
40_61_16.10 - Specific Control Strategies	Specific Control Strategies	Witnessed
40_67_01 - Control Systems - Panels, Enclosures, and Panel Components	Control Systems - Panels, Enclosures, and Panel Components	Witnessed
40_80_01 - Commissioning for Instrumentation and Controls	Commissioning for Instrumentation and Controls	Witnessed

- b. Prerequisite requirements:
 - 1) Engineer approval of the hardware and equipment Source Testing Submittal is required before proceeding to preliminary FAT.
- c. FAT Platform Testing - Control logic test:
 - 1) Verify the PLC, HMI, and SCADA, provides monitoring and control functionality based upon specified and designed control requirements.
 - 2) Testing requirements:
 - a) Demonstrate each function described in the Control Strategies.
 - b) Demonstrate in detail how each function operates under a variety of operating scenarios:
 - (1) Test to verify the application of each general control strategy function to each specific control strategy or loop description.
 - c) Demonstrate the proper operation of the programming and configuration for each control strategy or loop description:
 - (1) Test each strategy or loop description on a sentence by sentence and function by function basis.
 - (2) Loops with similar or identical logic must each be tested individually.
 - (3) Test the boundaries of each numeric operator input by entering values outside of the allowable range.
 - d) Demonstrate the proper operation of digital communication links and networks.
 - (1) Verify each digital communication I/O point.
 - e) Failure testing: Demonstrate how the system responds to and recovers from abnormal conditions, including, but not limited to, equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to HMI and/or SCADA hardware), process equipment failure, and high system loading conditions.
 - 3) Test forms:
 - a) Submit completed test forms for each loop, including, but not limited to, the fully revised and approved control strategy.
 - b) Identify the cause and effect as each I/O point is toggled through the simulator:
 - (1) Identify and track proper and/or improper operation of the loop.

- c) Note any deficiencies or operational changes on the forms for correction and documentation:
 - (1) Include signature and date lines.
 - 4) Engineer approval of the FAT Submittal is required prior to shipment of system components.
 - 2. Owner Training:
 - a. Perform Owner Training as specified in Section 01_75_17 - Commissioning.

Course Title	Minimum Course Length (Hours per Session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
System Overview	8	10	1
Operator Training - Basic	24	10	2

- 3. Training course requirements:
 - a. System overview training:
 - 1) Furnish training courses that give the Owner's supervisory level personnel and overview of all elements of the PCIS system that focus on the overall functional aspect of elements of the control system and provide an understanding of the interaction of the various components.
 - 2) Furnish a training course that gives the Owner's supervisory level personnel and overview of the new Contractor-provided elements of the PCIS system. Focus on the overall functional aspects of each new elements of the control system, particularly the mechanical system vendor-provided control packages.
 - b. Operator training:
 - 1) Furnish training courses that instruct system operators in the efficient operation of all aspects of the PCIS that include not only the general operation of the control system but also the operation of specific system features.
 - 2) Furnish training courses that instruct system operators in the efficient operation of Contractor-provided aspects of the PCIS that include not only the general operation of each control system but also the operation of specific system features.
 - 3) Operator's training shall include the following for each vendor package and programmable device:
 - a) Control system overview: Architecture, equipment functions, software components, etc.
 - b) Display navigation, overview, and types of displays.
 - c) Process and equipment monitoring and control: Basic principles and operation.
 - d) Logging ON and OFF the system and description of the security and access system.
 - e) Alarm subsystem.
 - f) Trending: Provide a thorough session on how to use trending functions.
 - g) Reports: How to access, print, and review content.

- h) Control strategies: Present an average 15-minute review of each control strategy, including a hands-on demonstration of screens and operator functions for each.
 - i) Instruction on the use of operational functionality alarm logging, trending, displays, database, reports, and control software developed for the Project and incorporated in the installed PCIS system.
- 4. Installation testing:
 - a. Calibration:
 - 1) Performed by the Contractor and ICSC.
 - 2) Calibrate and adjust instruments, devices, valves, and systems, in accordance 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) Discrete devices:
 - (1) Calibrate and adjust devices for reliable operation and to avoid nuisance tripping.
 - b) 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 the manufacturer.
 - c) 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.
 - 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 the 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) PLC may or may not be connected to the network.
 - 3) Engineer approval of the loop validation test Submittal is required before proceeding to CEET.
- d. Copper Ethernet cable acceptance testing:
 - 1) Testing procedures and field-test instruments shall be in accordance with applicable requirements of:
 - a) TIA-1152 - Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling.
 - b) TIA-568.0-E - Generic Telecommunications Cabling for Customer Premises.
 - c) TIA-568.1-E - Commercial Building Telecommunications Infrastructure Standard.
 - d) TIA-568.2-D - Balanced Twisted-Pair Telecommunications Cabling and Components Standard.
 - e) Copper Ethernet cable installation testing as specified in Section 26_08_50 - Field Electrical Acceptance Tests.
 - 2) Testing shall be performed by trained technicians who have successfully completed an appropriate training program and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:
 - a) Manufacturer of the connectors or cable.
 - b) Manufacturer of the test equipment used for the field certification.
 - c) Training organizations (e.g., BICSI).
 - 3) Submit the following information before testing begins:
 - a) Manufacturer's catalog sheets, specifications, and the most recent calibration report for the test equipment.
 - b) Certificate of testing technician's training.
 - c) A schedule of balanced twisted-pair copper links to be tested, including:
 - (1) Cable identification as it appears on the cable records.
 - (2) Cable identification as it appears on the individual test reports.
 - (3) Cable identification as specified in Section 26_05_53 - Identification for Electrical Systems.
 - d) Sample test reports.
 - e) Installed cabling Permanent Links shall be field-tested and pass the test requirements and analysis as described below:
 - (1) Any Permanent Link that fails these requirements shall be diagnosed and corrected.
 - (2) Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected Permanent Link meets performance requirements.

- (3) Final and passing result of the tests for Permanent Links shall be provided in the test results documentation in accordance with the testing requirements.
 - f) Acceptance of the test results shall be given in writing after the Project is fully completed and tested in accordance with the Contract Documents and to the satisfaction of the Engineer.
- 4) Cable field-test instruments:
 - a) Field-test instrument shall be within the calibration period recommended by the manufacturer, typically 12 months.
 - b) Certification tester requirements:
 - (1) Level III in accordance with TIA-1152.
 - (2) Independent verification of accuracy.
 - (3) Must be capable of storing more than 10,000 results for all required measurements.
 - (4) Manufacturers: The following or equal:
 - (a) Fluke CableAnalyzer Industrial Ethernet Kit, DSX2-5-IE-K1.
 - c) Permanent Link adapters:
 - (1) Use the manufacturer's adapter for connecting to tested equipment.
 - (a) Patch cables shall not be used for testing.
 - (2) RJ45 plug must meet the requirements for NEXT, FEXT, and return loss in accordance with TIA-568.2-D Annex C.
 - d) Measurement capabilities:
 - (1) Wire map.
 - (2) Length.
 - (3) Propagation delay.
 - (4) Delay skew.
 - (5) DC loop resistance.
 - (6) DC resistance unbalance.
 - (7) Insertion loss.
 - (8) NEXT (near-end crosstalk).
 - (9) PS NEXT (power sum near-end crosstalk).
 - (10) ACR-N (attenuation to crosstalk ratio near-end).
 - (11) PS ACR-N (power sum attenuation to crosstalk ratio near-end).
 - (12) ACR-F (attenuation to crosstalk ratio far-end).
 - (13) PS ACR-F (power sum attenuation to crosstalk ratio far-end).
 - (14) Return loss.
 - (15) TCL (transverse conversion loss).
 - (16) ELTCTL (equal level transverse conversion transfer loss).
 - (17) Time domain reflectometer.
 - (18) Time domain crosstalk analyzer.
- 5) Testing requirements:
 - a) Field-test instruments shall have the latest software and firmware installed.
 - b) Permanent Link test results, including the individual frequency measurements from the tester shall be recorded in the test instrument upon completion of each test for subsequent

- uploading to a PC in which the administrative documentation (reports) may be generated.
- c) Testing shall be performed on each cabling segment from connector to connector:
 - (1) Sampling is not acceptable.
 - d) Installer shall build a reference link:
 - (1) Components shall be anchored so it is not possible to disturb them.
 - (2) Technician is to conduct a Permanent Link test each day, for each type of category cable used, to ensure no degradation of the tester or its Permanent Link adapters.
 - e) Unless noted otherwise tests shall use the following frequency resolution:
 - (1) 1 to 31.25 MHz: 150 kHz.
 - (2) 31.25 to 100 MHz: 250 kHz.
 - (3) 100 to 250 MHz: 500 kHz.
 - f) Wire map measurement:
 - (1) Wire map test is intended to verify pin-to-pin termination at each end and check for installation connectivity errors. For each of the 8 conductors in the cabling, the wire map indicates:
 - (a) Continuity to the remote end.
 - (b) Shorts between any 2 or more conductors.
 - (c) Reversed pairs.
 - (d) Split pairs.
 - (e) Transposed pairs.
 - (f) Distance to open on shield.
 - (g) Any other miss-wiring.
 - (h) Correct connectivity of telecommunications outlets/connectors is defined in TIA-568.2-D:
 - 2 color schemes are permitted.
 - User shall define which scheme is to be used.
 - Field tester shall document which color scheme was used.
 - g) Length measurement:
 - (1) Record the length of each cable. Use the physical length of the link calculated using the pair with the shortest electrical delay for reporting and to determine pass/fail.
 - (2) Pass or fail criteria is based on the maximum length allowed for the Permanent Link as specified in TIA-568.2-D plus the nominal velocity of propagation (NVP) uncertainty of 10 percent. For a Permanent Link, the length measurement can be 325 feet before a fail is reported.
 - h) Propagation delay measurement:
 - (1) Is the time it takes for a signal to reach the end of the link.
 - (2) Measurement shall be made at 10 MHz in accordance with TIA-1152.
 - (3) Propagation delay of each balanced twisted pair shall be recorded.
 - (4) Is not to exceed 498 ns in accordance with TIA-568.2-D Section 6.4.21.

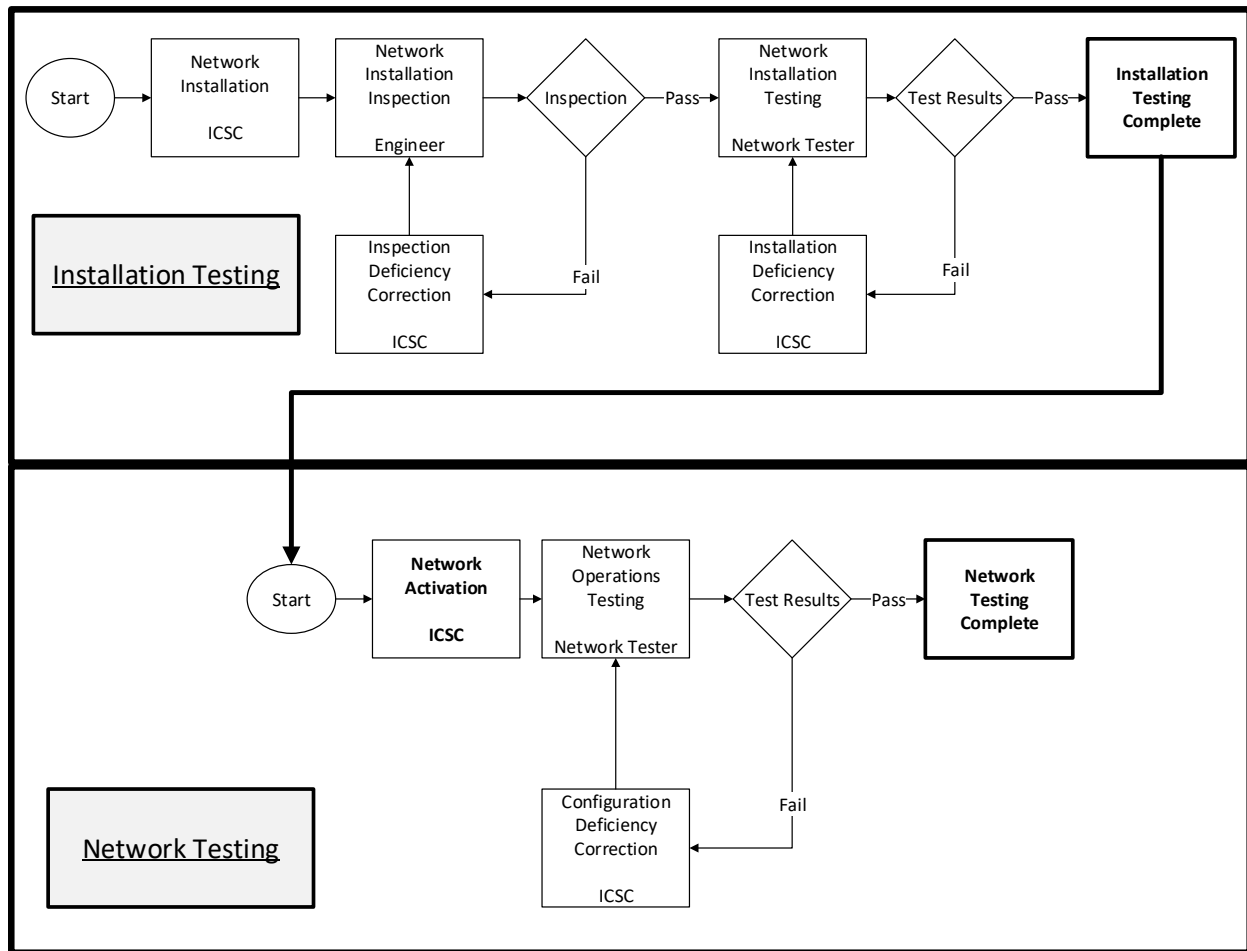
- i) Delay skew measurement:
 - (1) Is the difference in propagation delay at 10 MHz between the shortest delay and the delays of the other wire pairs.
 - (2) Delay skew of each balanced twisted pair shall be recorded.
 - (3) Is not to exceed 44 ns in accordance with TIA-568.2-D Section 6.4.22.
- j) DC resistance:
 - (1) Often reported as resistance, is the loop resistance of both conductors in the pair.
 - (2) Is not specified in TIA-1152 but shall be recorded for all 4 pairs.
- k) DC resistance unbalance:
 - (1) Often reported as resistance unbalance, is the difference in resistance of the 2 wires within the pair.
 - (2) Is not specified in TIA-1152 for a Permanent Link but shall be recorded for all 4 pairs.
- l) Insertion loss:
 - (1) Is the loss of signal strength over the cabling (in dB).
 - (2) Worst case shall be reported for all 4 pairs in one direction only.
 - (3) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk.
 - (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.10.
- m) NEXT (near-end crosstalk):
 - (1) Is the difference in amplitude (in dB) between a transmitted signal and the crosstalk received on other wire pairs at the same end of the cabling.
 - (2) Shall be measured in both directions (12 pair to pair possible combinations).
 - (3) Both worst case and worst margins shall be reported.
 - (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.11.
 - (5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
 - (6) Time domain crosstalk data shall be stored for any marginal or failing NEXT results.
- n) PS NEXT (power sum near-end crosstalk):
 - (1) Is the difference (in dB) between the test signal and the crosstalk from the other pairs received at the same end of the cabling.
 - (2) Shall be measured in both directions (8 pair possible combinations).
 - (3) Both worst case and worst margins shall be reported.
 - (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.12.
 - (5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
 - (6) Time domain crosstalk data shall be stored for any marginal or failing PS NEXT results.

- o) ACR-N (attenuation crosstalk ratio near-end):
 - (1) Is a calculation of NEXT minus insertion loss of the disturbed pair in dB.
 - (2) Shall be calculated in both directions.
 - (3) Is not specified in TIA-1152 but shall be recorded for all 12 possible combinations.
- p) PS ACR-N (power sum attenuation crosstalk ratio near-end):
 - (1) Is a calculation of PS NEXT minus insertion loss of the disturbed pair in dB.
 - (2) Shall be calculated in both directions.
 - (3) Is not specified in TIA-1152 but shall be recorded for all 8 possible combinations.
- q) ACR-F (attenuation crosstalk ratio far-end):
 - (1) Is a calculation of FEXT minus insertion loss of the disturbed pair in dB.
 - (2) Shall be measured in both directions (24 pair to pair possible combinations).
 - (3) Both worst case and worst margins shall be reported.
 - (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.14.
 - (5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
- r) PS ACR-F (power sum attenuation crosstalk ratio far-end):
 - (1) Is a calculation of PS FEXT minus insertion loss of the disturbed pair in dB.
 - (2) Shall be measured in both directions (8 pair possible combinations).
 - (3) Both worst case and worst margins shall be reported.
 - (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.16.
 - (5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
- s) Return loss:
 - (1) Is the difference (in dB) between the power of a transmitted signal and the power of the signals reflected back.
 - (2) Shall be measured in both directions (8 pair possible combinations).
 - (3) Both worst case and worst margins shall be reported.
 - (4) Shall be ignored at all frequencies where the insertion loss is less than 3 dB for that pair.
 - (5) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.9.
 - (6) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
 - (7) Time domain reflectometer data shall be stored for any marginal or failing return loss results.
- t) TCL (transverse conversion loss):
 - (1) Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the near-end on the same wire pair.
 - (2) Shall be measured in both directions.

