PROJECT MANUAL

VOLUME II OF II

CITICO PUMP RELIABILITY IMPROVEMENTS

CONTRACT NO. W-16-013-201

MAYOR AND CITY COUNCIL

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CITY OF
CHATTANOOGA, TENNESSEE

APRIL 2017
ISSUED FOR CONSTRUCTION

BURNS McDONNELL

CITICO PUMP RELIABILITY IMPROVEMENTS

CITY OF
CHATTANOOGA, TENNESSEE

CITY OF CHATTANOOGA
PUBLIC WORKS DEPARTMENT
ENGINEERING DIVISION

CERTIFICATION AND SEAL

I hereby certify that the Project Drawings and the Contract Documents and Specifications for the following contract were prepared by me or under my direct supervision, and I am a duly registered engineer or architect under the laws of the state in which these projects are located:

CITICO PUMP RELIABILITY IMPROVEMENTS

CONTRACT NO. W-16-013-201

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APPROVED FOR RELEASE

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City Engineer

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Appendices

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section includes:

1. Trap-seal primer systems.

1.03 Reference Standards

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

B. ASME International (ASME):

1. ASME A112.1.2 - Air Gaps in Plumbing Systems (for Plumbing Fixtures and Water-Connected Receptors).
2. ASME A112.18.1 - Plumbing Supply Fittings.
3. ASME B1.20.7 - Hose Coupling Screw Threads, Inch.

C. ASTM International (ASTM):

1. ASTM B62 - Specification for Composition Bronze or Ounce Metal Castings.
2. ASTM B88 - Specification for Seamless Copper Water Tube.
3. ASTM B88M - Specification for Seamless Copper Water Tube [Metric].

D. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):

1. MSS SP-80 - Bronze Gate, Globe, Angle and Check Valves.
2. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

E. NFPA:

1. NFPA 70 - National Electrical Code.

F. NSF International (NSF):

1. NSF 61 - Drinking Water System Components - Health Effects; Sections 1 through 9 (ANSI).

2. NSF 372 – Drinking Water System Components – Lead Content

G. Plumbing & Drainage Institute (PDI):

1. PDI-WH 201 - Water-Hammer Arresters.

1.04 Submittals

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.

1. Include layout of piping between trap-seal primer and trap to be protected.

C. Field quality-control reports.

D. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - Products

2.01 General Requirements for Piping Specialties

A. Potable-water piping and components shall comply with NSF 61 and 372.

2.02 Performance Requirements

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig (860 kPa), unless otherwise indicated.

2.03 Trap-Seal Primer Device

A. Continuous Flow, Trap-Seal Primer Device:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. MIFAB, Inc.

    b. Precision Plumbing Products, Inc.

    c. Sioux Chief Manufacturing Company, Inc.

    d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.

    e. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.

2. Standard: ASSE 1018.

3. Pressure Rating: 125 psig (860 kPa) minimum.

4. Body: Bronze.

5. Inlet and Outlet Connections: NPS 1/2 (DN 15) threaded, union, or solder joint.

6. Gravity Drain Outlet Connection: NPS 1/2 (DN 15) threaded or solder joint.

7. Finish: Rough bronze.

PART 3 - Execution

3.01 Installation

A. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1%, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.02 Connections

A. Comply with requirements for piping specified in other DIVISION 22 sections. Drawings indicate general arrangement of piping, fittings, and specialties.

3.03 Labeling and Identifying

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

    1. Supply-type, trap-seal primer valves.

3.04 Field Quality Control

A. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

B. Prepare test and inspection reports.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section includes:

1. Floor drains.

B. Applicable Standards (Latest Edition):

1. ASME International (ASME):
    a. ASME A112.6.3 - Floor Drains.

1.03 Quality Assurance

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - Products

2.01 Floor Drains

A. Stainless-Steel Floor Drains

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Josam Company; Josam Div.
    b. Watts Drainage Products, Inc.
    c. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.6.3.
3. Outlet: Bottom.
4. Top or Strainer Material: Stainless-steel.
5. Top Shape: Round.
6. Dimensions of Top or Strainer: 4.0”.

7. Anchor Flange: Required.

8. Trap-Primer Connection: Required.

9. Trap Material: Stainless-steel.

10. Trap Pattern: Deep-seal P-trap.

PART 3 - Execution

3.01 Installation

A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

  1. Position floor drains for easy access and maintenance.

  2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:

    a. Radius, 30 Inches (750 mm) or Less: Equivalent to 1% slope, but not less than 1/4 inch (6.35 mm) total depression.

    b. Radius, 30 to 60 Inches (750 to 1500 mm): Equivalent to 1% slope.

    c. Radius, 60 Inches (1500 mm) or Larger: Equivalent to 1% slope, but not greater than 1 inch (25 mm) total depression.

  3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.

  4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

B. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

  1. Exception: Fitting may be omitted if trap has trap-seal primer connection.

  2. Size: Same as floor drain inlet.

3.02 Connections

A. Install piping adjacent to equipment to allow service and maintenance.

B. Ground equipment according to Division 26.

C. Connect wiring according to Division 26.

3.03 Field Quality Control

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.04 Protection

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when Work stops.

END OF SECTION

PART 1 - General

1.01 Related documents:

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

1.02 Summary:

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.03 Reference standards:

A. Applicable Standards (latest edition):

1. The Institute of Electrical and Electronics Engineers, Inc. (IEEE):

    a. IEEE 841-2009 - Standard for Petroleum and Chemical Industry - Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500 hp).

2. National Electrical Manufacturers Association (NEMA):

    a. NEMA MG 1 - Motors and Generators.

1.04 Coordination:

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.

2. Torque, speed, and horsepower requirements of the load.

3. Ratings and characteristics of supply circuit and required control sequence.

4. Ambient and environmental conditions of installation location.

PART 2 - Products

2.01 General motor requirements:

A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

2.02 Motor characteristics:

A. Duty: Continuous duty at ambient temperature of 40º and at altitude of 560 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.03 Polyphase motors:

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Rotor: Random-wound, squirrel cage.

E. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating.

G. Insulation: Class F.

H. Code Letter Designation:

   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.

   2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

I. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.04 Polyphase motors with additional requirements:

A. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.

   2. Bearing Protection: All motors operated on variable frequency drives shall be equipped with maintenance free, 360 degree circumferential conductive micro fiber shaft grounding ring with a minimum two continuous rows of conductive micro fibers completely surrounding the motor shaft to discharge electrical shaft

voltages away from the motor's bearings to ground. Note: Friction/spring contact brushes shall not be acceptable.

3. Application Note: Motors up to 100HP shall be provided with a minimum of one shaft grounding ring as described above installed by the manufacturer internally to the motor or externally on the drive end. Motors over 100HP shall be provided with an insulated bearing on the non-drive end and a shaft grounding ring on the drive end of the motor. Grounding rings shall be provided and installed by the motor manufacturer or contractor and shall be installed in accordance with the manufacturer's recommendations.

4. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.

5. Inverter-Duty Motors: Class F temperature rise; Class H insulation.

6. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

B. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.05 Single-phase motors:

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

   1. Permanent-split capacitor.

   2. Split phase.

   3. Capacitor start, inductor run.

   4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - Execution (not applicable)

END OF SECTION

PART 1 - General

1.01 Summary:

A. This Section includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.

1.02 Related requirements:

A. SECTION 233113 - METAL DUCTS and SECTION 233116 - NONMETAL DUCTS for duct hangers and supports.

1.03 Reference standards:

A. Applicable Standards (Latest Edition):

1. American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI):
    a. ASCE/SEI 7 - Minimum Design Loads for Buildings and Other Structures.
2. American Welding Society (AWS):
    a. AWS D1.1/D1.1M - Structural Welding Code - Steel.
3. ASME International (ASME):
    a. ASME B31.9 - Building Services Piping.
    b. ASME Boiler and Pressure Vessel Code - Section IX, "Welding and Brazing Qualifications."
4. ASTM International (ASTM):
    a. ASTM A36/A36M - Specification for Carbon Structural Steel.
    b. ASTM A780 - Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
    c. ASTM C533 - Specification for Calcium Silicate Block and Pipe Thermal Insulation.
    d. ASTM C552 - Specification for Cellular Glass Thermal Insulation.

        e. ASTM C591 - Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.

        f. ASTM C1107 - Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).

    5. Manufacturers Standardization Society of The Valve and Fittings Industry, Inc. (MSS):

        a. MSS SP-58 - Pipe Hangers and Supports - Materials, Design and Manufacture.

        b. MSS SP-69 - Pipe Hangers and Supports - Selection and Application.

        c. MSS SP-89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

    6. Metal Framing Manufacturers Association, Inc. (MFMA):

        a. MFMA-4 - Metal Framing Standards Publication.

        b. MFMA-103 - Guidelines for the Use of Metal Framing.

    7. The Society for Protective Coatings (SSPC):

        a. SSPC-PA 1 - Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel.

1.04 Definitions:

A. MSS: Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.

1.05 Performance requirements:

A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

    1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

    2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

    3. Design seismic-restraint hangers and supports for piping and equipment [and obtain approval from authorities having jurisdiction].

1.06 Submittals:

A. Product Data: For each type of product indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include layout drawings and Product Data for components:

1. Trapeze pipe hangers.

PART 2 - Products

2.01 Metal pipe hangers and supports:

A. Description: MSS SP-58, Types 1 through 58 (except as noted in Part 3 - Execution), factory-fabricated components.

B. Galvanized Metallic Coatings: Pre-galvanized or hot-dipped.

C. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.02 Trapeze pipe hangers:

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.03 Miscellaneous materials:

A. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.

2. Design Mix: 5,000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - Execution

3.01 Hanger and support installation:

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. The following figure types given in Figure 1 of MSS SP-69 will not be acceptable: Types 5, 6, 7, 9, 10, 11, 12, 16, 19, 20, 23, 25, 27, 28, 29, and 30. However, Types 7, 9, 10, 11, 19, and 23 may be used for nonferrous and plastic piping systems 2 inches and smaller.

C. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.

2. Field fabricate from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

D. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

E. Install lateral bracing with pipe hangers and supports to prevent swaying.

F. Install building attachments within concrete slabs or attach to structural steel. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

G. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

H. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

I. Insulated Piping:

1. Attach clamps and spacers to piping.

a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.

b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.

c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

3.02 Metal fabrications:

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with qualified procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.03 Adjusting:

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.04 Painting:

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

3.05 Hanger and support schedule:

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

D. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Exception: The following figure types given in Figure 1 of MSS SP-69 will not be acceptable: Types 5, 6, 7, 9, 10, 11, and 12. However, Types 7, 9, 10, and 11 may be used for nonferrous and plastic piping systems 2 inches and smaller.

2. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).

3. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Exception: The following figure type given in Figure 1 of MSS SP-69 will not beacceptable: Type 16.

2. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following type

1. Exception: The following figure types given in Figure 1 of MSS SP-69 will not be acceptable: 19, 20, 23, 25, 27, 28, 29, 30, and 34.

2. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

4. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

5. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 pounds (340 kg).
    b. Medium (MSS Type 32): 1,500 pounds (680 kg).
    c. Heavy (MSS Type 33): 3,000 pounds (1360 kg).
6. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
7. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25% to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25% to allow expansion and contraction of piping system from base support.

7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25% to allow expansion and contraction of piping system from trapeze support.

8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

   a. Horizontal (MSS Type 54): Mounted horizontally.

   b. Vertical (MSS Type 55): Mounted vertically.

   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

L. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

M. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION

PART 1 - General

1.01 Related documents:

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

1.02 Summary:

A. This Section includes:

1. Equipment labels.
2. Pipe labels.
3. Duct labels.

1.03 Reference standards:

A. Applicable Standards (Latest Edition):

1. ASME International (ASME):
    a. ASME A13.1 - Scheme for the Identification of Piping Systems.

1.04 Submittals:

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.05 Coordination:

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - Products

2.01 Equipment labels:

A. Metal Labels for Equipment:

1. Material and Thickness: Stainless steel, 0.025 inch (0.64 mm) minimum thickness, and having predrilled or stamped holes for attachment hardware.

2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inches (64 by 19 mm).

3. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

4. Fasteners: Stainless-steel rivets or self-tapping screws

5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.

2. Letter Color: BlackBackground Color: White

3. Maximum Temperature: Able to withstand temperatures up to 160ºF (71ºC).

4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inches (64 by 19 mm).

5. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

6. Fasteners: Stainless-steel rivets or self-tapping screws.

7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2 by 11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 Pipe labels:

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

2. Lettering Size: At least 1-1/2 inches (38 mm) high.

2.03 Duct labels:

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black Background Color: White

C. Maximum Temperature: Able to withstand temperatures up to 160ºF (71ºC).

D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inches (64 by 19 mm).

E. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

F. Fasteners: Stainless-steel rivets or self-tapping screws.

G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

H. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.

2. Lettering Size: At least 1-1/2 inches (38 mm) high.

PART 3 - Execution

3.01 Preparation:

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.02 Equipment label installation:

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.03 Pipe label installation:

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.

4. At access doors, manholes, and similar access points that permit view of concealed piping.

5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 ft. (15 m) along each run. Reduce intervals to 25 ft. (7.6 m)in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Pipe Label Color Schedule:

1. Refrigerant Piping:

   a. Background Color: Yellow

b. Letter Color: Black.

3.04 Duct label installation:

A. Install plastic-laminated duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue For cold-air supply ducts.

2. Yellow For hot-air supply ducts.

3. Green For exhaust-, outside-, relief, return, and mixed-air ducts.

4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 ft. (15 m)in each space where ducts are exposed or concealed by removable ceiling system.

END OF SECTION

PART 1 - General

1.01 Related documents:

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

1.02 Summary:

A. This Section includes:

1. Balancing Air Systems:
   a. Constant-volume air systems.
2. Other Systems/Equipment:
   a. Motors.
   b. Condensing units.
3. Existing System:

1.03 Reference standards:

A. Applicable Standards (latest edition):

1. Air Movement and Control Association International Inc. (AMCA):
   a. 201 - Fans and Systems.
2. American National Standards Institute (ANSI):
   a. S1.4 - Specification for Sound Level Meters.
   b. S1.11 - Specification for Octave Band and Fraction Octave Band Analog and Digital Filters.
   c. S1.13 - Methods for the Measurement of Sound Pressure Levels.
   d. S1.40 - Specification for Acoustical Calibrators.
3. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
   a. 62.1 - Ventilation for Acceptable Indoor Air Quality (ANSI).

   b. 111 - Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.

4. Associated Air Balance Council (AABC):

   a. National Standards for Total System Balance.

5. National Environmental Balancing Bureau (NEBB):

   a. Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

6. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):

   a. HVAC Systems - Duct Design.

   b. HVAC Systems - Testing, Adjusting, and Balancing.

1.04 Definitions:

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, Adjusting, and Balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

F. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

G. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

H. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

I. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin that is normally dissipated.

J. NC: Noise criteria.

K. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

L. RC: Room criteria.

M. Report Forms: Test data sheets for recording test data in logical order.

N. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.

O. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.

P. Stair Pressurization System: A type of smoke-control system that is intended to positively pressurize stair towers with outdoor air by using fans to keep smoke from contaminating the stair towers during an alarm condition.

Q. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

R. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

S. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

T. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

U. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

V. Test: A procedure to determine quantitative performance of systems or equipment.

W. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.05 Submittals:

A. Qualification Data: Within 15 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 15 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. Certified TAB reports.