- (3) Is not specified in TIA-1152 for a Permanent Link but shall be recorded for all 8 possible combinations.
 - u) ELTCTL (equal level transverse conversion transfer loss):
 - (1) Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the far end on the same wire pair minus the insertion loss of that pair.
 - (2) Shall be measured in both directions.
 - (3) Is not specified in TIA-1152 for a Permanent Link but shall be recorded for all 8 possible combinations.
- 6) Test results documentation:
 - a) Detailed test results documentation data is to be provided in an electronic database for each tested balance twisted pair and shall contain the following information:
 - (1) Overall pass/fail evaluation of the link-under-test.
 - (2) Date and time the test results were saved in the memory of the tester.
 - (3) Identification of the customer site as specified by the end user.
 - (4) Name of the test limit selected to execute the stored test results.
 - (5) Name of the personnel performing the test.
 - (6) Version of the test software and the version of the test limit database held within the test instrument.
 - (7) Manufacturer, model, and serial number of the field-test instrument.
 - (8) Adapters used.
 - (9) Factory calibration date.
 - (10) Wire map.
 - (11) Propagation delay values, for all 4 pairs.
 - (12) Delay skew values, for all 4 pairs.
 - (13) DC resistance values, for all 4 pairs.
 - (14) DC resistance unbalance, values for all 4 pairs.
 - (15) Insertion loss, worst case values for all 4 pairs.
 - (16) NEXT, worst case margin and worst case values, both directions.
 - (17) PS NEXT, worst case margin and worst case values, both directions.
 - (18) ACR-F, worst case margin and worst case values, both directions.
 - (19) PS ACR-F, worst case margin and worst case values, both directions.
 - (20) Return loss, worst case margin and worst case values, both directions.
 - (21) TCL, worst case values both directions.
 - (22) ELTCTL, worst case values, both directions.
 - (23) Time domain crosstalk data if the link is marginal or fails.
 - (24) Time domain reflectometer data if the link is marginal or fails.
 - b) Maintain a set of "red-line" throughout during construction:
 - (1) Drawings shall be available for review at any time as requested by the Owner or Engineer.

- (2) Provide record copy drawings at the end of the Project.
 - (a) Shall be in CAD format and include notations reflecting the as-built conditions of any additions to or variation from the drawings provided, such as, but not limited to, cable paths and termination point.
 - (3) As-built drawings shall include, but are not limited to, block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details.
 - (4) As-builts shall include field changes made up to construction completion:
 - (a) Field directed changes to pull schedule.
 - (b) Horizontal cable routing changes.
 - 7) Associated detail drawings. Engineer approval of the copper Ethernet cable acceptance-testing Submittal is required before proceeding to CEET.
- e. Industrial network testing:
 - 1) General test requirements:
 - a) Contractor will hire a network tester who is a Certified Profibus Installer for testing for the proper installation and operation of the Profibus network.
 - b) Provide necessary components and labor required to address changes required to bring the network into compliance.
 - c) Personnel shall be available at the time of network inspection and testing to address network deficiencies.
 - d) Before commencing any network inspection or testing activities:
 - (1) Verify that network segments and nodes are in their final installed condition:
 - (a) Network node devices installed.
 - (b) Field devices physically disconnected from the network.
 - (2) Process and process equipment is not dependent on operation of the network.
 - (3) Inspect network components and deficiencies addressed.
 - (4) Manufacturer's data and specifications for installed network components, available on site for use by the network testing firm.
 - (5) A complete set of Contract Documents included addenda and change orders are available on site for use by the network testing firm.
 - e) Network operation may be interrupted for inspection and testing.
 - f) Figure 1, Network Test Sequence and Responsibilities, defines the general test sequence.

Figure 1. Network Test Sequence and Responsibilities



- 2) Test equipment:
 - a) Use the following:
 - (1) Network line analyzer: ProfiTrace v1.6 or equivalent.
 - (2) Oscilloscope: Fluke Scopemeter Series 190 or equivalent.
 - (3) Digital VOM: Fluke 87 Multimeter or equivalent.
 - (4) Network bus monitor, ProfiTrace v1.6 or equivalent.
- 3) Network installation testing:
 - a) Performed by the Contractor/ICSC, network tester, and the Owner's representative working together.
 - b) This activity focuses on the physical media and its installation.
 - c) Conduct a physical inspection to establish the network configuration as indicated on the Drawings:
 - (1) Validate the node type and quantity.
 - (2) Identify improper installation and damaged components.
 - d) Validate integrity of cables and connectors via a physical media test to confirm the signal propagation capabilities of the network media using visual and mechanical inspection:
 - (1) Compare network devices nameplate data with Drawings and Specifications.
 - (2) Confirm network components are PTO compliant.
 - (3) Verify labeling of trunk cables.

- (4) Confirm permissible cable length.
- (5) Confirm correct cable type.
- (6) Verify the presence/absence of stub lines.
- (7) Verify network terminators are in place.
- (8) Verify power supply source and connections for active terminations.
- (9) Verify total network node count.
- (10) Verify power supply specifications, including quantity, ratings, locations, and configuration. Verify power supply source of supply location, conductor size, and rating.
- (11) Inspect accessible network cabling for adherence to specified installation practices:
 - (a) Cable installed in conduit or protective raceway.
 - (b) Cable proximity to high voltage wiring.
 - (c) Exposure to extreme temperatures, shock, vibration, chemicals, or moisture.
 - (d) Bend radius.
- (12) Inspect cable and conductor terminations for adherence to specified installation practices.
- (13) Check accessible components for evidence of physical damage.
- (14) Check grounding techniques, including ground conductor sizes and termination points.
- (15) Eliminate signal reflections.
- e) Electrical tests:
 - (1) Measure total network resistance.
 - (2) Cable length and configuration evaluation:
 - (a) Confirm the network cable topology (length and configuration) does not exceed data rate limitations.
 - (b) Confirm total stub length (if required by design) does not exceed data rate limitations.
 - (c) Calculate spare trunk length for the specified data rate.
 - (3) Line analysis for the following conditions:
 - (a) Short circuit between signal lines A and B.
 - (b) Short circuit between signal lines A and B and the cable shield.
 - (c) Shield continuity.
 - (d) Cross-wired signals lines.
 - (e) Terminator installed in wrong position.
 - (f) Poor transmission or reception levels.
 - (g) Non-permissible stub line.
 - (4) Examine the data traffic between the controller and each agent device.
 - (5) Verify baud rate meets specified requirements.
 - (6) Confirm signal level meets specified requirements.
 - (7) Verify network cycle time meets specified requirements.
 - (8) Generate agent device list.
 - (9) Verify and record scanner diagnostic data, including node status and error codes.
 - (10) Monitor and capture network waveform.

- (11) Measure and record power supply voltage at active terminations.
- f) Submit corrective measures recommendations based on the results of the inspections and testing.
- g) Engineer approval of the network installation validation and testing Submittal is required before proceeding to network operations validation and testing.
- 4) Network operations testing:
 - a) Performed by the Contractor/ICSC, network tester, and the Owner's representative, and programmer working together.
 - b) General requirements:
 - (1) Network performance is monitored and measured using non-intrusive test equipment and procedures in accordance with the referenced standards:
 - (a) Profibus networks.
 - (2) Modifications required as a result of network operations validation and shall be in accordance with the applicable standards from Profibus organization, North America, PTO.
 - c) Online evaluation:
 - (1) Confirm specified agent devices appear on the live list.
 - (2) Evaluate data traffic between controller and each agent to confirm proper agent configuration and performance.
 - (3) Inspect waveform capture for evidence of excessive noise.
 - (4) Evaluate and report any failed or questionable network tests.
 - (5) Evaluate and report network error codes and related symptoms.
 - d) Network operations validation and testing report:
 - (1) Prepare a report that documents the results of the qualification and testing activities, including, but not limited to, the following:
 - (a) Document the installed condition of the network and provide baseline values for future network maintenance and testing activities.
 - (b) Executive summary for each network, including the following:
 - Inspection and test results for each network.
 - Calculated network parameters.
 - Recommendations.
 - Description of test procedures and required test equipment.
 - Network agency specifications.
 - (c) Manufacturer's specifications and guidelines:
 - Include applicable manufacturer's specifications and guidelines.
 - May supersede the specifications of the applicable governing body for the associated network but at a minimum must meet the governing body's requirements.
 - e) Submit final report of the industrial network testing to the Engineer upon successful completion of the testing.

- 5) Engineer approval of the industrial network testing Submittals is required before proceeding to CEET.
- f. Complete End-to-End Testing (CEET):
 - 1) Performed by the Contractor, ICSC, and the manufacturer's representative and programmer working together with assistance from the Owner or the inspection staff, as needed:
 - a) Participants need to be dedicated full-time to CEET.
 - b) ICSC and Programmer will provide staff to verify input signals at, and create output signals from, an HMI or engineering workstation.
 - c) Contractor and ICSC will be responsible for creating field signals and verifying proper operation of final control elements.
 - 2) Prerequisites:
 - a) CEET cannot begin until the successful completion of the preceding tests:
 - (1) Calibration.
 - (2) Loop check.
 - (3) Loop validation tests.
 - (4) Copper Ethernet cable acceptance testing.
 - (5) Industrial network testing.
 - 3) Testing description:
 - a) This testing is to ensure 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. 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.
 - c) Observe and record responses at intermediate devices.

- 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.
5. 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 the Contractor, ICSC, and the manufacturer's representative, and programmer working together, with assistance from the Owner or the inspection staff, as needed.

- 3) Additional tests are specified in other instrumentation and control Sections.
- 4) Follow approved detailed test procedures and check lists for Functional test activities.
- b. Control logic operational validation:
 - 1) The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the HMI/SCADA system, control panels (including vendor control panels), control circuits, control stations, monitored/controlled equipment, and final control elements.
 - 2) Demonstrate control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, electrical Specifications, and mechanical equipment Specifications.
 - 3) Test in detail on a function-by-function and sentence-by-sentence basis.
 - 4) Thoroughly test hardware and software functions, including hardwired and software control circuit interlocks and alarms.
 - 5) Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify logic and control is achieved.
 - 6) Control logic validation tests to include, but not be limited to, a repeat of control logic tests from the FAT, modified and expanded to include field instruments, control panels, circuits, and equipment.
- c. Loop tuning:
 - 1) Optimally tune 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.
 - a) 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 the 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) Including test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that Functional

C. Process Start-up Phase:

- 1. Process Start-up:
 - a. Programmer shall be on site to support process Start-up activities and provide functional changes as required:
 - 1) ICSC shall be available as needed.
 - b. ICSC shall be on site to support process Start-up activities and provide functional changes as required.
- 2. Process operation period:
 - a. Programmer shall be available to support process operational period and provide functional changes as required:
 - 1) ICSC shall be available as needed.
 - b. ICSC shall be available to support process operational period and provide functional changes as required.
- 3. PCIS optimization and fine-tuning:
 - a. General:
 - 1) After the process operational period, test PCIS system for additional 60 days as specified in this Section to identify issues and make corrections, as needed.
 - 2) This is part of the Work that must be completed as a condition of Substantial Completion and final completion for the entire Project.
 - 3) Complete PLC control and HMI/SCADA system must run continuously for the duration of the PCIS optimization and fine-tuning.
 - 4) Test and use the entire process control system under standard operating conditions.
 - 5) Exercise system functions.
 - 6) Log failure, any system interruption and accompanying component, subsystem, or program failure, including time of occurrence, duration of each failure, failure classification, and cause:
 - a) Provide a competently trained technician or programmer on call for the Project Site during normal working days and hours from

the start of the PCIS optimization and fine-tuning until final acceptance of the system:

- (1) Response time to the Project Site: 24 hours or less, for a major failure.
- b. SCADA system testing:
 - 1) Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates "normal" system operation.
 - 2) Failure of the HMI/SCADA system during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications:
 - a) Corrective action is required before restarting the PCIS optimization and fine-tuning.
 - 3) Only those components, sub-systems, and systems covered in this Section and supplied under this Contract shall be considered for this acceptance test. Problems and failures of other systems shall not be considered as part of this test, except as they display the capabilities of this system to detect failures.
 - 4) Failures:
 - a) Classify failures as either major or minor:
 - (1) Minor failure:
 - (a) A small and non-critical component failure or software problem that can be corrected by the Owner's operators.
 - (b) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
 - (c) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
 - (d) Failure of 1 printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator station, and repairs can be made, and equipment returned to service within 3 working days.
 - (2) Major failure:
 - (a) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
 - (b) Cause termination of the PCIS optimization and fine-tuning.
 - (c) Start a new acceptance test when the causes of a major failure have been corrected.
 - (d) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.
 - 5) Technician report:
 - a) Each time a technician is required to respond to a system malfunction, they must complete a report, which includes details

concerning the nature of the complaint or malfunction and the resulting repair action required and taken.

- b) If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
- c) If a technician has performed work but no report is written, then a major failure is considered to have occurred.
- d) Each report shall be submitted within 24 hours to the Engineer and the Owner, or its representative.

3.04 SCHEDULES

A. Example test forms:

- 1. 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. 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

ATTACHMENT A - FACTORY ACCEPTANCE TEST - CONTROL PANELS

	FACTORY ACCEPTANCE TEST - CONTROL PANELS	
1. GENERAL INSPECTION A. Structural Inspection ☐ Verify lifting lugs installed. ☐ Verify enclosure has lock and lock is functional. ☐ Confirm that seismic bracing components are provided in accordance with manufacturer's installation instructions. B. Exterior Inspection ☐ Cabinet exterior is clean, scratch, and dent free. ☐ Inspect externally for corrosion and damage. ☐ Verify enclosure door opens and closes easily. ☐ Verify enclosure has a 3-point latch. ☐ Verify enclosure has a flange mounted disconnect (where voltages greater than 120 VAC enter the cabinet). ☐ Verify enclosure has the appropriate NEMA rating (1, 1G, 12, 3R, 4, 4X, etc.). ☐ Verify enclosure is the appropriate size (not grossly larger than design, and will still fit in the plant). Nameplates ☐ Cabinet has identification nameplate. ☐ All door labels are straight, spelled correctly, and match the tagging defined in the Contract. ☐ Cabinet has a nameplate that includes the following: ☐ Power source(s). ☐ Integrator's logo. ☐ Circuit ID(s). ☐ Short Circuit KAIC ratings. ☐ If labels are screwed to door, silicone was utilized to cover screw holes. (Labels screwed to the door of a NEMA 4/4X panel technically violates the NEMA rating.) Door Devices ☐ All devices penetrating the outside of panel have gaskets, silicone or both. ☐ All door devices are installed (HMIs, Pilot Devices, etc.). ☐ Door mounted equipment is mounted straight and square. ☐ All exterior or door mounted equipment present and accounted for, installed and securely fastened. ☐ NEMA classification has not been violated due to penetrations. ☐ Door mounted equipment has the same NEMA rating as the panel. ☐ All door mounted equipment installed at the correct height. ☐ All door mounted equipment installed in the correct positions and order (layout of door mounted equipment is grouped properly and in a logical manner). ☐ Doors with multiple penetrations have adequate bracing (if needed). ☐ Visually check condition of indicators, controllers, and annunciators. ☐ Check that pilot lights illuminate correctly. ☐ Check the Push-To-Test function. ☐ Ensure correct pilot light color. Peripheral Devices ☐ Horn/Beacon is installed (where required). ☐ Silence and Reset pushbutton.		
PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____		TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____