E. Instrument calibration reports, to include the following:

1. Instrument type and make.

2. Serial number.

3. Application.

4. Dates of use.

5. Dates of calibration.

1.06 Quality assurance:

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC, NEBB, or TABB.

   1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC, NEBBor TABB.

   2. TAB Technician: Employee of the TAB contractor and who is certified by AABC NEBB or TABB as a TAB technician.

B. TAB Report Forms: Use standard TAB contractor's forms approved by Engineer.

C. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

D. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.

   1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.07 Project conditions:

A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.08 Coordination:

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air distribution systems have been satisfactorily completed.

PART 2 - Products (not applicable)

PART 3 - Execution

3.01 Examination:

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Section 23 31 13 - Metal Ducts Section 23 31 16 - Nonmetal Ducts and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine Equipment performance data including fan and pump curves.

    1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

    2. Calculate system-effect factors to reduce performance ratings of HVAC Equipment when installed under conditions different from the conditions used to rate Equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC Equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC Equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

Q. Examine automatic temperature system components to verify the following:

  1. Dampers, valves, and other controlled devices are operated by the intended controller.
  2. Dampers and valves are in the position indicated by the controller.
  3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
  4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
  5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
  6. Sensors are located to sense only the intended conditions.
  7. Sequence of operation for control modes in according to the Contract Documents.
  8. Controller set points are set at indicated values.
  9. Interlocked system are operating.
  10. Changeover from heating to cooling mode occurs according to indicated values.

3.02 Preparation:

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.03 General procedures for testing and balancing:

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

  1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 33 00 - Duct Accessories.
  2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 07 00 - Mechanical Insulation.

C. Mark Equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) and metric (SI) units.

3.04 General procedures for balancing air systems:

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

D. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling-unit components.

K. Verify that air duct system is sealed as specified in Section 23 31 13 - Metal Ducts.

3.05 Procedures for constant-volume air systems:

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

    a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.

    b. Measure static pressure directly at the fan outlet or through the flexible connection.

    c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.

    d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

    a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.

5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.

6. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 23 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.

7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.

   a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.

3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.

2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.06 Procedures for motors:

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.

2. Motor horsepower rating.

3. Motor rpm.

4. Efficiency rating.

5. Nameplate and measured voltage, each phase.

6. Nameplate and measured amperage, each phase.

7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.07 Procedures for condensing units:

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.08 Tolerances:

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: ±10%.

2. Air Outlets and Inlets: -5 to +10%] .

3.09 Reporting:

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare monthly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.10 Final report:

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.

    b. Notable characteristics of systems.

    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.

13. Data for terminal units, including manufacturer's name, type, size, and fittings.

14. Notes to explain why certain final data in the body of reports vary from indicated values.

15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.

    b. Conditions of filters.

    c. Cooling coil, wet- and dry-bulb conditions.

    d. Face and bypass damper settings at coils.

    e. Fan drive settings including settings and percentage of maximum pitch diameter.

    f. Inlet vane settings for variable-air-volume systems.

    g. Settings for supply-air, static-pressure controller.

    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.

2. Water and steam flow rates.

3. Duct, outlet, and inlet sizes.

4. Pipe and valve sizes and locations.

5. Terminal units.

6. Balancing stations.

7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:
    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches (mm), and bore.
    i. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
    j. Number, make, and size of belts.
    k. Number, type, and size of filters.
2. Motor Data:
    a. Motor make, and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches (mm), and bore.
    f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
3. Test Data (Indicated and Actual Values):
    a. Total air flow rate in cfm (L/s).
    b. Total system static pressure in inches w.g. (Pa).
    c. Fan rpm.
    d. Discharge static pressure in inches w.g. (Pa).
    e. Filter static-pressure differential in inches w.g. (Pa).

        f. Preheat-coil static-pressure differential in inches w.g. (Pa).
        g. Cooling-coil static-pressure differential in inches w.g. (Pa).
        h. Heating-coil static-pressure differential in inches w.g. (Pa).
        i. Outdoor airflow in cfm (L/s).
        j. Return airflow in cfm (L/s).
        k. Outdoor-air damper position.
        l. Return-air damper position.
        m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:
    a. System identification.
    b. Location.
    c. Coil type.
    d. Number of rows.
    e. Fin spacing in fins per inch (mm) o.c.
    f. Make and model number.
    g. Face area in ft.^{2} (m^2).
    h. Tube size in NPS (DN).
    i. Tube and fin materials.
    j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
    a. Air flow rate in cfm (L/s).
    b. Average face velocity in fpm (m/s).
    c. Air pressure drop in inches w.g. (Pa).
    d. Outdoor-air, wet- and dry-bulb temperatures in ºF (ºC).
    e. Return-air, wet- and dry-bulb temperatures in ºF (ºC).

        f. Entering-air, wet- and dry-bulb temperatures in ºF (ºC).
        g. Leaving-air, wet- and dry-bulb temperatures in ºF (ºC).
        h. Water flow rate in gpm (L/s).
        i. Water pressure differential in feet of head or psig (kPa).
        j. Entering-water temperature in ºF (ºC).
        k. Leaving-water temperature in ºF (ºC).
        l. Refrigerant expansion valve and refrigerant types.
        m. Refrigerant suction pressure in psig (kPa).
        n. Refrigerant suction temperature in ºF (ºC).
        o. Inlet steam pressure in psig (kPa).

G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

    1. Unit Data:
        a. System identification.
        b. Location.
        c. Coil identification.
        d. Capacity in Btu/hr. (kW).
        e. Number of stages.
        f. Connected volts, phase, and hertz.
        g. Rated amperage.
        h. Air flow rate in cfm (L/s).
        i. Face area in ft.² (m²).
        j. Minimum face velocity in fpm (m/s).
    2. Test Data (Indicated and Actual Values):
        a. Heat output in Btu/hr. (kW).
        b. Air flow rate in cfm (L/s).
        c. Air velocity in fpm (m/s).

- d. Entering-air temperature in ºF (ºC).
- e. Leaving-air temperature in ºF (ºC).
- f. Voltage at each connection.
- g. Amperage for each phase.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:
    - a. System identification.
    - b. Location.
    - c. Make and type.
    - d. Model number and size.
    - e. Manufacturer's serial number.
    - f. Arrangement and class.
    - g. Sheave make, size in inches (mm), and bore.
    - h. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
2. Motor Data:
    - a. Motor make, and frame type and size.
    - b. Horsepower and rpm.
    - c. Volts, phase, and hertz.
    - d. Full-load amperage and service factor.
    - e. Sheave make, size in inches (mm), and bore.
    - f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
    - g. Number, make, and size of belts.
3. Test Data (Indicated and Actual Values):
    - a. Total airflow rate in cfm (L/s).
    - b. Total system static pressure in inches w.g. (Pa).

c. Fan rpm.

d. Discharge static pressure in inches w.g. (Pa).

e. Suction static pressure in inches w.g. (Pa).

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

    a. System and air-handling-unit number.

    b. Location and zone.

    c. Traverse air temperature in ºF (ºC).

    d. Duct static pressure in inches w.g. (Pa).

    e. Duct size in inches (mm).

    f. Duct area in ft.² (m²).

    g. Indicated air flow rate in cfm (L/s).

    h. Indicated velocity in fpm (m/s).

    i. Actual air flow rate in cfm (L/s).

    j. Actual average velocity in fpm (m/s).

    k. Barometric pressure in psig (Pa).

J. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, or water-cooled condensing units, include the following:

1. Unit Data:

    a. Unit identification.

    b. Location.

    c. Unit make and model number.

    d. Compressor make.

    e. Compressor model and serial numbers.

    f. Refrigerant weight in lb. (kg).

    g. Low ambient temperature cutoff in ºF (ºC).

2. Test Data (Indicated and Actual Values):
    a. Inlet-duct static pressure in inches w.g. (Pa).
    b. Outlet-duct static pressure in inches w.g. (Pa).
    c. Entering-air, dry-bulb temperature in ºF (ºC).
    d. Leaving-air, dry-bulb temperature in ºF (ºC).
    e. Condenser entering-water temperature in ºF (ºC).
    f. Condenser leaving-water temperature in ºF (ºC).
    g. Condenser-water temperature differential in ºF (ºC).
    h. Condenser entering-water pressure in feet of head or psig (kPa).
    i. Condenser leaving-water pressure in feet of head or psig (kPa).
    j. Condenser-water pressure differential in feet of head or psig (kPa).
    k. Control settings.
    l. Unloader set points.
    m. Low-pressure-cutout set point in psig (kPa).
    n. High-pressure-cutout set point in psig (kPa).
    o. Suction pressure in psig (kPa).
    p. Suction temperature in ºF (ºC).
    q. Condenser refrigerant pressure in psig (kPa).
    r. Condenser refrigerant temperature in ºF (ºC).
    s. Oil pressure in psig (kPa).
    t. Oil temperature in ºF (ºC).
    u. Voltage at each connection.
    v. Amperage for each phase.
    w. Kilowatt input.
    x. Crankcase heater kilowatt.
    y. Number of fans.

z. Condenser fan rpm.

aa. Condenser fan airflow rate in cfm (L/s).

bb. Condenser fan motor make, frame size, rpm, and horsepower.

cc. Condenser fan motor voltage at each connection.

dd. Condenser fan motor amperage for each phase.

K. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.

b. Serial number.

c. Application.

d. Dates of use.

e. Dates of calibration.

3.11 Additional tests:

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

PART 1 - General

1.01 Related documents:

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

1.02 Summary:

A. This Section includes requirements for insulating sheet metal ductwork.

1.03 Related requirements:

A. Section 23 07 16 - HVAC Equipment Insulation.

B. Section 23 07 19 - HVAC Piping Insulation.

C. Section 23 31 13 - Metal Ducts for duct liners.

1.04 Reference standards:

A. Applicable Standards (Latest Edition):

1. ASTM International (ASTM):
2. ASTM A167 - Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
3. ASTM A240/A240M - Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
4. ASTM B209 - Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
5. ASTM B209M - Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric].
6. ASTM C534 - Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
7. NFPA:
8. NFPA 90A - Installation of Air-Conditioning and Ventilating Systems.
9. NFPA 90B - Installation of Warm Air Heating and Air-Conditioning Systems.

1.05 Submittals:

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and field-applied jackets (if any).

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

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.
5. Detailed layouts of which type and thickness of insulation to be applied to each section of duct.

C. Qualification Data: For qualified Installer.

1.06 Quality assurance:

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

1.07 Delivery, storage, and handling:

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.08 Coordination:

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.09 Scheduling:

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - Products

2.01 Insulation materials:

A. Comply with requirements in "Duct Insulation Schedule, General," "Aboveground Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type II for sheet materials.

1. Products: Subject to compliance with requirements, provide products by one of the following:

    a. Aeroflex USA, Inc.; Aerocel.

    b. Armacell, LLC; AP Armaflex.

    c. K-Flex USA; Insul-Sheet, K-Flex Gray Duct Liner, and K-FLEX LS.

2.02 Adhesives:

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide products by one of the following:

a. Aeroflex USA, Inc.; Aeroseal.

b. Armacell, LLC; Armaflex 520 Adhesive.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.

d. K-Flex USA; R-373 Contact Adhesive.

2.03 Mastics:

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.

   b. Eagle Bridges - Marathon Industries; 570.

   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.

2. Water-Vapor Permeance: ASTM F1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.

3. Service Temperature Range: -50 to +220ºF (-46 to +104ºC).

4. Solids Content: ASTM D1644, 33% by volume and 46% by weight.

5. Color: White.

2.04 Sealants:

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

   b. Eagle Bridges - Marathon Industries; 405.

   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.

      d. Mon-Eco Industries, Inc.; 44-05.

   2. Materials shall be compatible with insulation materials, jackets, and substrates.

   3. Fire- and water-resistant, flexible, elastomeric sealant.

   4. Service Temperature Range: -40 to +250ºF (-40 to +121ºC).

   5. Color: Aluminum.

2.05 Field-applied jackets:

A. Metal Jacket:

   1. Products: Subject to compliance with requirements, provide products by one of the following:

      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.

      b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.

      c. RPR Products, Inc.; Insul-Mate.

   2. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.

      a. Finish and thickness are indicated in field-applied jacket schedules.

      b. Moisture Barrier for Indoor Applications: 3-mil (0.075-mm) thick, heat-bonded polyethylene and Kraft paper or 2.5-mil (0.063-mm) thick polysurlynMoisture Barrier for Outdoor Applications: 3-mil (0.075-mm) thick, heat-bonded polyethylene and Kraft paper or 2.5-mil (0.063-mm) thick polysurlyn.

   3. Stainless-Steel Jacket: ASTM A167 or ASTM A240/A240M.

      a. Material, finish, and thickness are indicated in field-applied jacket schedules.

      b. Moisture Barrier for Indoor Applications: 3-mil (0.075-mm) thick, heat-bonded polyethylene and Kraft paper or 2.5-mil (0.063-mm) thick polysurlyn.

      c. Moisture Barrier for Outdoor Applications: 3-mil (0.075-mm) thick, heat-bonded polyethylene and Kraft paper or 2.5-mil (0.063-mm) thick polysurlyn.

2.06 Securements:

A. Bands:

1. Products: Subject to compliance with requirements, provide products by one of the following:
    a. ITW Insulation Systems; Gerrard Strapping and Seals.
    b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.
3. Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H 14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch (2.6-mm) diameter shank, length to suit depth of insulation indicated.
    a. Products: Subject to compliance with requirements, provide products by one of the following:
        (1) AGM Industries, Inc.; CWP-1.
        (2) GEMCO; CD.
        (3) Midwest Fasteners, Inc.; CD.
        (4) Nelson Stud Welding; TPA, TPC, and TPS.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch (3.5-mm) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
    a. Products: Subject to compliance with requirements, provide products by one of the following:
        (1) AGM Industries, Inc.; CHP-1.
        (2) GEMCO; Cupped Head Weld Pin.
        (3) Midwest Fasteners, Inc.; Cupped Head.
        (4) Nelson Stud Welding; CHP.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, provide products by one of the following:

    (1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.

    (2) GEMCO; Perforated Base.

    (3) Midwest Fasteners, Inc.; Spindle.

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.

c. Spindle: Aluminum, fully annealed, 0.106-inch (2.6-mm) diameter shank, length to suit depth of insulation indicated.

d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

    a. Products: Subject to compliance with requirements, provide products by one of the following:

        (1) GEMCO; Nylon Hangers.

        (2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

    b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.

    c. Spindle: Nylon, 0.106-inch (2.6-mm) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).

    d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

    a. Products: Subject to compliance with requirements, provide products by one of the following:

        (1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers.

(2) GEMCO; Peel & Press.

(3) Midwest Fasteners, Inc.; Self Stick.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.

c. Spindle: Aluminum, fully annealed, 0.106-inch (2.6-mm) diameter shank, length to suit depth of insulation indicated.

d. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch (0.41-mm) thick, galvanized-steel or stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

a. Products: Subject to compliance with requirements, provide products by one of the following:

(1) AGM Industries, Inc.; RC-150.

(2) GEMCO; R-150.

(3) Midwest Fasteners, Inc.; WA-150.

(4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch (0.41-mm) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

(1) GEMCO.

(2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch (19-mm) wide, stainless steel or Monel.

D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. C & F Wire.

2.07 Corner angles:

A. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1- by 1-inch (25- by 25-mm) aluminum according to ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.