	FACTORY ACCEPTANCE TEST - CONTROL PANELS			
1. GENERAL INSPECTION (continued) C. Interior Inspection ☐ Cabinet is cleaned of marks and dirt. ☐ Inspect internally for corrosion and damage. ☐ Back panel is clean of marks and dirt. ☐ Interior of panel vacuumed and shall be free of all debris. ☐ Check that the panel roof is clean and clear of foreign materials. ☐ Bottom of panel has been cut out (where bottom entry is required), with angle iron welded around the bottom perimeter. Re-painting has been performed. ☐ If internal light door limit switch is provided, ensure the light automatically turns "on" when the doors are open. ☐ Check that a document pocket has been provided. ☐ Intrusion alarms (where required). Interior Labeling ☐ All panel mounted equipment has identification labeling, by using either a Brothers or Phenolic type tags. ☐ Verify that door mounted components are mounted square and symmetrical. ☐ Verify that nameplates are straight, legible, and spelled correctly. ☐ All terminal blocks are identified/labeled with permanent labels, including tight end blocks and caps. ☐ All wiring shrink labeled and or phased correctly to the specifications. ☐ All wire labels shrunk completely rotated and aligned alike for easy identification. ☐ All fuses and circuit breakers are labeled with ID and current rating. ☐ System Integrator's label or labels installed on door. ☐ Panel manufacturer model/serial number tag is present. ☐ All required safety/warning tags installed and straight. ☐ Correct UL (typically UL 508) or cUL tag installed and registered and all other associated tags installed and straight. (The UL tag might not be installed in the panel at the factory test. If the panel is modified due to changes during the factory test or a punch list generated from the factory test, the UL labeling would need to be re-applied. Some UL shops do not apply the UL label until the panel is released to be shipped.) Wireways ☐ Plastic wire way covers installed properly. ☐ Plastic wireways have no sharp edges. ☐ No wire ties inside the wireways. ☐ No sharp edges on wire ties. ☐ Separation: White duct is used for DC voltages; Gray duct is used for AC voltages. ☐ Ensure wiring duct is not over-full, includes provision for 20% more wiring and the cover may easily be installed. Panduit recommends 50% duct fill, but 40% is a better practice.				
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	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
1. GENERAL INSPECTION (continued) C. Interior Inspection (continued) Wiring ☐ Visually check terminals and condition of internal wirings. ☐ Verify that the control panel has been assembled and wired as designed. ☐ Verify that all components are operational and perform the functions intended. ☐ Verify that all components are sized appropriately for the application. ☐ Verify that equipment control circuits function as intended. ☐ Back of door wiring is labeled and neatly formed. ☐ Back panel to door wiring has sufficient bending radius with spiral wrap. ☐ Wire connection has been verified wired to correct points within the panel. ☐ Individual wires have been given a pull test to verify a good terminal connection. ☐ Wire and cable minimum bending radius have not been violated. ☐ All equipment installed straight and square to back panel. ☐ Wire colors are correct: ☐ Black and White > AC hot and neutral, respectively. ☐ Red > AC control signals. ☐ Blue > DC power and control. ☐ White w/Blue stripes > DC ground. ☐ Yellow > Foreign voltages (those still present when panel power is disconnected). ☐ Green > AC equipment ground. ☐ Black > TSP (+). ☐ White > TSP(-). ☐ Analog wiring shields are continuous (connected by a dedicated terminal block for such shields). ☐ Analog shield wires are grounded within the panel, where not otherwise grounded at the transmitter itself. ☐ Discrete inputs are separately fused or protected by a circuit breaker on a "per loop" basis. ☐ Intrinsic Safety Wiring. ☐ Ensure wiring associated with intrinsic safety circuits or intrinsic safety barriers is kept away from all other wiring by UL minimum distances or by a physical (grounded metal) barrier preventing non-intrinsically safe wiring from coming in contact with intrinsically safe circuits or wiring. ☐ Verify all spare terminals are installed according to the percentage listed in the specifications. Grounding ☐ Equipped with "Blackburn" or other grounding type lug. ☐ Lug is securely fastened to the panel structure. ☐ Verify grounding bar is installed. ☐ Verify isolated ground bar is installed.												
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FACTORY ACCEPTANCE TEST - CONTROL PANELS	
2. POWER TEST A. AC Power ☐ AC power is routed correctly within the panel and is isolated from DC and network wiring. ☐ All fuses are installed and sized properly. ☐ All breakers are installed and sized properly. ☐ 24 VDC Power Supplies are functional. ☐ 24 VDC Power fail contacts are functional. ☐ 24 VDC power supplies are redundant and have diode modules enabling the hot swap-over between supplies. ☐ 24 VDC supplies are equipped with dry contact failure alarms, wired as PLC inputs to signal failure of any DC power supply. Such alarm inputs to the PLC have been tested as being functional. ☐ Dedicated receptacle is wired to receive a dedicated AC supply. ☐ Verify continuity for all DC commons, ground and AC neutrals. ☐ Verify that the CP temporary input power is connected correctly and is the correct voltage. ☐ Close the CP main circuit breaker(s). ☐ Verify that voltages at subsequent circuit breakers are correct. ☐ Close circuit breakers. ☐ Verify that power feeding interruptible and uninterruptible power supplies is correct. ☐ Turn on power supplies if they are not already on. ☐ Verify that voltages at distribution terminals are correct. ☐ Energize any remaining hardware such as the PLC. B. Uninterruptible Power Supply (UPS) ☐ Mounted appropriately within the cabinet, on a dedicated shelf, or rear of a swing-out sub panel. ☐ Is equipped with maintenance bypass switch (or at least plug/receptacle means for bypassing the unit). ☐ Test all UPS alarms (on inverter, failure, battery failure etc.). ☐ Turn off the AC power supply and verify that the UPS will be switched on to supply the designated vital loads in the control panel. 3. CONTROLS & AUXILIARY DEVICES TEST ☐ Verify all interposing and auxiliary relays are functioning. ☐ Verify panel lights are functioning. Ventilation and Heating ☐ If ventilation fans are fitted, check the fans operate correctly any associated air filters are clean and not blocked. ☐ Verify components are installed in the correct orientation for proper air flow. 4. HARDWIRED INTERLOCK AND SAFETY TEST ☐ Verify that hardwired interlocks through the control panel as shown on schematic drawings are functioning. For example, outlet high pressure switch interlock to a pump. ☐ Verify that all hardwired safety devices through the control panel is functioning. For example, the pull cord emergency stops of conveyors.	
PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____	TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____

FACTORY ACCEPTANCE TEST - CONTROL PANELS	
5. PLC TEST A. Components ☐ PLC interior High Temperature alarm is installed, wired to the PLC, and is shown to be functional. ☐ Relays have transient suppression across their coils. This is particularly important for DC coil relays, where diodes in reverse polarity are often used. ☐ TVSS is installed across the main incoming 120 VAC. PLC and PLC Rack ☐ Verify all cards are securely seated. ☐ Ensure clearance around PLC rack has been met, such that convective heat transfer is not impeded by devices erroneously mounted in the "no encroachment" area. Confirm with manufacturer clearance recommendations. B. PLC I/O Test ☐ Furnish I/O test forms and test all the listed input and output points as follows: ☐ Discrete Inputs: Simulate a field contact closure by "shorting" across the appropriate terminal blocks. Observe the transition between a logical "0" and "1" in the PLC software. ☐ Discrete Outputs: Force the output bit to toggle between logical "0" and logical "1" using the PLC software. Measure contact resistance at the wired terminal blocks using a digital meter selected for the "ohms" setting. ☐ Analog Inputs: Connect a signal generator to the appropriate terminal blocks. Tailor the connection depending on whether a 2-wire or 4-wire simulation is required. Modulate the 4-20mA signal. Observe the associated PLC internal memory register to transition between 0-65535 or if scaled in engineering units, between 0 and the maximum scaled engineering unit. The latter method is preferred. ☐ Analog Outputs: Force the output register to a value between 0-65535 or 0-100%, if the scaling block can be manipulated. Observe the measured 4-20mA value increment and decrement using a digital ammeter. C. Redundant Controllers (where required) Test ☐ Remove Communication cable from primary PLC to verify switching to backup PLC. ☐ Remove Communication cable from backup PLC to verify switching back to primary PLC. ☐ Remove Power cable from primary PLC to verify switching to backup PLC. ☐ Remove Power cable from backup PLC to verify switching back to primary PLC. D. PLC Control Logic Verification ☐ The PLC control strategy is verified by following the Control Logic Verification Form based on the specifications. Each control strategy will be verified by simulating the process and checking the state or value of PLC outputs. The results of equipment status and alarms and process instrument values and trends shall also be verified on the Plant SCADA graphic screens stored in a temporary SCADA computer. Since all PLC input and output wiring has been verified and some field devices are not available during Factory Acceptance Testing, certain inputs will be simulated either by means of additional hardware and/or software as described below. ☐ ☐ ☐ DI states are either simulated by hardwired switches or forced inputs using a programming terminal. ☐ For example, when starters and drives are not provided as part of the Contract, jumpers may be installed from the output call relays to the running confirmation inputs to simulate the running state of the motors.	
PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____	TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____

	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
5. PLC TEST (continued) D. PLC Control Logic Verification (continued) Typical Fault Logic ☐ If the fault input is high and the disable (if applicable) for the fault is not high and the common disable (if applicable) is not high begin timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output. If the fault alarm is a shutdown alarm stop the associated motor and latch the alarm so that it remains present even if the condition clears. ☐ The fault condition must return to normal and the alarm must be reset for a latched alarm to clear. Typical Fail to Start Logic ☐ If the motor is called to run (call output high) and no running feedback is received (running input is low) and the fail to start and common alarm disables (if applicable) are not high start timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output, stop calling the motor and latch the alarm. 6. HMI OR OIT TEST HMI/OIT Functionality ☐ Communication with PLC. ☐ Screen Layouts. ☐ Screen Navigation. ☐ Set Point Entry. ☐ Animation. ☐ Color Correctness (Green=Run, Red=Off, Amber=Alarm, or the agreed upon convention). ☐ Alarms. ☐ Acknowledge and Reset. ☐ Security/Access Levels/Passwords. 7. NETWORK COMMUNICATION TEST A. Network Components ☐ Fiber optic cabling terminates in a patch panel. ☐ Media converters are installed and functional. ☐ Terminating resistors have been installed for trunk/tap topologies or where required. ☐ Wire and cable bending limitations have not been violated. B. Networking Functions ☐ Verify data transfer via the network to different PLCs as shown on the Network Block Diagrams. ☐ Verify network traffic rate and error margin is acceptable.												
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;">PROJECT NAME: _____</td> <td style="width: 50%; border: none;">TEST DATE: _____</td> </tr> <tr> <td style="border: none;">FACILITY NAME: _____</td> <td style="border: none;">TESTED BY: _____</td> </tr> <tr> <td style="border: none;">PROCESS AREA: _____</td> <td style="border: none;">COMPANY: _____</td> </tr> <tr> <td style="border: none;">NETWORK ID: _____</td> <td style="border: none;">PAGE: _____</td> </tr> <tr> <td style="border: none;">WITNESSED BY: _____</td> <td style="border: none;">SIGNATURE: _____</td> </tr> </table>			PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____
PROJECT NAME: _____	TEST DATE: _____											
FACILITY NAME: _____	TESTED BY: _____											
PROCESS AREA: _____	COMPANY: _____											
NETWORK ID: _____	PAGE: _____											
WITNESSED BY: _____	SIGNATURE: _____											

	FACTORY ACCEPTANCE TEST - CONTROL PANELS			
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.				
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top;"> PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____ </td> <td style="width: 50%; vertical-align: top;"> TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____ </td> </tr> </table>			PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____	TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____
PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____	TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____			

ATTACHMENT B - INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION

	INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

REMARKS: _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

ATTACHMENT C - SWITCHES INSTALLATION AND CALIBRATION CHECKLIST

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER DETAIL NO. _____
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

FIELD CALIBRATION CHECK					
CONTACT NO.	FUNCTION	FOR SIGNAL	CONTACT IS TO	AT SPECIFIED VALUE FOR	ACTUAL TRIP POINT WAS
1	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____
2	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____
3	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____
4	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____

NOTE: PERM IS ABBREVIATION FOR PERMISSIVE

**ATTACHMENT D - TRANSMITTER/CONTROLLER/INDICATOR
INSTALLATION AND CALIBRATION CHECKLIST**

	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				

**ATTACHMENT E - CONTROL VALVES
INSTALLATION AND CALIBRATION CHECKLIST**

	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		ON LOSS OF POWER SOLENOID FAILS
	☐ OPEN ☐ CLOSE	☐ TO VENT ☐ TO VALVE	
TRAVEL CHECK	FULL OPEN AT _____ PSI	FULL CLOSED AT _____ PSI	MEASURED TRAVEL _____ INCHES
SEATING CHECK	☐ ON BENCH	RESULTS	ACTUATOR BENCH SET
	☐ IN-LINE		
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 _____

SECTION 40_96_15

SCHEDULES: I/O LIST

PART 1 GENERAL

1.01 SUMMARY

- A. The I/O List is not a take-off list.
 - 1. Additional information is as indicated on the Drawings and specified in the Contract Documents.
 - 2. 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 indicated on the Drawings.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 I/O LIST

- A. As specified in Attachment A - I/O List.

END OF SECTION

ATTACHMENT A - I/O LIST



PLC I/O Listing for PLC-910



Drawing	Tag	I/O	Location	Description	Service	(E/F)
65N02	65-F-930	AI	PLC-910	FLOW	MAGNETIC FLOW METER	
65N02	65-SPDF-931	AI	PLC-910	SPEED FBK	THICKENED SLUDGE TRANSFER PUMP NO.1	
65N02	65-SPDF-932	AI	PLC-910	SPEED FBK	THICKENED SLUDGE TRANSFER PUMP NO.2	
65N03	67-L-981	AI	PLC-910	LEVEL	RADAR PTOF	
65N03	67-L-982	AI	PLC-910	LEVEL	RADAR PTOF	
65N04	65-F-921	AI	PLC-910	FLOW	MAGNETIC FLOW METER	
65N04	65-F-922	AI	PLC-910	FLOW	MAGNETIC FLOW METER	
65N04	65-F-934	AI	PLC-910	FLOW	MAGNETIC FLOW METER	
65N04	65-SPDF-941	AI	PLC-910	SPEED FBK	THICKENED SLUDGE FEED PUMP NO. 1	
65N04	65-SPDF-942	AI	PLC-910	SPEED FBK	THICKENED SLUDGE FEED PUMP NO.2	
65N06	L-921	AI	PLC-910	LEVEL	SLUDGE BLANKET	
65N07	L-922	AI	PLC-910	LEVEL	SLUDGE BLANKET	
PLC-910	Total AI Points = 12					
65N02	65-SPDC-931	AO	PLC-910	SPEED CMD	THICKENED SLUDGE TRANSFER PUMP NO.1	
65N02	65-SPDC-932	AO	PLC-910	SPEED CMD	THICKENED SLUDGE TRANSFER PUMP NO.2	
65N04	65-SPDC-941	AO	PLC-910	SPEED CMD	THICKENED SLUDGE FEED PUMP NO. 1	
65N04	65-SPDC-942	AO	PLC-910	SPEED CMD	THICKENED SLUDGE FEED PUMP NO.2	
PLC-910	Total AO Points = 4					



PLC I/O Listing for PLC-910



Drawing	Tag	I/O	Location	Description	Service	(E/F)
65N01	65-REM-930	DI	PLC-910	REMOTE	IN-LINE SLUDGE GRINDER	
65N01	65-REM-930A	DI	PLC-910	REMOTE	GRAVITY THICKENER VALVE NO.1	
65N01	65-REM-930B	DI	PLC-910	REMOTE	GRAVITY THICKENER VALVE NO.2	
65N01	65-RNG-930	DI	PLC-910	RUNNING	IN-LINE SLUDGE GRINDER	
65N01	65-XA-930	DI	PLC-910	FAIL	IN-LINE SLUDGE GRINDER	
65N01	65-ZSC-930A	DI	PLC-910	CLOSED	GRAVITY THICKENER VALVE NO.1	
65N01	65-ZSC-930B	DI	PLC-910	CLOSED	GRAVITY THICKENER VALVE NO.2	
65N01	65-ZSO-930A	DI	PLC-910	OPENED	GRAVITY THICKENER VALVE NO.1	
65N01	65-ZSO-930B	DI	PLC-910	OPENED	GRAVITY THICKENER VALVE NO.2	
65N02	65-FAIL-931	DI	PLC-910	FAILED	THICKENED SLUDGE TRANSFER PUMP NO.1	
65N02	65-FAIL-932	DI	PLC-910	FAILED	THICKENED SLUDGE TRANSFER PUMP NO.2	
65N02	65-FSL-931	DI	PLC-910	SEAL WATER OK	THICKENED SLUDGE TRANSFER PUMP NO.1	
65N02	65-FSL-932	DI	PLC-910	SEAL WATER OK	THICKENED SLUDGE TRANSFER PUMP NO.2	
65N02	65-PSH-931	DI	PLC-910	HI PRES	THICKENED SLUDGE TRANSFER PUMP NO.1	
65N02	65-PSH-932	DI	PLC-910	HI PRES	THICKENED SLUDGE TRANSFER PUMP NO.2	
65N02	65-REM-931	DI	PLC-910	REMOTE	THICKENED SLUDGE TRANSFER PUMP NO.1	
65N02	65-REM-932	DI	PLC-910	REMOTE	THICKENED SLUDGE TRANSFER PUMP NO.2	
65N02	65-RNG-931	DI	PLC-910	RUNNING	THICKENED SLUDGE TRANSFER PUMP NO.1	
65N02	65-RNG-932	DI	PLC-910	RUNNING	THICKENED SLUDGE TRANSFER PUMP NO.2	
65N02	65-TSH1-931	DI	PLC-910	STATOR TEMP	THICKENED SLUDGE TRANSFER PUMP NO.1	
65N02	65-TSH1-932	DI	PLC-910	STATOR TEMP	THICKENED SLUDGE TRANSFER PUMP NO.2	
65N02	65-TSH-931	DI	PLC-910	MTR WND TEMP	THICKENED SLUDGE TRANSFER PUMP NO.1	
65N02	65-TSH-932	DI	PLC-910	MTR WND TEMP	THICKENED SLUDGE TRANSFER PUMP NO.2	
65N03	67-REM-940A	DI	PLC-910	REMOTE	SLUDGE DAY TANK VALVE NO. 1	
65N03	67-REM-940B	DI	PLC-910	REMOTE	SLUDGE DAY TANK VALVE NO. 1	
65N03	67-REM-981	DI	PLC-910	REMOTE	SLUDGE DAY TANK MIXER NO. 1	
65N03	67-REM-982	DI	PLC-910	REMOTE	SLUDGE DAY TANK MIXER NO. 2	