B. Stainless-Steel Corner Angles: 0.024 inch (0.61 mm) thick, minimum 1- by 1-inch (25- by 25-mm) stainless steel according to ASTM A167 or ASTM A240/A240M, Type 304 or Type 316.

PART 3 - Execution

3.01 Examination:

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

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

3.02 Preparation:

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.03 General installation requirements:

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

J. Install insulation continuously through hangers and around anchor attachments.

K. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

L. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

M. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

N. Cut insulation in a manner to avoid compressing insulation more than 75% of its nominal thickness.

O. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

P. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.04 Penetrations:

A. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

  1. Seal penetrations with flashing sealant.

  2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

  3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).

  4. Seal jacket to wall flashing with flashing sealant.

B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

3.05 Installation of flexible elastomeric insulation:

A. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1-inch (25-mm) o.c.

C. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

D. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

E. Install vapor stops for ductwork and plenums operating below 50ºF (10ºC) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).

3.06 Field-applied jacket installation:

A. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12-inches (300-mm) o.c. and at end joints.

3.07 Finishes:

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.08 Duct insulation schedule, general:

A. Plenums and Ducts Requiring Insulation:

1. Indoor, supply and return ductwork.

2. Outdoor exposed ductwork.

B. Items Not Insulated:

1. Fibrous-glass ducts.

2. Factory-insulated flexible ducts.

3. Flexible connectors.
4. Vibration-control devices.
5. Factory-insulated access panels and doors.

3.09 Aboveground indoor duct and plenum insulation schedule:

A. Indoor supply, return, and outside air duct insulation shall be one of the following:

1. Flexible Elastomeric: 1 inch (20 mm) thick.

3.10 Aboveground, outdoor duct and plenum insulation schedule:

A. Aboveground outdoor rectangular duct insulation shall be one of the following:

1. Flexible Elastomeric: 2.0 inches (50 mm) thick.

3.11 Outdoor, field-applied jacket schedule:

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts:

1. Aluminum, Smooth or Stucco Embossed: 0.024 inch (0.61 mm) thick.
2. Stainless Steel, Type 304 or Type 316, Smooth 2B Finish or Stucco Embossed: 0.016 inch (0.41 mm) thick.

END OF SECTION

PART 1 - General

1.01 Related documents:

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

1.02 Summary:

A. This Section includes requirements for insulating HVAC piping systems:

1. Indoor and outdoor condensate piping.
2. Indoor and outdoor cold piping.
3. Indoor and outdoor hot piping.

1.03 Related requirements:

1. Section 23 07 13 - Duct Insulation.

1.04 Reference standards:

A. Applicable Standards (Latest Edition):

1. ASTM International (ASTM):
    a. ASTM C534 - Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
    b. ASTM E84 - Test Method for Surface Burning Characteristics of Building Materials.
    c. ASTM E96/E96M - Test Methods for Water Vapor Transmission of Materials.
2. Military Specifications (MIL):
    a. MIL-A-24179A - Adhesive, Flexible Unicellular-Plastic Thermal Insulation.
    b. MIL-A-3316C - Adhesives, Fire-Resistant, Thermal Insulation.
    c. MIL-C-20079H - Cloth, Glass; Tape, Textile Glass and Thread, Glass and Wire-Reinforced Glass.
    d. MIL-PRF-19565C - Coating Compounds, Thermal Insulation, Fire- and Water-Resistant, Vapor Barrier.

1.05 Submittals:

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

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

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at pipe expansion joints for each type of insulation.
3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
4. Detail removable insulation at piping specialties.
5. Detail application of field-applied jackets.
6. Detail application at linkages of control devices.
7. Detailed layouts of which type and thickness of insulation to be applied to each section of piping.

C. Qualification Data: For qualified Installer.

1.06 Quality assurance:

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.07 Delivery, storage, and handling:

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.08 Coordination:

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.09 Scheduling:

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - Products

2.01 Insulation materials:

A. Comply with requirements in "Piping Insulation Schedule, General" and " Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials.

   1. Products: Subject to compliance with requirements, provide products by one of the following:

      a. Aeroflex USA, Inc.; Aerocel.

b. Armacell, LLC; AP Armaflex.

c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

2.02 Adhesives:

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide products by one of the following:

    a. Aeroflex USA, Inc.; Aeroseal.

    b. Armacell, LLC; Armaflex 520 Adhesive.

    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.

    d. K-Flex USA; R-373 Contact Adhesive.

2.03 Mastics:

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, provide products by one of the following:

    a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.

    b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E96/E96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.

3. Service Temperature Range: -20 to +180ºF (-29 to -82ºC).

4. Solids Content: ASTM D1644, 58% by volume and 70% by weight.

5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, provide products by one of the following:
    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
    b. Eagle Bridges - Marathon Industries; 501.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
    d. Mon-Eco Industries, Inc.; 55-10.
2. Water-Vapor Permeance: ASTM F1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
3. Service Temperature Range: 0 to 180ºF (-18 to +82ºC).
4. Solids Content: ASTM D1644, 44% by volume and 62% by weight.
5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

1. Products: Subject to compliance with requirements, provide products by one of the following:
    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
    b. Eagle Bridges - Marathon Industries; 570.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
2. Water-Vapor Permeance: ASTM F1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
3. Service Temperature Range: -50 to +220ºF (-46 to +104ºC).
4. Solids Content: ASTM D1644, 33% by volume and 46% by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Products: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.

b. Eagle Bridges - Marathon Industries; 550.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.

d. Mon-Eco Industries, Inc.; 55-50.

e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.

3. Service Temperature Range: -20 to +180ºF (-29 to +82ºC).

4. Solids Content: 60% by volume and 66% by weight.

5. Color: White.

2.04 Field-applied jackets:

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with Kraft-paper backing.

C. Metal Jacket:

1. Products: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.

b. ITW Insulation Systems; Aluminum and Stainless-Steel Jacketing.

c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Finish and thickness are indicated in field-applied jacket schedules.

b. Moisture Barrier for Indoor Applications: 3 mil (0.075 mm) thick, heat-bonded polyethylene and Kraft paper or 2.5 mil (0.063 mm) thick polysurlyn.

c. Moisture Barrier for Outdoor Applications: 3 mil (0.075 mm) thick, heat-bonded polyethylene and Kraft paper or 2.5 mil (0.063 mm) thick polysurlyn.

        d. Factory-Fabricated Fitting Covers:

            (1) Same material, finish, and thickness as jacket.

            (2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.

            (3) Tee covers.

            (4) Flange and union covers.

            (5) End caps.

            (6) Beveled collars.

            (7) Valve covers.

            (8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

    3. Stainless-Steel Jacket: ASTM A167 or ASTM A240/A240M.

        a. Material, finish, and thickness are indicated in field-applied jacket schedules.

        b. Moisture Barrier for Indoor Applications: 3 mil (0.075 mm) thick, heat-bonded polyethylene and Kraft paper or 2.5 mil (0.063 mm) thick polysurlyn.

        c. Moisture Barrier for Outdoor Applications: 3 mil (0.075 mm) thick, heat-bonded polyethylene and Kraft paper or 2.5 mil (0.063 mm) thick polysurlyn.

        d. Factory-Fabricated Fitting Covers:

            (1) Same material, finish, and thickness as jacket.

            (2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.

            (3) Tee covers.

            (4) Flange and union covers.

            (5) End caps.

            (6) Beveled collars.

            (7) Valve covers.

            (8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.05 Securements:

A. Bands:

1. Products: Subject to compliance with requirements, provide products by one of the following:
    a. ITW Insulation Systems; Gerrard Strapping and Seals.
    b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.
3. Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4 inch (19 mm) wide, stainless steel or Monel.

C. Wire: 0.080-inch (2.0-mm) nickel-copper alloy 0.062-inch (1.6-mm) soft-annealed, stainless steel or 0.062-inch (1.6-mm) soft-annealed, galvanized steel.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. C & F Wire.

PART 3 - Execution

3.01 Examination:

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 Preparation:

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.03 General installation requirements:

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Cut insulation in a manner to avoid compressing insulation more than 75% of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

O. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.

2. Testing agency labels and stamps.

3. Nameplates and data plates.

4. Manholes.

5. Handholes.

6. Cleanouts.

3.04 Penetration:

A. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).

4. Seal jacket to wall flashing with flashing sealant.

B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

C. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.

3.05 General pipe insulation installation:

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gauges, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

3.06 Installation of cellular-glass insulation:

3.07 installation of flexible elastomeric insulation:

A. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.

4. Secure insulation to flanges and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.

2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.

2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.08 Finishes:

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.09 Piping insulation schedule, general:

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.

2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.10 Piping insulation schedule:

A. Indoor and Outdoor Condensate and Equipment Drain Water below 60ºF (16ºC):

1. All Pipe Sizes: Insulation shall be one of the following:

a. Flexible Elastomeric: 1.0 inch (25 mm) thick.

2. Protect outdoor piping with heat tape under insulation.

3. Provide metal jacket on outdoor piping.

B. Indoor and Outdoor Refrigerant Suction Gas Piping:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Flexible Elastomeric: 1 inch (25 mm) thick.

END OF SECTION

PART 1 - General

1.01 Related documents

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

1.02 Summary

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Related Sections include the following:

1.03 Reference standards

A. Applicable Standards (Latest Edition):

1. Air Movement and Control Association International, Inc. (AMCA):
    a. AMCA 500D - Methods of Testing Dampers for Rating.
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
    a. ASHRAE 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks.
3. ASME International (ASME):
    a. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
    b. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
4. ASTM International (ASTM):
    a. ASTM A126 - Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
    b. ASTM A536 - Specification for Ductile Iron Casting.
    c. ASTM B88 - Specification for Seamless Copper Water Tube.
    d. ASTM B88M - Specification for Seamless Copper Water Tube [Metric].

    e. ASTM B280 - Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.

    f. ASTM D2737 - Specification for Polyethylene (PE) Plastic Tubing.

5. Electronic Industries Alliance/Canadian Electricity Association (EIA/CEA):

    a. EIA/CEA 709.1-B - Control Network Protocol Specification.

6. The Instrumentation, Systems, and Automation Society (67 Alexander Dr., Research Triangle Park, NC 27709; 919-549-8411) (ISA):

    a. ISA 50.00.01 - Compatibility of Analog Signals for Electronic Industrial Process Instruments.

7. National Electrical Manufacturers Association (NEMA):

    a. NEMA 250 - Enclosures for Electrical Equipment (100V Maximum).

    b. NEMA DC 3 - Residential Controls - Electrical Wall-Mounted Room Thermostats.

8. NFPA:

    a. NFPA 70 - National Electrical Code.

1.04 Definitions

A. RTD: Resistance temperature detector.

1.05 Submittals

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

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

    1. Bill of materials of equipment indicating quantity, manufacturer, and model number.

    2. Wiring Diagrams: Power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, include the following:

1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
4. Calibration records and list of set points.

1.06 Quality assurance

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.07 Delivery, storage, and handling

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.08 Coordination

A. Coordinate location of thermostats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 26 to achieve compatibility with equipment that interfaces with that system.

C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - Products

2.01 Electronic sensors

A. Description: Vibration and corrosion resistant temperature sensor for high limit; for wall mounting as required.

B. RTDs and Transmitters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. BEC Controls Corporation.

    b. MAMAC Systems, Inc.
    c. RDF Corporation.
    d. Engineer approved equal.

2. Accuracy: ±0.5 º F at calibration point.
3. Room Sensor Cover Construction: Manufacturer's standard locking covers.
    a. Set-Point Adjustment: Exposed.
    b. Set-Point Indication: Exposed.
    c. Thermometer: Concealed.
    d. RTD Sensor: Nickel.
    e. Enclosure: White plastic.

2.02 Air flow switches

A. Description: vane-style adjustable air flow switch.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Dwyer.
    b. McDonnell & Miller; a Xylem Brand.
    c. Engineer approved equal.
2. Operating range: 300 to 1900 feet per minute (fpm).
    a. Flow: 1000 FPM.
    b. No Flow: 100 FPM
3. Vane Material: Stainless Steel.
4. Enclsoure: Rated for Class I Division 1.
5. Voltage: 120 VAC.

PART 3 - Execution

3.01 Installation

A. Connect and configure equipment and software to achieve sequence of operation specified.

B. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

1. Install thermostat devices 48 inches (1220 mm) above the floor.

2. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

C. Install labels and nameplates to identify control components according to Section 23 05 53 – "Identification For HVAC Piping and Equipment."

3.02 Electrical wiring and connection installation

A. Install raceways, boxes, and cabinets according to Division 26.

B. Install building wire and cable according to Division 26.

C. Connect manual-reset limit controls independent of manual-control switch positions.

D. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.03 Field quality control

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.

2. Test and adjust controls and safeties.

3. Test each point through its full operating range to verify that safety and operating control set points are as required.

4. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.

5. Test each system for compliance with sequence of operation.

6. Test software and hardware interlocks.

C. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.04 Adjusting

A. Calibrating and Adjusting:

1. Calibrate instruments.

2. Make three-point calibration test for both linearity and accuracy for each analog instrument.

3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.

4. Control System Inputs and Outputs:

   a. Check analog inputs at 0, 50, and 100% of span.

   b. Check analog outputs using milliampere meter at 0, 50, and 100% output.

   c. Check digital inputs using jumper wire.

   d. Check digital outputs using ohmmeter to test for contact making or breaking.

   e. Check resistance temperature inputs at 0, 50, and 100% of span using a precision-resistant source.

5. Flow:

   a. Set differential pressure flow transmitters for 0 and 100% values with 3-point calibration accomplished at 50, 90, and 100% of span.

   b. Manually operate flow switches to verify that they make or break contact.

6. Temperature:

   a. Calibrate resistance temperature transmitters at 0, 50, and 100% of span using a precision-resistance source.

   b. Calibrate temperature switches to make or break contacts.

7. Provide diagnostic and test instruments for calibration and adjustment of system.

8. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.05 Demonstration

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01.

END OF SECTION

PART 1 - General

1.01 Related documents:

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

1.02 Summary:

A. This Section includes:

1. Single-wall rectangular ducts and fittings.
2. Sealants and gaskets.
3. Hangers and supports.

1.03 Related requirements:

A. Section 23 05 93 - Testing, Adjusting and Balancing for HVAC for testing, adjusting, and balancing requirements for metal ducts.

B. Section 23 31 16 - Nonmetal Ducts for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.

C. Section 23 33 00 - Air Duct Accessories for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.04 Reference standards:

A. Applicable Standards (Latest Edition):

1. American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI):
    a. ASCE/SEI 7 - Minimum Design Loads for Buildings and Other Structures.
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
    a. ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality (ANSI).
3. American Society of Heating, Refrigerating and Air-Conditioning Engineers/Illuminating Engineering Society of North America (ASHRAE/IESNA):
    a. ASHRAE/IESNA 90.1 - Energy Standard for Buildings except Low-Rise Residential Buildings (ANSI).