PLC I/O Listing for PLC-910



Drawing	Tag	I/O	Location	Description	Service	(E/F)
65N03	67-RNG-981	DI	PLC-910	RUNNING	SLUDGE DAY TANK MIXER NO. 1	
65N03	67-RNG-982	DI	PLC-910	RUNNING	SLUDGE DAY TANK MIXER NO. 2	
65N03	67-TSH-981	DI	PLC-910	HI TEMP	SLUDGE DAY TANK MIXER NO. 1	
65N03	67-TSH-982	DI	PLC-910	HI TEMP	SLUDGE DAY TANK MIXER NO. 2	
65N03	67-ZSC-940A	DI	PLC-910	CLOSED	SLUDGE DAY TANK VALVE NO. 1	
65N03	67-ZSC-940B	DI	PLC-910	CLOSED	SLUDGE DAY TANK VALVE NO. 1	
65N03	67-ZSO-940A	DI	PLC-910	OPENED	SLUDGE DAY TANK VALVE NO. 1	
65N03	67-ZSO-940B	DI	PLC-910	OPENED	SLUDGE DAY TANK VALVE NO. 1	
65N04	65-FAIL-941	DI	PLC-910	FAILED	THICKENED SLUDGE FEED PUMP NO. 1	
65N04	65-FAIL-942	DI	PLC-910	FAILED	THICKENED SLUDGE FEED PUMP NO.2	
65N04	65-FSL-941	DI	PLC-910	SEAL WATER OK	THICKENED SLUDGE FEED PUMP NO. 1	
65N04	65-FSL-942	DI	PLC-910	SEAL WATER OK	THICKENED SLUDGE FEED PUMP NO.2	
65N04	65-PSH-941	DI	PLC-910	HI PRES	THICKENED SLUDGE FEED PUMP NO. 1	
65N04	65-PSH-942	DI	PLC-910	HI PRES	THICKENED SLUDGE FEED PUMP NO.2	
65N04	65-REM-941	DI	PLC-910	REMOTE	THICKENED SLUDGE FEED PUMP NO. 1	
65N04	65-REM-942	DI	PLC-910	REMOTE	THICKENED SLUDGE FEED PUMP NO.2	
65N04	65-RNG-941	DI	PLC-910	RUNNING	THICKENED SLUDGE FEED PUMP NO. 1	
65N04	65-RNG-942	DI	PLC-910	RUNNING	THICKENED SLUDGE FEED PUMP NO.2	
65N04	65-TSH1-941	DI	PLC-910	STATOR TEMP	THICKENED SLUDGE FEED PUMP NO. 1	
65N04	65-TSH1-942	DI	PLC-910	STATOR TEMP	THICKENED SLUDGE FEED PUMP NO.2	
65N04	65-TSH-941	DI	PLC-910	MTR WND TEMP	THICKENED SLUDGE FEED PUMP NO. 1	
65N04	65-TSH-942	DI	PLC-910	MTR WND TEMP	THICKENED SLUDGE FEED PUMP NO.2	
65N05	65-AUTO-980	DI	PLC-910	AUTO	AIR COMPRESSOR VCP	
65N05	65-FAIL-981	DI	PLC-910	FAULT	SUMP PUMP NO.1	
65N05	65-FAIL-982	DI	PLC-910	FAULT	SUMP PUMP NO.2	
65N05	65-LAH-980	DI	PLC-910	HI LEV	SUMP LEVEL	
65N05	65-RNG-981	DI	PLC-910	RUNNING	SUMP PUMP NO.1	



PLC I/O Listing for PLC-910



Drawing	Tag	I/O	Location	Description	Service	(E/F)
65N05	65-RNG-982	DI	PLC-910	RUNNING	SUMP PUMP NO.2	
65N06	REM-921	DI	PLC-910	REMOTE	THICKENER 1	
65N06	RNG-921	DI	PLC-910	RUNNING	THICKENER 1	
65N06	TSH-921	DI	PLC-910	HI TEMP	THICKENER 1	
65N06	XSHA-921	DI	PLC-910	TORQUE	THICKENER 1	
65N06	XSHB-921	DI	PLC-910	TORQUE	THICKENER 1	
65N07	REM-922	DI	PLC-910	REMOTE	THICKENER 2	
65N07	RNG-922	DI	PLC-910	RUNNING	THICKENER 2	
65N07	TSH-922	DI	PLC-910	HI TEMP	THICKENER 2	
65N07	XSHA-922	DI	PLC-910	TORQUE	THICKENER 2	
65N07	XSHB-922	DI	PLC-910	TORQUE	THICKENER 2	
65N08	LLSL-971	DI	PLC-910	LEVEL	CENTRATE PUMP STATION LEVEL	
65N08	LSH-971	DI	PLC-910	LEVEL	CENTRATE PUMP STATION LEVEL	
65N08	RNGA-971	DI	PLC-910	RUNNING	CENTRATE PUMP NO.1	
65N08	RNGB-971	DI	PLC-910	RUNNING	CENTRATE PUMP NO.2	
65N09	LSA-991	DI	PLC-910	LEVEL	LEVEL FLOATS	
65N09	LSB-991	DI	PLC-910	LEVEL	LEVEL FLOATS	
65N09	LSHH-991	DI	PLC-910	LEVEL	LEVEL FLOATS	
65N09	LSLL-991	DI	PLC-910	LEVEL	LEVEL FLOATS	
65N09	REM-991	DI	PLC-910	REMOTE		
65N09	REM-992	DI	PLC-910	REMOTE	RECYCLE DECANT WATER PUMP NO. 2	
65N09	RNG-991	DI	PLC-910	RUNNING		
65N09	RNG-992	DI	PLC-910	RUNNING	RECYCLE DECANT WATER PUMP NO. 2	
65N09	TSH-991	DI	PLC-910	HI TEMP		
65N09	TSH-992	DI	PLC-910	HI TEMP	RECYCLE DECANT WATER PUMP NO. 2	
65N09	XSH-991	DI	PLC-910	MOIST		
65N09	XSH-992	DI	PLC-910	MOIST	RECYCLE DECANT WATER PUMP NO. 2	



PLC I/O Listing for PLC-910



Drawing	Tag	I/O	Location	Description	Service	(E/F)
65N10	LSHB-1311	DI	PLC-910	LEVEL	LEVEL FLOATS	
65N10	LSHHB-1311	DI	PLC-910	LEVEL	LEVEL FLOATS	
70N01	IA-65-997	DI	PLC-910	SF CURRENT	SUPPLY FAN	
70N01	JS1-65-910	DI	PLC-910	PWR SUP OK	PCM CABINET	
70N01	JS2-65-910	DI	PLC-910	PWR SUP OK	PCM CABINET	
70N01	JS3-65-910	DI	PLC-910	REDUNDANCY OK	PCM CABINET	
70N01	JS4-65-910	DI	PLC-910	ACB OK	PCM CABINET	
70N01	JS5-65-910	DI	PLC-910	ON UPS POWER	UPS POWER STATUS	
70N01	TSH-65-910	DI	PLC-910	HIGH CABINET TEMP	PCM CABINET	
70N01	XA1-65-910	DI	PLC-910	SPD FAIL	PCM CABINET	
70N01	XA2-65-910	DI	PLC-910	SPD FAIL	PCM CABINET	
70N01	XA3-65-910	DI	PLC-910	LOW BATTERY	UPS POWER STATUS	
70N01	XA4-65-910	DI	PLC-910	UPS FAULT	UPS POWER STATUS	
70N01	XA5-65-910	DI	PLC-910	ES FAIL	PCM CABINET	
70N01	XA6-65-910	DI	PLC-910	ES FAIL	PCM CABINET	
70N01	XA7-65-910	DI	PLC-910	ECP FAIL	PCM CABINET	
70N01	XA8-65-910	DI	PLC-910	ECP FAIL	PCM CABINET	
70N01	ZS-65-910	DI	PLC-910	INTRUSION	PCM CABINET	
PLC-910	Total DI Points = 99					



PLC I/O Listing for PLC-910



Drawing	Tag	I/O	Location	Description	Service	(E/F)
65N01	65-RUN-930	DO	PLC-910	RUN	IN-LINE SLUDGE GRINDER	
65N01	65-ZCC-930A	DO	PLC-910	CLOSE	GRAVITY THICKENER VALVE NO.1	
65N01	65-ZCC-930B	DO	PLC-910	CLOSE	GRAVITY THICKENER VALVE NO.2	
65N01	65-ZCO-930A	DO	PLC-910	OPEN	GRAVITY THICKENER VALVE NO.1	
65N01	65-ZCO-930B	DO	PLC-910	OPEN	GRAVITY THICKENER VALVE NO.2	
65N02	65-RUN-931	DO	PLC-910	START	THICKENED SLUDGE TRANSFER PUMP NO.1	
65N02	65-RUN-932	DO	PLC-910	START	THICKENED SLUDGE TRANSFER PUMP NO.2	
65N03	67-RUN-981	DO	PLC-910	RUN	SLUDGE DAY TANK MIXER NO. 1	
65N03	67-RUN-982	DO	PLC-910	RUN	SLUDGE DAY TANK MIXER NO. 2	
65N03	67-ZCC-940A	DO	PLC-910	CLOSE	SLUDGE DAY TANK VALVE NO. 1	
65N03	67-ZCC-940B	DO	PLC-910	CLOSE	SLUDGE DAY TANK VALVE NO. 1	
65N03	67-ZCO-940A	DO	PLC-910	OPEN	SLUDGE DAY TANK VALVE NO. 1	
65N03	67-ZCO-940B	DO	PLC-910	OPEN	SLUDGE DAY TANK VALVE NO. 1	
65N04	65-RUN-941	DO	PLC-910	START	THICKENED SLUDGE FEED PUMP NO. 1	
65N04	65-RUN-942	DO	PLC-910	START	THICKENED SLUDGE FEED PUMP NO.2	
65N06	RUN-921	DO	PLC-910	RUN	THICKENER 1	
65N07	RUN-922	DO	PLC-910	RUN	THICKENER 2	
65N09	RUN-991	DO	PLC-910	RUN		
65N09	RUN-992	DO	PLC-910	RUN	RECYCLE DECANT WATER PUMP NO. 2	
PLC-910	Total DO Points = 19					

SECTION 43_23_57.10
PROGRESSING CAVITY PUMPS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Rotary, positive displacement, Moineau principal, single screw, progressing cavity type pumps with drivers, and specified components.
- B. Tag numbers: As specified in the 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 Gear Manufacturers Association (AGMA).
- C. American Society of Mechanical Engineers (ASME):
 - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 250.
 - 2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
- D. ASTM International (ASTM):
 - 1. A48 - Standard Specification for Gray Iron Castings.
 - 2. A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 3. A283 - Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
 - 4. A681 - Standard Specification for Tool Steels Alloy.
 - 5. D2240 - Standard Test Method for Rubber Property—Durometer Hardness.
- E. Hydraulic Institute (HI):
 - 1. 3.1-3.5 - Rotary Pumps.
 - 2. 3.6 - Rotary Pump Tests.
 - 3. 9.1-9.5 - Pumps - General Guidelines.
- F. National Electrical Manufacturers Association (NEMA).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section have the indicated meaning.
 - 1. 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 3.1-3.5, 3.6, and 9.1-9.5, and as modified in the Specifications.

2. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; average when using multiple suction pressure taps, regardless of variation in individual taps.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.
- C. Rotordynamic analysis.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product Submittals:
 1. As specified in Section 01_60_00 - Product Requirements.
 - a. Product data:
 - 1) Submit seal water pressure and flow requirements.
 - b. Shop Drawings.
 - c. Manufacturer's instructions.
 - d. Calculations:
 - 1) Torsional analysis: As scheduled.
 - e. Schedules.
 2. Submit seal water pressure and flow requirements
- C. Delegated Design Submittals:
 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
- D. Quality Control Submittals:
 1. Rotordynamic Analysis: Submit as specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
 2. Manufacturer's representative qualifications.
 3. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 4. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
 5. Manufacturer's Certificate of Functional Compliance as specified in Section 01_75_17 - Commissioning.
- E. Owner Training Submittals:
 1. As specified in Section 01_75_17 - Commissioning.
- F. Operation and maintenance manuals:
 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_00 - Product Requirements, Section 46_05_10 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 QUALITY ASSURANCE

- A. Provide pumps in this Section from the same manufacturer.
- B. Pump manufacturer to furnish and coordinate pump, driver, and pump components as specified and scheduled and to provide written installation and check out requirements.
- C. Warranty: As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Pump type, split casing: One of the following or equal:
 - 1. Moyno Industrial Products Division of Robbins & Meyers, Inc., Model Series 2000.
 - 2. Netzsch Inc., Model NM.
 - 3. Seepex, BN Series.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. Pump type and components:
 - 1. Rotary, positive displacement, Moineau principle, single screw, progressing cavity type pumps with components.
 - 2. System includes pump, motor, variable frequency drives, or other driver, drive arrangements, 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. Rotordynamic analysis level: As scheduled and as specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
 - 1) Vibration analysis expert: Provide when scheduled.
 - c. Performance tolerances shall be the same as the test tolerances specified in Section 46_05_94 - Mechanical Equipment Testing.
- C. Product requirements as specified in Section 01_60_00 - Product Requirements and Section 46_05_10 - Common Work Results for Mechanical Equipment.

2.03 MATERIALS

- A. Materials in the Pump Schedule shall be the type and grade as specified in this Section.
- B. Cast iron: ASTM A48, Class 30 minimum.
- C. Buna-N: Synthetic rubber with a minimum Durometer hardness of 70 in accordance with ASTM D2240 test methods.
- D. Tool steel: ASTM A681, with 0.020 inch minimum chrome plating thickness oversized and finish to Rockwell hardness of not less than C60.
- E. Stainless steel: ASTM A276, type as scheduled.
- F. Structural steel: ASTM A283, Grade D.

2.04 PUMP CASINGS

- A. Material as scheduled of sufficient strength, weight, and thickness to provide accurate alignment, and prevent excessive deflection.
- B. Split casing:
 - 1. Housing cover one of the following:
 - a. 2-piece split housing for 360-degree access to split coupling rod and pump de-ragging.
 - b. Include 2 rectangular inspection/clean-out ports, 180 degrees apart, to provide access to universal joints and enable de-ragging/unblocking of suction chamber.
- C. Design working pressure: Not less than the maximum of 1.25 times the rated design point head or 1.1 times the maximum discharge pressure at the maximum revolutions per minute in vendor published information for the specified model.
- D. Hydrostatic test: 5-minute hydrostatic test minimum 1.5 times design working pressure.
- E. Suction and discharge piping connections: Flanged in accordance with ASME B16.1, Class 125, or ASME B16.5, Class 150; provide higher pressure class as required to meet design working pressure.
- F. Vent and taps: Provide casings with both 3/4-inch NPT high point vent and low point drain taps.

2.05 STATOR AND ROTOR

- A. Stages: One.
- B. Materials:
 - 1. Stator: Buna-N.
 - 2. Rotor: Alloy Steel 4140 or 4150 - Hard Chrome Plated.

- A. Stator removal: Removable for maintenance replacement.
- B. Rotation: Clockwise looking from driver, unless otherwise indicated on the Drawings.
- C. Balance: As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment to meet the vibration criteria as specified in Section 46_05_94 - Mechanical Equipment Testing.

2.06 DRIVE SHAFTS

- A. Shaft: Hollow or solid.
 - 1. Shaft turned and polished.
 - 2. Pin shaft joints or flexible shafts are not acceptable.
- B. Material: As scheduled.
- C. Joint shall be rated for a minimum of 10,000 hours of operation.
- D. Strength: Able to withstand minimum 1.5 times maximum operating torque and other loads, and of ample strength and stiffness to operate without distortion or vibration which may reduce pump life at normal speeds as shown in the manufacturer's literature.
- E. Resonant frequency: As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment and Section 46_05_94 - Mechanical Equipment Testing.
- F. Shaft connecting rod: Design to limit operating angle to within 1-degree angular deflection.
- G. Shaft-rotor connection:
 - 1. Shaft shall be rigidly connected to the rotor through a connecting rod and grease lubricated, gear type U-joint. Pin joints are not acceptable, except as scheduled.

2.07 BEARINGS AND BEARING FRAME

- A. Bearing type: Mount shaft in 2 sets of antifriction tapered roller bearings or radial ball bearings in accordance with ABMA standards and adequate to withstand radial or axial thrust forces and complying with the following:
 - 1. Inboard set: Single.
 - 2. Outboard set: Dual.
 - 3. Shaft expansion: Make provisions in shaft and bearing mounting to prevent distortion of shaft due to temperature expansion.
- B. Bearing lubrication: Grease with external grease fittings.
 - 1. Size sufficiently to safely absorb heat energy normally generated in bearing under maximum ambient temperature of 60 degrees Celsius.
 - 2. Equip with grease relief pipe.

- C. Bearing life: Minimum L10 life of 100,000 hours at rated design point but not less than 24,000 hours in accordance with ABMA 9 or ABMA 11 at bearing design load imposed by pump shutoff with maximum sized impeller at rated speed.

2.08 SHAFT STUFFING BOX

- A. Size: As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- B. Materials: Same as pump casing.
- C. Shaft seal type: As scheduled and as specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- D. Drain size: Minimum 3/4 inch, with drain line routed to nearest equipment floor drain.

2.09 COUPLINGS

- A. Types: When driver or gear coupled to pump, provide flexible coupling as specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- B. Flexible coupling life: Infinite at up to 0.30-degree misalignment angle total or per disk for disk type at maximum operating loads.
- C. Design coupling to withstand a minimum of 1.5 times the maximum operating torque and other imposed loads.

2.10 SUPPORTS, PEDESTALS, AND BASEPLATES

- A. Type: Single piece base plate with drive arrangement as scheduled and as specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- B. Materials: Structural steel, hot-dip galvanized after fabrication and coated as specified in Section 09_96_01 - High-Performance Coatings.
- C. Pump and driver support strength: Able to withstand minimum 1.5 times maximum imposed operating loads or imposed seismic loads, whichever is greater.
- D. Configuration: Allow easy access to stuffing boxes, bearing frames, suction housing and couplings; suction flange at least 2 inches above pump foundation; factory mount pump and driver to baseplate.
- E. Motor arrangement:
 - 1. For overhead, piggyback or side motor arrangements: Provide motor base with slide rails to allow for adequate belt and alignment adjustment of pump and motor.
 - 2. When in-line motor arrangement scheduled:
 - a. Motor centerline to coincide with pump centerline.
 - b. Provide gearbox as needed to provide specified pump speed.
 - 3. When piggyback or overhead motor arrangement scheduled:
 - a. Support motor directly above pump centerline.

- b. Mount motor minimum of 6 inches above top of pump on structural frame.
- 4. When side-mounted motor arrangement scheduled:
 - a. Mount side-mounted motors adjacent to pump, secured directly to baseplates.
 - b. Provide side-mounted motors “left-handed” or “right-handed” as indicated on the Drawings.

2.11 SPEED REDUCERS

- A. Gear reducers (when scheduled or required for a pump in this Section):
 - 1. Provide with NEMA C face connection between motor and gearbox.
 - 2. Provide helical reduction gears, rated for AGMA Class II service with a 1.5 service factor.
 - 3. Provide oil bath lubricated.
 - 4. As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- B. V-belt drives (when scheduled or required for a pump in this Section):
 - 1. Design to transfer torque of installed driver.
 - 2. Limit speed reduction ratio to 5-to-1.
 - 3. As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.

2.12 EQUIPMENT GUARDS

- A. Provide equipment safety guards as specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.

2.13 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 structural, mechanical, and electrical changes required to accommodate increased horsepower.
- B. Provide motors as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower and as specified in this Section:
 - 1. Revolutions per minute: As scheduled.
 - 2. Enclosure: As scheduled.
 - 3. Electrical characteristics: As scheduled.
 - 4. Efficiency, service factor, insulation, and other motor characteristics: As specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
 - 5. Motor accessories: As specified in Section 26_05_09 - 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.
 - a. Coordinate pump starting torque requirements to ensure supplied variable frequency drive provides sufficient starting torque capacity for all operational conditions, including after extended shutdown periods while in service pumping process fluids and sludge.
- 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.

2.14 FINISHES

- A. Prepare surfaces and apply protective coatings as specified in Section 09_96_01 - High-Performance Coatings.

2.15 SPARE PARTS AND SPECIAL TOOLS

- A. Spare parts:
 1. Provide the following items with each pump:
 - a. Pump thrust bearing set
 - b. Pump radial bearing set
 2. Provide the following items:
 - a. Stator
 - b. Shaft coupling or U-joint
 - c. Motor bearing set
 - d. Rotor
 - e. Mechanical seal
- B. Special tools: Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.

2.16 SOURCE QUALITY CONTROL

- A. Source Testing (Factory Acceptance Tests):
 1. Witnessed, virtual only.
 2. Test as specified in Section 46_05_94 - Mechanical Equipment Testing and the Pump Schedule.
 3. Pump casing: Hydrostatic pressure tests if specified in this Section.
 4. Furnish test reports and the Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. Furnish Manufacturer's Certificate of Installation Verification.

3.03 FIELD QUALITY CONTROL

- A. Functional Testing:
 - 1. Witnessed.
 - 2. Test as specified in Section 46_05_94 - Mechanical Equipment Testing and the Pump Schedule.
 - 3. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.04 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.
 - 1. Number of sessions:
 - a. Operations: 1.
 - b. Maintenance: 1.

3.05 PUMP SCHEDULE

- A. Pump 65-PMP-932 is a "SWING" pump that is normally used as a Thickened Sludge Transfer Pump but can also be used as a Thickened Sludge Feed Pump in the event one or both Thickened Sludge Feed Pumps 65-PMP-941 and 65-PMP-942 are unavailable.
 - 1. The schedule below lists this SWING pump as a Thickened Sludge Feed pump.

<u>Tag Numbers</u>	65-PMP-931	65-PMP-932, 65-PMP-941; 65-PMP-942
<u>General Characteristics:</u>		
Service	Thickened Sludge Transfer	Thickened Sludge Feed
Quantity	1	3
Minimum Pumped Fluid Temperature, degrees Fahrenheit	40	40
Normal Pumped Fluid Temperature, degrees Fahrenheit	70	70
Maximum Pumped Fluid Temperature, degrees Fahrenheit	85	85
Rotordynamic Analysis Level	1	1
Vibration Analysis Expert	Not Required	Not Required
Fluid Viscosity, Maximum Centipoise	-	-
Fluid Viscosity, Minimum Centipoise	-	-
<u>Pump Characteristics:</u>		
Number of Rotor Sealing Stages	1	1
Bearing Lubrication	Grease	Grease
Shaft Seal Type	Type 3	Type 3
Coupling Type	Spacer couplings	Spacer couplings
Speed Control	Constant Torque Variable Frequency Drive	Constant Torque Variable Frequency Drive
Maximum Pump Speed, rpm	250	250
Minimum Pump Speed, rpm	50	50
<u>Rated Design Point (at Maximum Revolutions per Minute):</u>		
Flow, gpm	200	200
Head, feet	43	64
<u>Required Condition 2 (at Maximum Revolutions per Minute):</u>		
Flow, gpm	40	40
Head Range, feet	14	31
<u>Pump Materials:</u>		
Pump Casing	Cast Iron	Cast Iron
Stator	Nitrile	Nitrile
Rotor	Alloy Steel 4140 or 4150 - Hard Chrome Plated	Alloy Steel 4140 or 4150 - Hard Chrome Plated

<u>Tag Numbers</u>	65-PMP-931	65-PMP-932, 65-PMP-941; 65-PMP-942
Shaft	316 Stainless	316 Stainless
Pump Bearing Frame	Cast Iron	Cast Iron
<u>Driver Characteristics:</u>		
Driver Type	Motor	Motor
Drive Arrangement	Close Coupled	Close Coupled
Non-reverse Ratchets	Required	Required
Minimum Driver Horsepower	10	15
Maximum Driver Speed, rpm	1,800	1,800
<u>Motor Characteristics (when motor is driver type):</u>		
Inverter Duty Rated	Yes	Yes
Motor Voltage/Phases/hertz	460/3/60	460/3/60
Enclosure Type	TEFC	TEFC
<u>Source Testing:</u>		
Performance Test Level	1	1
Vibration Test Level	1	1
Noise Test Level	1	1
<u>Functional Testing:</u>		
Performance Test Level	1	1
Vibration Test Level	1	1
Noise Test Level	1	1

END OF SECTION

SECTION 43_25_00.10
SUBMERSIBLE SUMP PUMPS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Requirements for submersible sump pump systems, including pumps, control panels, and level controls.
- B. Tag numbers: As specified in the Pump Schedule.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. A48 - Standard Specification for Gray Iron Castings.
 - 2. A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 3. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
- B. Hydraulic Institute (HI):
 - 1. 9.1-9.5 - Pumps - General Guidelines.
 - 2. 11.6 - Rotodynamic Submersible Pump Tests.
 - 3. 14.1-14.2 - Rotodynamic Pumps for Nomenclature and Definitions.
 - 4. 14.3 - Rotodynamic Pumps for Design and Application.
- C. National Electrical Manufacturers Association (NEMA).

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section have the indicated meaning.
 - 1. Allowable operating region (AOR): 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.
 - 2. Preferred operating region (POR): 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.
 - 3. 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 9.1-9.5, 11.6, 14.1-14.2, 14.3, and as modified in this Section.
 - 4. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; average when using multiple suction pressure taps, regardless of variation in individual taps.

1.04 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.
- C. Rotordynamic analysis.

1.05 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures.
- B. Product Submittals:
 - 1. As specified in Section 01_60_00 - Product Requirements.
 - 2. Product data.
 - a. Include pump curves.
 - 3. Shop Drawings.
 - 4. Manufacturer's instructions.
 - 5. Calculations.
 - 6. Schedules.
- C. Delegated Design:
 - 1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
 - b. For equipment installed outdoors.
- D. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
- E. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_00 - Product Requirements, Section 46_05_10 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

- A. As specified in Section 01_60_00 - Product Requirements.
- B. Factory finish:
 - 1. Exterior cast iron parts:
 - a. Water-thinned industrial enamel.
 - b. 3 to 4 mils.
 - 2. Manufacturer to supply touch-up paint for field use.

2.02 DESIGN AND PERFORMANCE CRITERIA

- A. As specified Section 01_81_50 - Design Criteria and in the Pump Schedule.
- B. Design working pressure: Minimum 1.5 times shut off pressure.

2.03 TYPE 1: SUMP PUMP, GENERAL SERVICE

- A. Suitable for continuous operation:
 - 1. With pump unit dry or unsubmerged at ambient temperature rating.
 - 2. When immersed in water up to 104 degrees Fahrenheit.
- B. Manufacturers: One of the following or equal:
 - 1. Barnes, SE series.
 - 2. ITT Goulds, WS series.
 - 3. Pentair Hydromatic, SKHS series.
- C. Housing:
 - 1. Cast iron: In accordance with ASTM A48, Class 30.
 - 2. Inlet: Open and clear, without screening, capable of passing 2-inch spheres.
 - 3. 3-inch NPT vertical discharge connection.
 - 4. External mating parts shall be machined and Buna-N, O-ring sealed.
 - 5. Fasteners exposed to the pumped liquid: Type 316 stainless steel.
- D. Impeller:
 - 1. Cast iron: In accordance with ASTM A48, Class 30.
 - 2. Two-vane, semi-open.
 - 3. Pump-out vanes on backside.
 - 4. Mechanically locked to shaft.
- E. Bearings:
 - 1. Upper radial and lower thrust bearings required.
 - 2. Single row, oil lubricated.
 - 3. Permanently sealed.
 - 4. Shaft seal:
 - a. Type 21 mechanical seal.
 - 1) Carbon versus ceramic faces
 - 2) Elastomer:
 - a) Buna-N in accordance with ASTM D2000.

- 3) Hardware:
 - a) Type 316 stainless steel in accordance with ASTM A276.
- F. Motor:
 - 1. Oil-filled, NEMA B with horsepower as scheduled.
 - a. 3-phase, 480 volts.
 - b. 1.15 service factor.
 - c. 3,450 revolutions per minute.
 - 2. Shaft: Type 416 stainless steel in accordance with ASTM A276.
 - 3. Insulation:
 - a. 1.5 horsepower and above: Class B.
 - b. Under 1.5 horsepower: Class F.
- G. Power cable:
 - 1. STW sized for motor and length requirements, 16 gauge minimum.
 - 2. Length to reach connection (control panel or junction box) indicated on the Drawings plus 10 feet.
 - a. 20 feet minimum.
- H. Source Quality Control (Factory Acceptance Tests):
 - 1. Visual inspect for imperfections.
 - 2. Check ground continuity.
 - 3. High potential test (Hipot).
 - 4. Air pressure test of housings for motor and volute.
 - 5. Test run to:
 - a. Monitor voltage and current.
 - b. Detect excessive noise.
 - 6. Furnish test reports and the Manufacturer's Certificate of Source Testing.

2.04 VENDOR CONTROL PANEL

- A. As specified in the Pump Schedule.
- B. Construction and components as specified in Section 40_67_01 - Control Systems: Panels, Enclosures, and Panel Components.
- C. Electrical components:
 - 1. Main circuit breaker:
 - a. As specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
 - b. Flange-mounted operator:
 - 1) Pad-lockable in the off position.
 - 2) Disconnects all power to the panel.
 - 3) Interlock with the panel door.
 - 4) Defeat mechanism.
 - 2. Motor starter for each pump:
 - a. Motor circuit protector circuit breaker.
 - b. Full voltage non-reversing magnetic starter.
 - c. Thermal or electronic overloads.
 - 3. Control power transformer:
 - a. Primary voltage: 230/460 VAC, 3-phase, 60 hertz.

- b. Secondary voltages:
 - 1) Control and status points: 120 volts.
 - c. Sized for all panel components plus 10 percent spare capacity.
 - d. Primary and secondary fuses.
- 4. Control components:
 - a. Terminal strips:
 - 1) For landing all external wiring.
 - b. Relays, timers, and other components as required for the specified functionality and remote monitoring connections.
- 5. Simplex operation:
 - a. Front panel controls:
 - 1) HAND/OFF/AUTO switch.
 - 2) START pushbutton.
 - 3) STOP pushbutton.
 - 4) Momentary LOW-LEVEL OVERRIDE pushbutton.
 - 5) Running pilot light.
 - 6) Stopped pilot light.
 - 7) Power pilot light.
 - 8) Pump fault pilot light.
 - 9) High-High-level alarm.
 - b. Remote monitoring and control:
 - 1) Provide dry relay contact outputs for the following:
 - a) Pump fault alarm.
 - b) Pump run status.
 - c) High-High-Level Alarm.
 - c. Operation:
 - 1) HAND:
 - a) START pushbutton starts pump.
 - b) STOP pushbutton stops pump.
 - c) LOW-level switch activation stops pump.
 - (1) Momentary LOW-LEVEL OVERRIDE pushbutton overrides.
 - 2) OFF: Pump stops operation and alarm conditions are re-set.
 - 3) AUTO: Pump operates automatically in response to level switch signals.
 - a) Start when the HIGH-level switch is activated.
 - b) Stop when the LOW-level switch is activated.
 - d. Alarm: High-High alarm with activation of HIGH-HIGH-level switch.
- 6. Duplex operation:
 - a. Front panel controls:
 - 1) HAND/OFF/AUTO switch.
 - 2) LEAD-STANDBY selector switch:
 - a) Designates the lead pump automatic operation.
 - 3) START pushbutton for each pump.
 - 4) STOP pushbutton for each pump.
 - 5) Momentary LOW-LEVEL OVERRIDE pushbutton.
 - 6) Running pilot light for each pump.
 - 7) Stopped pilot light for each pump.
 - 8) Power pilot light.
 - 9) Pump fault pilot light for each pump.
 - 10) High-High-level alarm.
 - 11) Audible alarm horn.

- 12) Alarm beacon:
 - a) Alarm silence pushbutton.
- b. Remote monitoring and control:
 - 1) Provide dry relay contact outputs for the following:
 - a) Pump fault alarm: Each pump.
 - b) Pump run status: Each pump.
 - c) High-High Level Alarm.
- c. Operation:
 - 1) HAND:
 - a) START pushbutton starts pump.
 - b) STOP pushbutton stops pump.
 - c) LOW-level activation stops pump:
 - (1) Momentary LOW-LEVEL OVERRIDE pushbutton overrides.
 - 2) OFF: Pump stops operation and alarm conditions are re-set.
 - 3) AUTO: Pumps operate automatically in response to level switch signals.
 - a) Lead pump starts when HIGH-level switch is activated.
 - b) Lead pump stops when LOW-level switch is activated.
 - c) When lead pump fault alarm is activated, standby pump becomes the lead pump.
 - d) Activation of HIGH-HIGH-level switch activates HIGH-HIGH-level alarm and standby pump becomes the lead pump.

2.05 LEVEL SWITCHES

- A. Type: Ball float.
- B. Cable length: Equal to sump depth to the VCP plus 5 feet.

2.06 ACCESSORIES

- A. Lifting cables:
 - 1. Material: Type 316 stainless steel.
 - 2. Attached to balance point of pump.
 - 3. Suitable for lifting pump from sump.
 - 4. Extend from pump attachment to hanger.
- B. Lifting hangars:
 - 1. Material: Type 316 stainless steel.
 - 2. Suitable to provide storage of extra lift cable and electrical cables at wall sump.

2.07 SPARE PARTS AND SPECIAL TOOLS

- A. As specified in Section 01_60_00 - Product Requirements.
- B. Special tools: For each type or size of pump, provide 1 set.
- C. Touch-up paint: 1 pint of finish coating paint.

PART 3 EXECUTION

3.01 PREPARATION

- A. Anchoring and bracing to structures:
 - 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 - 2. Install anchors of type and material indicated on approved anchoring designs.
 - 3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

- A. Install the equipment in accordance with the accepted installation instructions and anchorage details.
- B. In accordance with the manufacturer's instructions.
- C. Install lifting hanger 3 feet-6 inches above floor.
- D. Remove any extra length of power and control cables at connection point (panel, junction box, or receptacle).
- E. Repair damaged finish with the manufacturer's supply of touch up paint.
- F. Furnish Manufacturer's Certificate of Installation Verification.

3.03 PUMP SCHEDULE

- A. Attributes:

Tag Numbers	65-PMP-981 & 982
<u>General Characteristics:</u>	
Sump Pump Type	Type 1
<u>Rated Performance:</u>	
Total Head, feet	6
Minimum flow, gpm	50
<u>Motor:</u>	
Maximum, hp	1.5
<u>Vendor Control Panel:</u>	
Enclosure	NEMA 4X Stainless Steel
Operation	Duplex

END OF SECTION

SECTION 46_05_10

COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Mechanical equipment requirements for:
 - a. Basic design and performance criteria.
 - b. Prescriptive requirements for common components.
 - c. Installation requirements.

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 Gear Manufacturers Association (AGMA) Standards.
- C. American Petroleum Institute (API):
 - 1. 682 - Pumps—Shaft Sealing Systems for Centrifugal and Rotary Pumps.
- D. 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 and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - 3. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
 - 4. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 - 5. F594 - Standard Specification for Stainless Steel Nuts.
- E. Hydraulic Institute (HI):
 - 1. 9.6.8 - Guideline for Dynamics of Pumping Machinery.
- F. International Concrete Repair Institute (ICRI):
 - 1. Guideline No. 310.2R, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.
- G. International Organization for Standardization (ISO):
 - 1. 21940 - Mechanical Vibration - Rotor Balancing - Part 1: Introduction.
- H. National Electrical Manufacturers Association (NEMA):
 - 1. MG-1 - Motors and Generators.

- I. Society for Protective Coatings (SSPC):
 - 1. SP 1 - Solvent Cleaning.