4. American Welding Society (AWS):
    a. AWS D1.1/D1.1M - Structural Welding Code - Steel.
    b. AWS D1.2/D1.2M - Structural Welding Code - Aluminum.
    c. AWS D9.1M/D9.1 - Sheet Metal Welding Code.
5. ASTM International (ASTM):
    a. ASTM A36/A36M - Specification for Carbon Structural Steel.
    b. ASTM A653/A653M - Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
    c. ASTM A1008/A1008M - Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
    d. ASTM B209 - Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
    e. ASTM B209M - Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric].
    f. ASTM C916 - Specification for Adhesives for Duct Thermal Insulation.
    g. ASTM C920 - Specification for Elastomeric Joint Sealants.
    h. ASTM E84 - Test Method for Surface Burning Characteristics of Building Materials.
    i. ASTM E488 - Test Methods for Strength of Anchors in Concrete and Masonry Elements.
6. National Air Duct Cleaners Association (NADCA):
    a. NADCA 1992 - Mechanical Cleaning of Non-Porous Air Conveyance System Components.
    b. NADCA ACR - Assessment, Cleaning and Restoration of HVAC Systems.
7. NFPA:
    a. NFPA 90A - Installation of Air Conditioning and Ventilating Systems (ANSI).
    b. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems (ANSI).
8. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):

a. HVAC Air Duct Leakage Test Manual.

b. HVAC Duct Construction Standards - Metal and Flexible.

c. IAQ Guidelines for Occupied Buildings under Construction - Appendix G, Duct Cleanliness for New Construction Guidelines.

d. Seismic Restraint Manual: Guidelines for Mechanical Systems.

9. Underwriters Laboratories, Inc. (UL):

a. UL 723 - Test for Surface Burning Characteristics of Building Materials.

1.05 Performance/design criteria:

A. Structural Performance: Duct hangers and supports shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.

1.06 Submittals:

A. Product Data: For each type of the following products:

1. Liners and adhesives.

2. Sealants and gaskets.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.

2. Factory- and shop-fabricated ducts and fittings.

3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.

4. Elevation of top of ducts.

5. Dimensions of main duct runs from building grid lines.

6. Fittings.

7. Reinforcement and spacing.

8. Seam and joint construction.

9. Penetrations through fire-rated and other partitions.

10. Equipment installation based on equipment being used on Project.

11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.

12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.

2. Joint and seam construction and sealing.

3. Reinforcement details and spacing.

4. Materials, fabrication, assembly, and spacing of hangers and supports.

PART 2 - Products

1.07 Single-wall rectangular ducts and fittings:

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class, unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1.08 Sheet metal materials:

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

C. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

D. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

1.09 Sealant and gaskets:

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65%.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch w.g. (2500 Pa), positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.

5. Use: O.

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

1.10 Hangers and supports:

A. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

C. Zinc-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

E. Trapeze and Riser Supports:

1. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - Execution

1.11 Duct installation:

A. Coordinate duct layout and duct accessory arrangement with Drawings.Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated, unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," unless otherwise indicated.

C. Install ducts with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

J. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 23 33 00 - Air Duct Accessories for fire and smoke dampers.

K. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.

1.12 Installation of exposed ductwork:

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

1.13 Duct sealing:

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.

4. Outdoor, Return-Air Ducts: Seal Class C.

5. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-inch w.g. (500 Pa) and Lower: Seal Class C.

6. Conditioned Space, Exhaust Ducts: Seal Class B.

7. Conditioned Space, Return-Air Ducts: Seal Class C.

1.14 Hanger and support installation:

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.

2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick. These fasteners shall not be used to support ductwork larger than 24 inches square.

4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1.15 Connections:

A. Make connections to equipment with flexible connectors complying with Section 23 33 00 - Air Duct Accessories.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

1.16 Painting:

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in DIVISION 09 Painting Sections.

1.17 Start up:

A. Air Balance: Comply with requirements in Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC.

1.18 Duct schedule:

A. Supply Ducts:

1. Ducts Connected to Packaged Units, and Air Handling Units:
   - a. Pressure Class: Positive w.g. 2-inch w.g. (500 Pa).
   - b. Minimum SMACNA Seal Class: B.
   - c. SMACNA Leakage Class for Rectangular: 24.

B. Return Ducts:

1. Ducts Connected to Packaged Units, and Air Handling Units:
   - a. Pressure Class: Positive or negative 1-inch w.g. (250 Pa)w.g. .
   - b. Minimum SMACNA Seal Class: B .
   - c. SMACNA Leakage Class for Rectangular: 24.
2. Ducts Connected to Equipment Not Listed Above:
   - a. Pressure Class: Positive or negative 2-inch w.g. (500 Pa)] .
   - b. Minimum SMACNA Seal Class: B.
   - c. SMACNA Leakage Class for Rectangular: 12.

C. Exhaust Ducts:

1. Ducts Connected to Air-Handling Units:
   - a. Pressure Class: Positive or negative 2-inch w.g. (500 Pa).

        b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.

        c. SMACNA Leakage Class for Rectangular: 24.

    2. Ducts Connected to Equipment Not Listed Above:

        a. Pressure Class: Positive or negative 2-inch w.g. (500 Pa).

        b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.

        c. SMACNA Leakage Class for Rectangular: 24.

D. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

    1. Ducts Connected to Packaged Units:

        a. Pressure Class: Positive or negative 1-inch w.g. (250 Pa)w.g. .

        b. Minimum SMACNA Seal Class: C.

        c. SMACNA Leakage Class for Rectangular: 24.

    2. Ducts Connected to Air-Handling Units:

        a. Pressure Class: Positive or negative 2-inch w.g. (500 Pa).

        b. Minimum SMACNA Seal Class: B.

        c. SMACNA Leakage Class for Rectangular: 24.

    3. Ducts Connected to Equipment Not Listed Above:

        a. Pressure Class: Positive or negative 2-inch w.g. (500 Pa).

        b. Minimum SMACNA Seal Class: B.

        c. SMACNA Leakage Class for Rectangular: 12.

        d. SMACNA Leakage Class for Round and Flat Oval: 12.

E. Intermediate Reinforcement:

    1. Aluminum Ducts: Aluminum.

F. Elbow Configuration:

    1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

        a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

G. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

   a. Rectangular Main to Rectangular Branch: 45-degree entry.

END OF SECTION

PART 1 - General

1.01 Related Documents:

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

1.02 Summary:

A. This Section Includes:

1. FRP ducts and fittings.

1.03 Related requirements:

A. Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC for testing, adjusting, and balancing requirements for nonmetal ducts.

B. Section 23 31 13 - Metal Ducts for single- and double-wall, rectangular and round ducts.

C. Section 23 33 00 - Air Duct Accessories for dampers, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.04 Reference standards:

A. Applicable Standards (Latest Edition):

1. American Society of -Civil Engineers/ Structural Engineering Institute (ASCE/SEI):
   a. ASCE/SEI 7 - Minimum Design Loads for Buildings and Other Structures.
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
   a. ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality (ANSI).
3. American Society of Heating, Refrigerating and Air-Conditioning Engineers/Illuminating Engineering Society of North America (ASHRAE/IESNA):
   a. ASHRAE/IESNA 90.1 - Energy Standard for Buildings except Low-Rise Residential Buildings (ANSI).
4. American Welding Society (AWS):
   a. AWS D1.1/D1.1M - Structural Welding Code - Steel.

   b. AWS D1.2/D1.2M - Structural Welding Code - Aluminum.

5. ASTM International (ASTM):
   a. ASTM A36/A36M - Specification for Carbon Structural Steel.
   b. ASTM A492 - Specification for Stainless Steel Rope Wire.
   c. ASTM A603 - Specification for Zinc-Coated Steel Structural Wire Rope.
   d. ASTM D2996 - Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
   e. ASTM E84 - Test Method for Surface Burning Characteristics of Building Materials.
   f. ASTM E488 - Test Methods for Strength of Anchors in Concrete and Masonry Elements.
6. NFPA:
   a. NFPA 90A - Installation of Air Conditioning and Ventilating Systems (ANSI).
   b. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems (ANSI).
7. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   a. HVAC Air Duct Leakage Test Manual.
   b. HVAC Duct Construction Standards - Metal and Flexible.
   c. IAQ Guidelines for Occupied Buildings Under Construction: Appendix G, Duct Cleanliness for New Construction Guidelines.
   d. Seismic Restraint Manual - Guidelines for Mechanical Systems.
   e. Thermoset FRP Duct Construction Manual.
8. Underwriters Laboratories, Inc. (UL):
   a. UL 181 - Factory-Made Air Ducts and Air Connectors.