1.03 TERMINOLOGY

- A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
 - 1. Definitions used in this specification and equipment Submittals for terms related to rotor-dynamic pumps shall be in accordance with HI 9.6.8, Appendix A, as clarified below.
 - 2. These definitions shall be applied to equipment other than pumps, unless otherwise specified in Technical Sections.
 - 3. Resonant frequency:
 - a. Frequency of a periodic excitation force that is close to the natural frequencies of an object. Also known as critical frequency, critical speed, or resonant speed.
 - b. An undamped resonant frequency within the separation margin is always considered harmful under Level 1 analysis.
 - c. A resonant frequency that occurs within a separation margin of 15 percent above or below the operating speed range and has a log decrement greater than +0.3 is considered harmful under Level 2 and Level 3 analysis.
 - 4. Rotordynamic analysis level:
 - a. Level of detail required for rotordynamic analysis is indicated in the Technical Sections schedules as None (no analysis required), Analysis Level 1, Analysis Level 2, or Analysis Level 3, which correlate to increasing levels of required detailed equipment design analysis. Analysis Levels 1, 2, and 3 are based on HI 9.6.8.
 - b. Where these specifications differ from HI the more stringent shall apply.
 - 5. Separation margin:
 - a. Span of operating speeds within which interference between excitation orders and resonant frequencies indicate the possibility of harmful vibrations.
 - b. Separation margin for a specific application extends 15 percent above and 15 percent below the span of operating speed required for the specified performance conditions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Roof coordination.
 - 1. Show roof penetrations for mechanical equipment on roof drawing Submittal and include mechanical equipment information:
 - a. Type.
 - b. Size.
 - c. Location.
 - d. Configuration of penetration and the surround.
 - e. Weight.
 - f. Anchoring and support details.

1.05 SUBMITTALS

- A. Items in this Section are components of equipment or systems specified in other Sections.
 - 1. Include data for this Section's components with the equipment or system Submittal.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

- A. General:
 - 1. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries to provide a complete, operable unit.
 - 2. Manufacturer shall analyze rubber-bearing vertical-column pumps and equipment identified as non-reversing in the Technical Sections for reverse rotation and provide non reversing motor ratchets.
 - 3. Equipment that prevents reverse rotation shall be capable of both:
 - a. Handling 150 percent of the maximum torque at maximum operating speed.
 - b. 150 percent of torque that will be generated in reverse direction due to equipment shutoff head as calculated by the manufacturer.
 - 4. Motor shall be designed to run safely in the reverse direction at up to 140 percent times the reverse runaway speed under shutoff head conditions.
- B. Rotordynamic analysis and vibration testing:
 - 1. Submit information for the rotordynamic analysis level specified for each piece of equipment as shown in the Technical Sections prior to manufacture of the equipment.
 - 2. Rotordynamic analysis shall be performed on "like-new" and "as-worn" conditions, representing conditions when first installed and conditions when parts wear to the manufacturer's maximum allowable operating tolerances.
 - a. Conditions assumed for the "as-worn" condition shall be 2 times the "like new" tolerances unless specified otherwise.
 - 3. Rotordynamic analysis criteria:
 - a. Torsional excitation forcing function magnitudes shall be no less than 1 percent of the maximum transmitted torque at given speed.
 - b. Motor mass elastic information in accordance with NEMA MG-1 shall be obtained from the original equipment manufacturer and included in the analysis. Motors shall be precision balanced to ISO 21940 Grade G2.5.
 - c. Bearings:
 - 1) At maximum bearing loads an L-10 life of 100,000 hours in accordance with ABMA 9-11 to be proven.
 - 4. Submit factory and field testing requirements as specified in the Technical Sections and specified in Section 46_05_94 - Mechanical Equipment Testing after manufacture and installation respectively.

5. Repair, replace, and modify equipment exhibiting vibration performance that does not meet criteria specified in this Section at no additional cost to the Owner.
 - a. Acceptable remedies include adjustments to equipment component geometry, materials, energy absorbing couplings, etc.
 - b. Locking out speed interval(s) within equipment specified operating range is unacceptable.
6. Vibration analysis expert:
 - a. Provide when specified in the equipment Technical Sections.
 - 1) Must be a 3rd party, unaffiliated with the equipment vendor or Contractor.
 - b. Analysis shall be provided by one of the following or equal:
 - 1) Engineering Dynamics Inc. (EDI, Texas).
 - 2) Mechanical Solutions, Inc. (MSI, New Jersey).
 - c. Analysis shall be:
 - 1) Stamped by a registered professional mechanical engineer.
 - 2) Verified in-situ by the vibration analysis expert, including certification that installation conforms to field conditions assumed in the reports.
 - 3) Verified in-situ by the vibration analysis expert, including witness of at least 1 field vibration test, and certification that vibration measurements corroborate the rotordynamic analysis.
 - 4) Supplemented with additional field investigation and analysis should conditions during field vibration testing activity indicate non-compliance with these specifications; supplemental field investigation and analysis shall indicate remedies to comply with the specifications and shall be stamped by a registered professional mechanical engineer.
7. Rotordynamic Analysis Level 1:
 - a. Before the equipment is released for manufacture it shall be determined that the equipment/motor structures do not have any harmful resonant frequencies in the lateral and torsional modes. Representative analysis results for identical equipment may be submitted.
 - b. Calculate rotor lateral and torsional and equipment structural components' lateral frequencies with a spreadsheet calculation or finite element analysis software.
 - 1) Equipment structure lateral frequency shall include the motor.
 - 2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
 - c. Determine the equipment system components (rotor and structure) resonant frequencies.
 - d. An intersection of an equipment component resonant frequency with the 1x run speed excitation order that occurs within separation margin is unacceptable.
8. Rotordynamic Analysis Level 2:
 - a. Before the equipment and motor are released for manufacture it shall be determined that the equipment/motor structures do not have any harmful critical speeds in the lateral and torsional modes.
 - b. Calculate rotor lateral and torsional and structure lateral frequencies with finite element analysis software.
 - 1) Equipment structure lateral frequency shall include the motor.

- 2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
- 3) Rotational inertia of water within the impeller, in the wet well, and inside the equipment structure, e.g., the column of a vertical pump, shall be included in the calculation at both the high level and low level conditions.
- c. Potentially harmful critical speeds shall be investigated further with a forced, damped analysis to determine component stresses do not exceed material properties.
- d. Forced damped analysis:
 - 1) Forced lateral analysis shall include forcing function magnitudes at least 10 percent of rotor disc weight at each disc position and hydraulic imbalance at 5 operating conditions spaced equally over the equipment operating range. If synchronous motors are used ensure that the rotor analysis includes startup, shutdown, and motor control transients.
 - 2) Forced torsional analysis shall include not less than 1 percent of the maximum permitted torque at any given speed. Damping shall be 1 percent of critical at all shaft elements.
 - 3) Equipment rotor total stress (steady-state and alternating torque components plus lateral-bending stresses) shall not exceed:
 - a) Constant torque: Total stress limited to 30 percent of the material fatigue limit and to a maximum of 18 percent of ultimate tensile strength.
 - b) Variable torque (including variable speed equipment): Total stress limited to 50 percent of the material fatigue limit and to a maximum of 4 percent of the material ultimate tensile strength.
 - c) Submit documentation of material fatigue limit.
- e. Report Submittals:
 - 1) Confirmation of compliance with this Section, or detailed exceptions taken.
 - 2) Software used for analysis.
 - 3) Results with interpretation.
 - 4) Preparer's professional engineering stamp and seal.
 - 5) Input data, including component properties, materials and connectivity to other components.
 - 6) Schematic diagram of model mode shapes, nodes and elements.
 - 7) Bearing stiffness and damping properties, impeller/diffuser interaction coefficients, and seal dynamic properties.
 - 8) Campbell diagrams showing the system natural frequencies, excitation orders, and operating speed range for both lateral and torsional analysis.
 - a) Include equipment operating range; excitation lines at 1x, 2x run speed, and vane pass (or equivalent); and critical speeds associated with equipment system components, including the rotor, each major equipment structural component and the motor.
 - 9) Forced, damped analysis indicating acceptable material stress limits are maintained at interference points shown on the Campbell diagram.

9. Rotordynamic Analysis Level 3:
- a. Before the equipment and motor are released for manufacture it shall be determined that the equipment/motor structures do not have any harmful critical speeds in the lateral and torsional modes.
 - b. Calculate rotor lateral and torsional and structure lateral frequencies with finite element analysis software.
 - 1) Equipment structure lateral frequency shall include the motor.
 - 2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
 - 3) Rotational inertia of water within the impeller, in the wet well, and inside the equipment structure, e.g., the column of a vertical pump, shall be included in the calculation at both the high level and low level conditions.
 - c. Potentially harmful critical speeds shall be investigated further with a forced, damped analysis to determine component stresses do not exceed material properties.
 - d. Forced damped analysis:
 - 1) Forced lateral analysis shall include forcing function magnitudes at least 10 percent of rotor disc weight at each disc position and hydraulic imbalance at 5 operating conditions spaced equally over the equipment operating range. If synchronous motors are used ensure that the rotor analysis includes startup, shutdown, and motor control transients.
 - 2) Forced torsional analysis shall include 1 percent of the maximum permitted torque at any given speed. Damping shall be 1 percent of critical at all shaft elements.
 - 3) Equipment rotor total stress (steady-state and alternating torque components plus lateral-bending stresses) shall not exceed:
 - a) Constant torque: Total stress limited to 30 percent of the material fatigue limit and to a maximum of 18 percent of ultimate tensile strength.
 - b) Variable torque (including variable speed equipment): Total stress limited to 50 percent of the material fatigue limit and to a maximum of 4 percent of the material ultimate tensile strength.
 - c) Submit documentation of material fatigue limit.
 - e. Report Submittals:
 - 1) Report 1: Executive Summary, including:
 - a) Confirmation of compliance with this Section, or detailed exceptions taken.
 - b) Software used for analysis.
 - c) Results with interpretation.
 - d) Preparer's professional engineering stamp and seal.
 - e) Campbell diagrams showing the system natural frequencies, excitation orders, and operating speed range for both lateral and torsional analysis.
 - (1) Include equipment operating range; excitation lines at 1x, 2x run speed, vane pass (or equivalent), line- and twice-line frequency, motor-pole frequency, torsional harmonics from reciprocating drivers (including up to 6 times operating speed), control pulse frequencies induced by variable frequency drives (VFDs) (with certification from VFD

- manufacturer of frequencies up to 24 times motor running speed), any torque harmonic greater than 1 percent of steady torque at primary excitation, and synchronous motor requirements; and critical speeds associated with equipment system components, including the rotor and each major equipment structural component.
- f) Report 1 shall not include detailed analysis elements listed for Submittal under Report 2 below, Submittal of full analysis details in Report 1 is unacceptable.
 - g) Following Submittal of Report 1, submit Report 2: Detailed Analysis, including responses to comments made on Report 1: Rotor-dynamic Executive Summary.
- 2) Report 2: Rotor-dynamic detailed analysis, including:
- a) Input data, including component properties, materials and connectivity to other components.
 - b) Schematic diagram of model mode shapes, nodes and elements.
 - c) Bearing stiffness and damping properties, impeller/diffuser interaction coefficients, and seal dynamic properties.
 - d) Forced, damped analysis indicating acceptable material stress limits are maintained at interference points shown on the Campbell diagram.
 - e) Synchronous motor information, including time-integration study results showing transient peak stresses at startup, shutdown and motor control transient events. Provide tomographic diagrams, including root and keyway stress concentration locations and the corresponding speeds that result in reported peak stresses.

2.02 POWER TRANSMISSION SYSTEMS

- A. V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, VFDs, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints:
 - 1. Rated for 24 hour-a-day continuous service, or for intermittent service with frequent stops-and-starts, whichever is most severe.
 - 2. Sized with a service factor of 1.5 or greater:
 - 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, or as specified in the Technical Sections.

2.03 BEARINGS

- A. Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.
 - 1. Design lubrication system based on the equipment location to operate in the temperatures as specified in Section 01_81_50 - Design Criteria.
 - a. To safely start after being shut off for 24 hours and operate safely:
 - 1) Suitable for the outdoor winter temperature as specified in Section 01_81_50 - Design Criteria.

- B. Oil-lubricated:
 - 1. Provide either pressure lubricating system or separate oil reservoir splash-type system as specified in the Technical Section.
 - 2. Design system to safely absorb heat energy generated in bearings when equipment is operating in the following conditions:
 - a. With the highest load and the temperature 15 degrees Fahrenheit above the outdoor summer temperature as specified in Section 01_81_50 - Design Criteria.
- C. Grease lubricated, except those specified to be factory sealed:
 - 1. Fit with easily accessible grease supply, flush, drain, and relief fittings.
 - 2. 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: In accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours.

2.04 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:
 - 1. Anti-static type when explosion-proof equipment or environment is specified.
 - 2. 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.

2.05 FLANGED PIPING CONNECTIONS

- A. Unless specified otherwise in the Technical Sections or indicated on the Drawings, provide flat face flanges.

2.06 ASSEMBLY FASTENERS

- A. General service: Stainless steel, Type 316:
 - 1. Bolts: In accordance with ASTM F593, Alloy Group 2.
 - 2. Nuts: In accordance with ASTM F594, Alloy Group 2.
 - 3. Washers: Alloy group matching bolts and nuts.
- B. High-temperature service or high-pressure service: Stainless steel, Type 316:
 - 1. Bolts: In accordance with ASTM A193, Grade B8M, Class 1, heavy hex.
 - 2. Nuts: In accordance with ASTM A194, Grade 8, heavy hex.
 - 3. Washers: Alloy group matching bolts and nuts.
- C. Low-temperature service: Stainless steel, Type 316:
 - 1. Bolts: In accordance with ASTM A320, Grade B8M, Class 1, heavy hex.
 - 2. Nuts: In accordance with ASTM A194, Grade B8M, heavy hex.
 - 3. Washers: Alloy group matching bolts and nuts.

2.07 GUARDS AT HIGH-TEMPERATURE SURFACES

- A. Exposed surfaces having an external surface temperature of 120 degrees Fahrenheit or higher and located within 7 feet, measured vertically from floor or working level, or within 15 inches measured horizontally from stairways, ramps, or fixed ladders.
- B. Cover with a thermal insulating material unless otherwise guarded against contact.
 - 1. Insulation thickness such that the insulation exterior temperature is below 120 degrees Fahrenheit.

2.08 GUARDS AT MOVING COMPONENTS

- A. On rotating components that are within 7.5 vertical feet of an operating floor or platform.
- B. Allow visual inspection of moving parts without removal.
- C. Allow access to lubrication fittings.
- D. Easily removable for maintenance.
- E. Prevent entrance of rain or dripping water for outdoor locations.
- F. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.
- G. Materials:
 - 1. Sheet metal: Carbon steel, 12-gauge minimum thickness, hot-dip galvanized after fabrication.
 - 2. Fasteners: Type 316 stainless steel.

2.09 SHOP FINISHES

- A. Manufacturer's standard primer and finish coatings.
 - 1. Primer only if field coatings are to be applied.

2.10 GEAR MOTORS

- A. Parallel shaft drives: Helical gearing.
- B. Right-angle drives: Worm gearing.
- C. Manufacturers: One of the following or equal:
 - 1. Baldor Electric Company.
 - 2. Bodine Electric Company.

2.11 GEAR REDUCTION UNITS

- A. Design and performance criteria:
 - 1. Gear type:
 - a. Helical or herringbone.
 - 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.

2.12 MOUNTING AND LIFTING PROVISIONS FOR EQUIPMENT

- A. Equipment bases and base plates:
 - 1. Provide equipment bases with machined support pads, dowels for alignment for mating of adjacent items, openings for electrical conduits, and openings to facilitate grouting.
 - 2. Provide jacking screws in bases and supports for equipment and for equipment weighing 500 pounds or more.
 - 3. Materials:
 - a. Match equipment material or steel.
 - b. Coating: Match equipment.
- B. Steel support frames:
 - 1. Carbon steel:
 - a. At exterior locations and at interior wet or moist locations, provide continuous welds on both sides to close seams and edges between steel members.
 - b. Grind closure welds smooth.
- C. Lifting lugs or eyes:
 - 1. Equipment units weighing 50 pounds or more:
 - a. Provide with lifting lugs or eyes to allow removal with lifting device.

2.13 NAMEPLATES

- A. Fastened to equipment at factory in an accessible and visible location.
- B. Metal engraved or stamped with text, holes drilled or punched for fasteners.
- C. Material: Aluminum or stainless steel.
- D. Fasteners: Number 4 or larger oval head stainless steel screws or drive pins.
- E. Text:
 - 1. Manufacturer's name, equipment model number, equipment serial number, and identification tag number.
 - 2. Additional items indicated in the Technical Sections.
 - 3. Indicate the following additional information as applicable:
 - a. Maximum and normal rotating speed.
 - b. Service class in accordance with applicable standards.
 - 4. 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.
 - 5. Include for motors:
 - a. Drive speed.
 - b. Motor horsepower with rated capacity.
 - 6. Include for gear reduction units:
 - a. AGMA class of service.
 - b. Service factor.
 - c. Input and output speeds.

2.14 PUMP SHAFT COUPLINGS

- A. General:
 - 1. Type and ratings: Non-lubricated 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, balance, and type of service.
 - 3. Suitable for an ambient temperature range between -40 degrees to +200 degrees Fahrenheit.
- B. Close-couplings for electric-motor-driven equipment:
 - 1. Manufacturers: One of the following or equal:
 - a. Lovejoy.
 - b. T.B. Woods.
 - 2. Provide flexible couplings designed to accommodate angular misalignment, parallel misalignment, and end float.
 - 3. Manufacture flexible component of coupling from synthetic rubber or urethane.
 - 4. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
 - 5. Do not allow metal-to-metal contact between driver and driven equipment.
- C. Flexible couplings for direct connected electric-motor-driven equipment:
 - 1. Manufacturers: One of the following or equal:

- a. Rexnord.
 - b. T.B. Woods.
 - 2. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.
 - 3. Provide flexible connecting element of rubber and reinforcement fibers.
 - 4. Provide service factor of 2.0.
 - 5. 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:
- 1. 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.

2.15 PUMP SEAL CHAMBER AND SEALS

- A. Seal chamber (stuffing box):
 - 1. Large enough to retrofit with double mechanical seal.
- B. Seal types: Based on the following and as specified in the Technical Section:
 - 1. Type 1: Packing:
 - a. Provide when specified in the Technical Section for wastewater, non-potable water, and sludge applications:
 - 1) Asbestos free.
 - 2) PTFE (Teflon™) free.
 - 3) Braided graphite.
 - 4) Manufacturers: One of the following or equal:
 - a) Chesterton, 1400.
 - b) John Crane.
 - b. Provide when specified for drinking water service:
 - 1) Asbestos free.
 - 2) Material: Braided PTFE (Teflon™).
 - 3) Manufacturers: One of the following or equal:
 - a) Chesterton, 1725.
 - b) John Crane.
 - c. Design:
 - 1) Packing gland to allow adjustment and repacking without dismantling pump, except to open up stuffing box.
 - 2) Seal chamber (stuffing box) large enough to retrofit with double mechanical seal.
 - 3) Manufacturers: One of the following or equal:
 - a) Chesterton, 1725.
 - b) John Crane.
 - 2. Type 2: Mechanical seal, flushing, cartridge, single O-ring.
 - a. Manufacturers: One of the following or equal:
 - 1) Chesterton, S10.
 - 2) John Crane, 5610 Series.
 - 3. Type 3: Mechanical seal, flushing, cartridge, double O-ring:
 - a. Manufacturers: One of the following or equal:
 - 1) Chesterton, S20.
 - 2) John Crane, 5620 Series.

4. Type 4: Mechanical seal, flushing, cartridge, double split-ring:
 - a. Manufacturers: One of the following or equal:
 - 1) Chesterton, S20.
 - 2) John Crane, 5620 Series.
 5. Type 5: Mechanical seal, flushing, cartridge, single split-ring:
 - a. Manufacturers: One of the following or equal:
 - 1) Chesterton, 442.
 - 2) John Crane, 5860.
 6. Type 6: Mechanical seal, flushless, cartridge, single split-ring:
 - a. Manufacturers: One of the following or equal:
 - 1) Chesterton, 156.
 - 2) John Crane, 3740 Series.
- C. Mechanical seals, Types 2 to 6:
1. Balanced hydraulically.
 2. Spring:
 - a. Stationary, out of pumping fluid.
 - b. Material as specified in the Technical Section. Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
 3. O-ring: Viton™ 747.
 4. Gland: Type 316L stainless steel.
 5. Set screws: Type 316L stainless steel.
 6. Faces: Reaction bonded, silicon carbide/carbon.
 7. Minimum differential pressures in either direction: 300 pounds per square inch gauge.
 - a. Manufacturers: One of the following or equal:
 - 1) Chesterton, 1400.
 - 2) John Crane, equivalent product.
 8. 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.
- D. Flushing system:
1. Provide flushing connections:
 - a. 3/4-inch size.
 - b. Provide API 682 seal water plan arrangement as specified in the Technical Section:
 - 1) Plan 11 - Product stream seal water from discharge thru seal.
 - 2) Plan 13 - Product stream seal water through seal to suction.
 - 3) Plan 23 - Closed loop seal water with cooler and pumping ring.
 - 4) Plan 32 - Production seal water discharged to product stream.
 - 5) Plan 54 - Production seal water excluded from product stream.

2.16 SAFETY SIGNS

- A. Material, sign size, and text: As specified in Section 10_14_00 - Signage.

2.17 SHIPPING

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

3.02 LUBRICATION LINES AND FITTINGS

- A. Support and protect lines from source to point of use.
- B. Fittings:
 - 1. 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.
 - 2. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
 - 3. For underwater bearings: Bring fittings above water surface and mount on edge of structure above.

3.03 ALIGNMENT OF DRIVERS AND EQUIPMENT

- A. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after driven equipment has been leveled on its foundation.

- B. 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:
 - 1. 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).
 - 2. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.
- C. Use reverse-indicator arrangement dial-type or laser-type alignment indicators:
 - 1. Mount on the driver/coupling flange and equipment/coupling flange.
 - 2. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.
- D. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.
- E. When alignment satisfies most stringent tolerance of system components, grout between base and foundation.
 - 1. Allow minimum 48 hours for grout to harden.
 - 2. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
 - 3. Correct alignment as required.

3.04 EQUIPMENT SUPPORT AND ANCHORING TO STRUCTURES

- A. Anchor equipment to structures as indicated on the Drawings and as specified.
- B. Obtain final anchor bolt layouts for equipment prior to:
 - 1. Detailing reinforcement for equipment pads.
 - 2. Preparation of Shop Drawings for metal structures supporting equipment.
- C. Anchor bolt templates:
 - 1. Provide templates as specified in the Technical Sections.
 - 2. Use final anchor bolt layout to construct templates for setting anchor bolts.
 - 3. Make templates:
 - a. Rigid, and non-deformable during use.
 - b. With longitudinal axes of anchors parallel.
 - c. With longitudinal axes of anchors perpendicular to surface supporting the equipment.
 - 4. Templates may be reused for multiple locations of the same equipment only if:
 - a. Templates are in "like-new" condition prior to each reuse.
 - b. Anchor layout has not been deformed or damaged by previous installation, removal, or handling of templates.
 - 5. Sequence:
 - a. Set and support templates prior construction of structures surrounding anchors.

- b. Position anchors in templates to provide designated embedment in supporting structure, with required projection for installation of grout, base plates, and hardware for tightening.
 - c. Construct concrete or masonry around anchors using methods that preserve required anchor positions and alignment, and clearances to edges of supports or structures.
- D. Anchor adjustment sleeves:
 - 1. Use of adjustment sleeves around anchors:
 - a. Is at the option of the Contractor.
 - b. Does not relieve the Contractor of obligation to construct and use templates for setting of anchors.
 - c. May require increased anchor embedment length to develop the strength of the anchor in the embedded length below the adjustment sleeve.
 - 2. Submittal requirements for anchor adjustment sleeves:
 - a. Provide within sufficient time for Engineer approval and not less than 10 working days before setting those items.
 - b. Proposed locations of sleeves.
 - c. Details and dimensions of sleeves.
 - d. Sleeve materials of construction, and coatings.
 - e. Information on sleeve filler material and means of filler removal.
 - f. Type, details, and dimensions of anchor bolts or anchor rods to be used with sleeves.
 - g. Calculations showing development of anchor load capacity below the bottom of the sleeve.
 - h. Plan for removal of sleeve fillers, if any.
 - i. Plan for placement and consolidation of flowable grout inside sleeves and to a level equal to top of concrete slab or equipment pad surrounding the sleeve.

3.05 GROUTING UNDER EQUIPMENT BASES, BASE PLATES, SOLE PLATES, AND SKIDS

- A. General:
 - 1. In accordance with the equipment manufacturer's installation instructions, including:
 - a. Tolerances for level.
 - b. Tolerances for vertical and horizontal alignment.
 - c. Requirements or recommendations for grouting spaces and grout installation.
 - d. Recommendations for tightening of equipment anchors after grout has cured.
 - 2. Install equipment over grout as indicated on the Drawings or specified only after:
 - a. Equipment is leveled and in proper alignment.
 - b. Piping connections are complete and in alignment with no strain transmitted to equipment.
 - 3. Install flowable grout, as specified in Section 03_60_00 - Grouting, placed with forms and head boxes.
 - a. Use flowable, non-shrink cement grout.

- b. Use flowable, non-shrink epoxy grout, only where indicated on the Drawings, where specified in Technical Sections, or when approved in advance by the Engineer.
 - c. Grouting with dry-pack materials is not permitted.
- B. Prepare equipment bases, base plates, soleplates, and skids for grouting:
 - 1. Concrete equipment bases:
 - a. Roughen surface in accordance with ICRI, Guideline No. 310.2R, Surface Preparation Profiles CSP-3 and CSP-4.
 - b. Clean roughened concrete surfaces.
 - 2. Base plates, soleplates, and skids:
 - a. Clean surfaces in accordance with SSPC-SP 1-Solvent Cleaning, to remove dirt, dust, oil, grease, paint, and other material.
- C. Level equipment for grouting:
 - 1. Use removable jack screws, or removable steel wedges and shims to support and level equipment bases, base plates, sole plates, and skids.
 - a. Do not use leveling nuts placed on equipment anchors to support or level equipment bases, base plates, sole plates, and skids.
 - 2. Removable jack screws:
 - a. Provide number, size, and locations of jack screws required to support and level equipment in accordance with the manufacturer's recommendations.
 - b. Drill and tap equipment base plates, sole plates, and skids for jack screws.
 - c. Support jack screws on circular steel plates that have been epoxy bonded to the equipment foundation.
 - 1) Provide plates fabricated from Type 316 stainless steel where edges of support plates will have grout side cover of 3 inches or less in the finished Work.
 - d. Make provision for removal of jack screws after grouting:
 - 1) Prevent grout from bonding to jack screws by wrapping jack screw threads that will be in contact with grout with multiple layers of tape or other material acceptable to the Engineer.
 - e. Place and cure grout.
 - f. After grout is placed and cured:
 - 1) Remove jack screws and material used to prevent grout from bonding to jack screws.
 - 2) Provide jack screws to the Owner for future use.
 - 3) Fill jack screw holes with grout.
 - 4) Cure grout as specified.
 - 3. Removable steel wedges and shims:
 - a. Use for equipment bases, base plates, sole plates, and skids where it is not practical to use jack screws.
 - b. Provide number, size, and locations of wedges and shims required to support and level equipment in accordance with the manufacturer's recommendations.
 - c. Make provision for removal of wedges and shims after grouting:
 - 1) Prevent grout from bonding to wedges and shims by wrapping wedges and shims that contact grout with multiple layers of tape or other material acceptable to the Engineer.
 - 2) Locate and orient wedges and shims to allow for removal after grouting, and to facilitate placement of grout in the remaining voids.

- d. Place and cure grout.
 - e. After grout is placed and cured:
 - 1) Remove wedges and shims, and material used to prevent grout from bonding to them.
 - 2) Fill jack screw holes with grout.
 - 3) Cure grout as specified.
- D. Construct grout forms:
- 1. Provide forms:
 - a. Rigid with adequate strength to withstand placement of grout.
 - b. With surfaces that will produce a smooth, uniform finish for grout edges exposed in the finished Work.
 - c. That allow grout to flow horizontally beyond the perimeter of the equipment base plate a distance not less than the thickness of the grout, and not less than 1 inch.
 - 2. Install forms:
 - a. Seal form cracks and joints with elastomeric sealant to make form watertight.
 - b. Line form surfaces in contact with grout with polyethylene film, or coat with 2 coats of heavy-duty paste wax.
 - 3. Construct grout "head box" over entire length of one side of form.
 - a. Make head box height sufficient to force grout to flow under full dimensions of equipment base and to the surrounding form faces.
- E. Pre-grouting procedures:
- 1. Concrete surfaces receiving flowable, non-shrink cement grout:
 - a. Saturate concrete surface in contact with grout and concrete surfaces extending not less than at least 6 inches beyond limits of grout with clean water for a minimum of 24 hours prior to grouting.
 - b. Just prior to grout placement, remove standing water using clean rags or oil-free compressed air. Provide saturated surface dry (SSD) concrete for grout placement.
 - 2. Concrete surfaces receiving flowable, non-shrink epoxy grout:
 - a. Do not saturate concrete prior to grout placement.
- F. Grout placement and curing:
- 1. Place and cure grout as specified in Section 03_60_00 - Grouting and in this Section.
 - 2. Grouting:
 - a. Keep level of grout in head box above bottom of equipment bases, base plates, sole plates, and skids always to drive flow under base.
 - b. Maintain continuous grout flow from head box to opposite sides of forms without trapping air or forming voids.
 - c. Vibrate, rod, or chain grout to facilitate grout flow, to consolidate grout, and to remove entrapped air.
 - 3. After grout sets, remove forms and trim grout edges at 45-degree angle from bottom edge of equipment bases, base plates, sole plates, and skids.
 - 4. Cure grout as specified in Section 03_60_00 - Grouting.

- G. After grout is cured:
 - 1. Remove jack screws or wedges and shims, and material used to prevent grout from bonding to leveling devices.
 - 2. Fill pockets from removed leveling devices with grout.
 - 3. Cure filled voids as specified in Section 03_60_00 - Grouting.
 - 4. Tighten equipment anchors in accordance with the equipment manufacturer's requirements.

3.06 FIELD FINISHES

- A. When touchup or repair is required, apply primer and coating systems as recommended by the equipment manufacturer.

END OF SECTION

SECTION 46_05_94

MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. American Gear Manufacturers Association:
 - 1. AGMA 6000-B96 - Specification for Measurement of Linear Vibration on Gear Units.
- B. American National Standards Institute (ANSI):
 - 1. S1.4 - Specification for Sound Level Meters.
- C. Hydraulic Institute (HI).
- D. National Institute of Standards and Technology (NIST).

1.03 SUBMITTALS

- A. Provide Source Test Plans as specified in Section 01_75_17 - Commissioning.
- B. Provide Installation and Functional Testing Plans as specified in Section 01_75_17 - Commissioning.
- C. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.
 - 2. Include motor rotor bar pass frequencies for motors larger than 500 horsepower.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. Commissioning of equipment as specified in:
 - 1. This Section.
 - 2. Section 01_75_17 - Commissioning.
 - 3. Equipment sections:
 - a. If testing requirements are not specified, provide Level 1 tests.

- B. Test and prepare piping as specified in Section 40_05_00.09 - Piping Systems Testing prior to equipment 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 specified in Section 01_75_17 - 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. Speed corresponding to the rated maximum capacity.
 - 2. Speed corresponding to the minimum capacity.
 - 3. Speed corresponding to the average operating conditions.

3.03 PUMP TESTS - ALL LEVELS OF TESTING

- A. Test in accordance with the following:
 - 1. Applicable HI standards.
 - 2. This Section.
 - 3. Equipment sections.
- B. Test tolerances: In accordance with appropriate HI standards, except the following modified tolerances apply:
 - 1. From 0 to plus 5 percent of head at the rated design point flow.
 - 2. From 0 to plus 5 percent of flow at the rated design point head.
 - 3. No tolerance for head and flow when ranges are specified.
 - 4. No negative tolerance for the efficiency at the rated design point, and other specified conditions.

5. Use of specified test tolerances shall not result in motor overload while operating at any point on the supplied pump operating head-flow curve, including runout.
6. 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 26_05_09 - 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.

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, 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 revolutions per minute (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) CSI, PeakVue.
 - b) Rockwell Automation, Entek Group, Spike Energy analysis.
 - 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 rpm.
 - h. High speed equipment: Equipment and equipment components operating at or above 600 rpm.
 - 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 rpm; 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) PCB, Model 393C.
 - (2) Wilcoxon Research, Model 797L.
 - 2) For high speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3 dB 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) Entek-IRD, Model 943.
 - (2) Wilcoxon Research, Model 793.
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 rpm or less is not to exhibit unfiltered readings in excess of the 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

Operating Conditions and Application Data	Overall Peak-to-Peak Displacement	
	Field (mils)	Factory (mils)
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 rpm is not to exceed the following peak velocity limits:

HI Pump Type	Horsepower	Field Test	Factory Test
		Overall RMS	Overall RMS
Horizontal Solids Handling Centrifugal Pumps	Below 33 hp	0.25	0.28
Horizontal and Vertical In-Line Centrifugal Pumps (other than Non-Clog type) 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 the 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 the 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 Performance Test:

a. General:

- 1) For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.
- 2) Operate at rated design load conditions.
- 3) Confirm that equipment is properly assembled.
- 4) Confirm the equipment moves or rotates in the proper direction.
- 5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
- 6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

b. Pumps:

- 1) In accordance with general performance test requirements as specified in this Section.
- 2) 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.
 - a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower, or the applicable equipment section.
 - b) Use actual driver for field tests.
- 3) Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.

2. 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.

3. 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 Performance Test:

a. General:

- 1) For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
- 2) Operate at rated design load conditions.
- 3) Confirm that equipment is properly assembled.
- 4) Confirm the equipment moves or rotates in the proper direction.

- 5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
- 6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
- b. Pumps:
 - 1) In accordance with general performance test requirements as specified in this Section.
 - 2) 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.
 - a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
 - b) Use actual driver for field tests.
 - 3) Test for flow and head at 2 additional conditions; one at 25 percent below the rated flow and one at 10 percent above the rated flow.
 - 4) Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.
2. 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.
3. 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 Performance Tests:

a. General:

- 1) For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
- 2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
- 3) Confirm that equipment is properly assembled.
- 4) Confirm the equipment moves or rotates in the proper direction.
- 5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
- 6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
- 7) 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.
- 8) Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.

b. Pumps:

- 1) In accordance with general performance test requirements as specified in this Section.
- 2) Test 4 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test at full speed.
 - a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
 - b) Use actual driver for field tests.
- 3) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
- 4) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.
- 5) Perform efficiency and/or net positive suction head required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
 - a) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
 - b) Perform efficiency testing with test fluids at maximum rated speed.

- c) Perform priming time testing with test fluids at maximum rated speed.
 - 2. 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.
 - 3. Level 3 Noise Test:
 - a. 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 Performance Test:
 - a. General:
 - 1) For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.
 - 2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
 - 3) Confirm that equipment is properly assembled.
 - 4) Confirm the equipment moves or rotates in the proper direction.
 - 5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
 - 6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
 - 7) 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.
 - 8) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
 - b. Pumps:
 - 1) In accordance with general performance test requirements as specified in this Section.

- 2) 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.
 - 3) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
 - 4) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.
 - 5) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
 - 6) Perform efficiency and/or NPSHr and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
 - a) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
 - b) Perform efficiency testing with test fluids at maximum rated speed.
 - c) Perform priming time testing with test fluids at maximum rated speed.
2. Level 4 Vibration Test: Same as Level 3 Vibration Test.
 3. Level 4 Noise Test: Same as Level 3 Noise Test, except with data taken at each operating condition tested.

END OF SECTION

SECTION 46_41_34.01
VERTICAL SHAFT SLUDGE MIXER

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Vertical shaft sludge day tank mixer with anchors and supports and all related equipment for proper operation, including complete drive motor.
- B. Equipment tag numbers:
 - 1. As scheduled.

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 Gear Manufacturers Association (AGMA):
 - 1. 6113-A06 - Standard for Industrial Enclosed Gear Drives.
- C. American Institute of Steel Construction (AISC).
- D. National Electrical Code (NEC)
- E. NSF International (NSF):
 - 1. 61 - Drinking Water System Components - Health Effects.

1.03 DELEGATED DESIGN

- A. As specified in Section 01_35_73 - Delegated Design Procedures.
- B. Anchoring and bracing.

1.04 SUBMITTALS

- A. Furnish Submittals as specified in Section 01_33_00 - Submittal Procedures and Section 01_60_00 - Product Requirements.
- B. Product data.
- C. Shop Drawings:
 - 1. Fabrication, assembly, and mounting drawings showing materials and dimensions as listed below:
 - a. Impellers:
 - 1) Diameter.
 - 2) Maximum shaft speed.

- 3) Tip speed at maximum shaft speed.
 - 4) Materials.
 - 5) Stress at maximum load.
 - 6) Setting elevation.
 - 7) Velocity gradient G at design conditions.
 - 8) Water horsepower at maximum speed.
 - 9) Power number.
 - 10) Flow number.
 - b. Impeller shaft:
 - 1) Diameter.
 - 2) Materials.
 - 3) Critical speed of rotating assembly.
 - 4) Torsional and bending stresses at maximum load.
 - 5) Coupling details:
 - a) Showing that the drive unit may be removed while the impeller shaft and impeller remain in service.
 - 6) Impeller connection details.
 - 7) Revolutions per minute at maximum motor speed.
 - c. Gear reducers:
 - 1) Manufacturer's literature and drawings.
 - 2) Model number.
 - 3) AGMA horsepower rating.
 - 4) Materials.
 - 5) Efficiency.
 - 6) Bearing ratings.
 - 7) Lubrication details.
 - 8) Bearing life under maximum loading conditions.
 - d. Motor data as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
 - e. Support design information:
 - 1) Weight of complete assembly.
 - 2) Impeller shaft and impeller weight.
 - 3) Torque load.
 - 4) Anchorage bolt calculations. Setting drawings and instructions for installation of anchor bolts and gear reducer, including tolerances.
 - f. Electrical Information.
 - 1) Wiring diagrams showing electrical connections to motor.
 - 2) Loop diagrams and control descriptions.
- D. Calculations:
1. Substantiate that the proposed flocculator will transmit the required energy to the process water.
- E. Documentation showing all lubricants are food grade or NSF H1 approved.
- F. Delegated Design Submittals:
1. Provide project-specific PE stamped calculations based on support conditions and requirements to resist loads specified in Section 01_81_50 - Design Criteria.
 - a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.

- b. For equipment installed outdoors.
- G. Installation instructions:
 - 1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
 - 2. Provide manufacturer's installation instructions.
- H. Quality Control Submittals:
 - 1. Manufacturer's representative qualifications.
 - 2. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 3. Manufacturer's Certificate of Installation Verification as specified in Section 01_75_17 - Commissioning.
 - 4. Manufacturer's Certificate of Functional Compliance as specified in Section 01_75_17 - Commissioning.
- I. Owner Training Submittals:
 - 1. As specified in Section 01_75_17 - Commissioning.
- J. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_24 - Operation and Maintenance Manuals.

1.05 QUALITY ASSURANCE

- A. Manufacturer's qualifications:
 - 1. Manufactured in the United States with minimum 5 years of experience of producing substantially similar equipment.
 - 2. Member of AGMA.
- B. Component supply and compatibility:
 - 1. Gear reducers shall be manufactured by the mixing equipment manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_00 - Product Requirements, Section 46_05_10 - Common Work Results for Mechanical, and the manufacturer's instructions.
- B. Packing:
 - 1. Inspect prior to packing. Verify that assemblies and components are complete and undamaged.
 - 2. Protect machined surfaces and mating connections.
 - 3. Protect bearings and gearing with a shop applied corrosion prevention coating.
 - 4. Cover openings into gearboxes with vapor inhibiting and water repellent material.
 - 5. Crate in a manner that will prevent damage during shipment, delivery, and on-site storage.
 - 6. Identify crate contents by a packing slip fastened to outside of crate.
- C. Store materials to permit easy access for inspection and identification.
- D. Keep steel members off ground, using pallets, platforms, or other supports.

- E. Protect steel members and packaged materials from corrosion and deterioration.
- F. Store in loose covered breathable storage area off the ground to prevent condensation.
 - 1. Use of plastic sheeting will not be allowed.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 01_81_50 - Design Criteria.

1.08 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

1.09 MAINTENANCE

- A. Provide 1 set of any special tools required for maintenance or operation.
- B. Spare parts for each size or type of mixing unit:
 - 1. Include 1 repair kit, including bearings, shims, gaskets, seals, retaining rings, packing rings, and adaptor sleeves.
 - 2. One spare impeller assembly with fasteners for each different type of mixer.
- C. Provide 1-year supply of bearing grease or oil for all units furnished, including the lubricant changes after the initial run-in period.
- D. Package and deliver spare parts as specified in Section 01_60_00 - Product Requirements.

PART 2 PRODUCTS

2.01 GENERAL

- A. Each mixer shall consist of a motor driven gear reducer directly connected to a vertical shaft equipped with an impeller.
- B. Design the equipment for uncovered, outdoor exposure all weather condition including wind, rain, and freezing temperatures as specified in Section 01_81_50 - Design Criteria.

2.02 MANUFACTURERS

- A. One of the following or equal:
 - 1. SPX; Lightnin, Series 70.
 - 2. SPX; Philadelphia Mixer, Series 3800.
 - 3. Chemineer, Series HT
 - 4. Mix-Tec; Model Type 1000

2.03 DESIGN AND PERFORMANCE CRITERIA

- A. Design the equipment for uncovered outdoor exposure to all weather conditions, including wind, rain, and freezing temperatures.
- B. Design mixers for operation in mixing vessels, as indicated on the Drawings, and for the following requirements:

Mixing Equipment Item	Mixers No. 1 and No. 2	Notes
Number Required, Each	2	
Equipment Tag Number	65-MIX-981 and 65-MIX-982	
Top Slab Elevation, feet	4884.0	To top of equipment pad on deck.
Mixing Chamber Floor Elevation, feet	4861.5	At the bottom of wall.
Mixing Center Sump Elevation, feet	4860.17	
Mixing Chamber Dimensions, Width by Length, feet	22 x 30	
Mixing Chamber Water Depth, feet Range:	3 to 19	From center sump.
Flow Rate per Mixing Chamber, GPM Design: Range:	150 50 to 200	
Mixing Chamber Design Water Volume, gals/cell.	93,805	
Water Temperature, Deg. C	4	
Maximum Power Number		
Number of Impellers	2	Two impellers for variable level mixing.
Impeller Type, Upper	Hydrofoil	
Impeller Type, Lower	Vertical Flat	
Pumping Direction	Down	
Number of Blades, Min., each	3 or 4	
Diameter, Min., inch	88	
Speed, Max., rpm	37	
Motor Power, Min., hp	15	
Motor Speed, Max., rpm	1,800	
Motor Speed Control	VFD	
Minimum Speed Turndown	4:1	

2.04 DRIVE ASSEMBLY

- A. Drive units:
 - 1. Designed for the specific requirements of mixer service and suitable for 24 hour a day operation.
 - 2. Gear drive efficiency: Not less than 90 percent.
- B. Pinion mounted directly on motor shaft:
 - 1. Prohibited.
- C. Lifting lugs:
 - 1. Provide on each motor and each speed reducer.
 - 2. Designed and located to permit lifting complete mixer and drive unit, or each component separately.
- D. Electric motor and speed reducer:
 - 1. With flexible coupling provided between motor and speed reducer.
 - 2. Electric motor shall be readily separated from speed reducers.
- E. Speed reducer:
 - 1. Furnished with independent bearing support construction.
 - 2. Designed and rated and nameplated in accordance with AGMA 6113-A06 with minimum service factor of 2.0 based on motor nameplate horsepower.
 - 3. Housing constructed of close grain cast iron or steel weldments.
 - 4. Unit capable of supporting overhung loads.
 - 5. Provided unit with a suitable lubrication system for all weather starting and operation.
- F. Speed reducer output shaft:
 - 1. Constructed and supported such that shaft deflections caused by operating loads do not affect alignment of antifriction bearings or cause misalignment of gearing during mixer operation.
- G. Gearing systems:
 - 1. Utilize precision ground, alloy steel, spiral bevel, and helical gear combinations.
 - 2. Reducers employing worm gearing will not be acceptable.
- H. Lubrication:
 - 1. Provide splash type or immersion type oil lubrication from a common sump for gearing.
 - 2. NSF H1 approved, or food grade lubricants.
 - 3. Oil changes shall not be required at an interval of less than 2,500 hours following initial run in period.
 - 4. Oil leakage down the low speed shaft shall be prevented by means of a stationary non-contacting dry well.
 - 5. Lubrication fill and drain lines shall be sized for efficient functioning and located for easy accessibility.
 - 6. Speed reducer breather shall be located above possible oil foam level.
 - 7. Provide an oil level gauge or dipstick and drain.
 - 8. Oil drain shall be extended from drive with a valve to prevent leakage and spillage during oil changes.

- I. External cooling:
 - 1. External cooling to dissipate heat is prohibited.
 - 2. Reducers requiring internal or external oil pumps are prohibited.
- J. Flanged pedestal:
 - 1. Provided for mounting speed reducer to base plate.
- K. Bearings:
 - 1. Antifriction type with minimum L10 life of following hours as defined by ABMA 9 and ABMA 11:
 - a. Typical: 100,000 hours.
 - b. Output shaft bearings: 300,000 hours.
 - c. Bearing life: Based on rated motor nameplate horsepower.
- L. Allowance for vacuum processed metals or special processing techniques:
 - 1. None.
- M. General maintenance, specifically including motor changes, gear changes, replacement of antifriction bearings (except bearings supporting output shaft), and oil system maintenance:
 - 1. Does not require removal of speed reducer housing from speed reducer housing foundation.
- N. Sound level:
 - 1. Maximum 85 dBA at 3 feet from drive assembly at operating speeds.

2.05 MOTORS

- A. As specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower:
 - 1. Horsepower: As scheduled.
 - 2. Speed: As scheduled.
 - 3. Enclosure: TEFC.
 - 4. Electrical characteristics: 460-volts, 3-phase, 60 hertz.
 - 5. Insulation: Class F.
 - 6. Inverter duty rated.
 - 7. Ambient temperature: 50 degrees Celsius.
 - 8. Severe duty.
 - 9. Winding temperature sensors: Thermostat type for motor shutdown protection.
 - 10. Direct connected to input shaft of speed reducer with a torsionally resilient flexible coupling, Falk Steelflex or equal.
 - 11. Efficiency, service factor, insulation, and other motor characteristics as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
 - 12. Motor accessories as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.

2.06 IMPELLER

- A. Type: As scheduled.
- B. Material:
 - 1. Fabricate from Type 316 stainless steel.
 - 2. Use Type 316L stainless steel grade for assemblies fabricated by welding.
- C. Stress at maximum load: Not greater than 11,000 pounds per square inch.
- D. Unit: With high pumping characteristics, dynamically and hydraulically stable.
- E. Use of shaft stabilizers is not acceptable.
- F. Impeller shall be keyed to shaft and field removable.
- G. Setting:
 - 1. Between 0.75 and 1.00 impeller diameters above floor of mixing chamber unless otherwise indicated on the Drawings.
 - 2. Field adjustable in increments of 3 inches or smaller, total adjustment capability not less than 18 inches.

2.07 IMPELLER SHAFT

- A. Diameter:
 - 1. As determined by analysis of torque, bending moment and the critical speed.
 - 2. Combined bending and torsional stress at maximum load not to exceed 6,000 pounds per square inch.
 - 3. First lateral critical speed of shaft, impeller, and bearing system not less than 170 percent of maximum operating speed.
- B. Strength of shaft, impellers, and couplings: As determined by the manufacturer's detailed structural calculations in accordance with AISC, including effects of specified flows through mixing chambers.
- C. Vertical shafting for impeller assembly: Of ample size and design for service intended and supported and steadied so that unit operates without shaft whip or vibration.
- D. Shaft:
 - 1. Supported on antifriction bearings, carrying only impeller shaft loads, and including thrust bearing capable of supporting entire weight of vertical impeller shaft and impeller.
 - 2. Shafts shall be of solid type made from Type 316 stainless steel.
 - 3. Output shaft shall be totally overhung.
 - a. Bearings external to the speed reducer are not acceptable.
 - b. When turned by hand, impeller shaft run out or deflection shall not exceed 1/8 inch per 10 feet of length.

- E. Rigid type couplings:
 - 1. As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
 - 2. Designed to transmit 200 percent of full torque and 150 percent of axial load on coupling.
 - 3. Mounting:
 - a. Mount coupling above the deck.
 - b. Design for maintenance access to flange bolts from deck level to remove (drop) shaft without disturbing the gear reducer or internal components.
 - c. Fabricate upper coupling half of steel and lower coupling half of Type 316L stainless steel.
 - 4. Below mounting deck level:
 - a. Required when shaft length exceeds 20 feet. Space couplings to limit shaft sections to 20 feet maximum.
 - b. Fabricate from Type 316L stainless steel.
 - 5. Coupling flanges: Turned and faced after being welded in place and provided with a rabbeted or registered fit.
 - 6. Coupling halves: Bolted together through flanges with Type 316 stainless steel bolts.
 - 7. Removal of drive unit:
 - a. Design and submit a blocking plate that allows the entire drive unit to be removed while the impeller shaft and impeller remain suspended from the concrete deck, allowing the installation of a standby drive unit.

2.08 FINISHES

- A. Shop prime and field finish coat ferrous metals as specified in Section 09_96_01 - High-Performance Coatings.
- B. Motors, speed reducers, and other components that could be damaged by blast cleaning may be furnished with the manufacturer's standard coating system, when approved by the Engineer.
- C. Coat gears, bearing surface and similar ferrous metal surfaces that are to remain unpainted with a heavy application of rust resistant coating.
 - 1. Maintain coating during storage and until equipment is placed in operation.

2.09 SOURCE QUALITY CONTROL

- A. Source Testing (Factory Acceptance Tests):
 - 1. As specified in Section 01_75_17 - Commissioning.
 - 2. Not witnessed.
 - 3. As specified in Section 46_05_94 - Mechanical Equipment Testing.
 - 4. Testing requirements:
 - a. Test 1 flocculator of each size to determine the horsepower it will transmit to the water.
 - 1) Testing shall be by measuring the torque developed.
 - 2) Make measurements at a minimum of 5 points (20, 40, 60, 80, 100 percent) over the speed range, which will be used to produce the velocity gradients specified below.

- 3) Prepare a water horsepower-speed curve with test water temperature shown.
- 4) Measure and record for each test run:
 - a) Motor revolutions per minute.
 - b) Torque on the drive shaft of the flocculator.
 - c) Remarks.
- b. Demonstrate that the power demand of each drive motor, at any speed setting of the drive, does not exceed the nameplate horsepower or nameplate full load ampere rating.
 - 1) Demonstrate each flocculator to be capable of speed variation required without undue noise vibration or shaft whip.
- c. Running test: Operate gear reducer at maximum speed using a rust inhibiting break in oil prior to shipment to check for proper operation and excessive noise and vibration.
- d. Visual inspection. Verify that equipment complies with Specifications and approved Shop Drawings.
5. Furnish test reports and the Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 PREPARATION

- A. Anchoring and bracing to structures:
 1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
 2. Install anchors of type and material indicated on approved anchoring designs.
 3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

- A. Install equipment in accordance with the accepted installation instructions and anchorage details.
- B. Install speed reducers on carbon steel mounting plates.
 1. Set, level and plumb, and grout plates with non-shrink cement grout as specified in Section 03_60_00 - Grouting.
- C. Install initial supply of break in and final lubricants as recommended by the manufacturer.
- D. Furnish Manufacturer's Certificate of Installation Verification.

3.03 FIELD QUALITY CONTROL

- A. Functional Testing:
 1. Witnessed.
 2. Equipment testing:
 - a. Demonstrate that power demand of each drive motor does not exceed nameplate horsepower or nameplate full load ampere rating.

- b. Demonstrate each mixer to be capable of operation without undue noise, vibration, or shaft whip over complete range of operating speeds.
 - 1) Adjust, repair, or replace defective equipment.
 - c. Furnish necessary equipment required for testing, properly calibrated.
- 3. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.04 OWNER TRAINING

- A. Perform Owner Training as specified in Section 01_75_17 - Commissioning.
 - 1. Number of sessions:
 - a. Operations: 1.
 - b. Maintenance: 1.

END OF SECTION