1.05 Performance requirements:

A. Static-Pressure Classes:

   1. Exhaust Ducts (Negative Pressure): 10 inch w.g and above.

1.06 Submittals:

B. Product Data: For each type of the following products:

1. FRP duct materials.

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Duct layout indicating sizes and pressure classes.
3. Elevation of top of ducts.
4. Dimensions of main duct runs from building grid lines.
5. Fittings.
6. Reinforcement and spacing.
7. Seam and joint construction.
8. Penetrations through fire-rated and other partitions.
9. Equipment installation based on equipment being used on Project.
10. Hangers and supports, including methods for duct and building attachment, seismic restraints,] and vibration isolation.

PART 2 - Products

2.01 FRP ducts and fittings:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Perry Fiberglass Products, Inc.
2. Spunstrand, Inc.
3. Viron.

B. Duct and Fittings:

1. Round Duct: ASTM D2996, Type I, Grade 2, Class E, filament-wound duct, minimum 0.125-inch (3.2-mm) wall thickness, with tapered bell and spigot ends for adhesive joints, or plain ends with couplings.

2. Round Fittings: Compression or spray-up/contact, molded of same material, pressure class, and joining method as duct.

3. Rectangular Fittings: Minimum 0.125-inch (3.2-mm) thick flat sheet with fiberglass roving and resin-reinforced joints and seams.

4. Double-Wall Insulated Duct: Inner and outer duct complying with requirements for "Round Duct" description above. Polyurethane foam or isocyanurate insulation with maximum thermal conductivity of 0.14 Btu x inch/h x sq. ft. (0.020 W/m x K) at 75ºF (24ºC) mean temperature.

C. Joining Materials: Roving and polyester resin.

D. Fabrication:

1. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoset FRP Duct Construction Manual," Chapter 7, "Requirements."

2. Fabricate 90-degree rectangular mitered elbows to include turning vanes, 90-degree round elbows with a minimum of three segments for 12 inches (300 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.

2.02 Hangers and supports:

A. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

C. Steel Cables: ASTM A492, stainless steel with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

E. Trapeze and Riser Supports: Steel shapes complying with ASTM A36/A36M.

PART 3 - Execution

3.01 Duct installation:

A. Install ducts with fewest possible joints.

B. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

C. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

D. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

E. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 23 33 00 - Air Duct Accessories for fire and smoke dampers.

F. Protect duct interiors from the moisture, construction debris and dust, and other foreign materials

G. Install thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual."

3.02 Hanger and support installation:

A. Install hangers and supports for thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual," Chapter 7, "Requirements."

3.03 Start up:

A. Air Balance: Comply with requirements in Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC.

3.04 Duct schedule:

A. Underground Ducts and Ducts connected to the Odor Control System:

B. FRP Round Ducts and Fittings:

C. Insulation Thickness: 1 inch (25 mm).

END OF SECTION

PART 1 - General

1.01 Related documents:

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

1.02 Summary:

A. This Section includes:

1. Smoke dampers.
2. Flange connectors.
3. Turning vanes.
4. Remote damper operators.
5. Duct-mounted access doors.
6. Flexible connectors.
7. Flexible ducts.
8. Duct accessory hardware.

1.03 Reference standards:

A. Applicable Standards (Latest Edition):

1. Air Movement and Control Association International, Inc. (AMCA):
    a. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating (ANSI).
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
    a. ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality (ANSI).
3. American Society of Heating, Refrigerating and Air-Conditioning Engineers/Illuminating Engineering Society of North America (ASHRAE/IESNA):
    a. ASHRAE/IESNA 90.1 - Energy Standard for Buildings except Low-Rise Residential Buildings (ANSI).
4. ASTM International (ASTM):

a. ASTM B209M-07 - Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric].

b. ASTM B221-07 - Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.

5. NFPA:

    a. NFPA 90A - Installation of Air Conditioning and Ventilating Systems (ANSI).

    b. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems (ANSI).

    c. NFPA 96 - Ventilation Control and Fire Protection of Commercial Cooking Operations.

6. North American Insulation Manufacturers Association (The) (NAIMA):

    a. NAIMA AH116 - Fibrous Glass Duct Construction Standards.

7. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).

    a. HVAC Duct Construction Standards - Metal and Flexible

8. Underwriters Laboratories, Inc. (UL):

    a. UL 181 - Factory-Made Air Ducts and Air Connectors.

    b. UL 555 - Fire Dampers.

    c. UL 555S - Smoke Dampers.

    d. Fire Resistance Directory.

1.04 Submittals:

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

    a. Special fittings.

   b. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.

   c. Wiring Diagrams: For power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

PART 2 - Products

2.01 Assembly description:

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.02 Materials:

A. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

B. Extruded Aluminum: Comply with ASTM B221 (ASTM B221M), Alloy 6063, Temper T6.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

D. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.03 Smoke dampers:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   1. Air Balance, Inc.; a division of Mestek, Inc.

   2. Greenheck Fan Corporation.

   3. Nailor Industries, Inc.

4. Ruskin Company.

B. General Requirements: Label according to UL 555S by an NRTL.

C. Smoke Detector: Integral, factory wired for single-point connection.

D. Frame: Hat-shaped, 0.094 inch (2.4 mm) thick, galvanized sheet steel, with welded corners and mounting flange.

E. Blades: Roll-formed, horizontal, interlocking0.063 inch (1.6 mm) thick, galvanized sheet steel.

F. Leakage: Class I.

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, 0.05 inch (1.3 mm) thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

I. Damper Motors: two-position action.

J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 - Common Motor Requirements for HVAC Equipment.

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in DIVISION 26.

3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.

4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 inch by lbf (17 N by m) and breakaway torque rating of 150 inch by lbf (17 N by m).

5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at -40ºF (-40ºC).

6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 inch by lbf (17 N by m) and breakaway torque rating of 300 inch by lbf (34 N by m).

7. Electrical Connection: 115V, single phase, 60 Hz

K. Accessories:

1. Auxiliary switches for per Division 26.

2.04 Flange connectors:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    1. Ductmate Industries, Inc.

    2. Nexus PDQ; Division of Shilco Holdings, Inc.

    3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Description: roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.05 Turning vanes:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    1. Ductmate Industries, Inc.

    2. Duro Dyne, Inc.

    3. Elgen Manufacturing.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

    1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

E. Vane Construction: Single wall.

F. Vane Construction: Single wall for ducts up to 48 inches (1200 mm) wide and double wall for larger dimensions.

2.06 Duct-mounted access doors:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. American Warming and Ventilating; a division of Mestek, Inc.

2. Ductmate Industries, Inc.

3. Greenheck Fan Corporation.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

    a. Double wall, rectangular.

    b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.

    c. Vision panel.

    d. Hinges and Latches: 1- by 1-inch (25- by 25-mm) butt or piano hinge and cam latches.

    e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Number of Hinges and Locks:

    a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.

    b. Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.

    c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges]and two compression latches with outside and inside handles.

    d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges and two compression latches with outside and inside handles.

2.07 Flexible connectors:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ductmate Industries, Inc.

2. Duro Dyne, Inc.

3. Elgen Manufacturing.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 5 3/4 inches (146 mm) wide attached to two strips of 2-3/4 inches (70 mm) wide, 0.028 inch (0.7 mm) thick, galvanized sheet steel or 0.032 inch (0.8 mm) thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).

2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.

3. Service Temperature: -40 to +200ºF (-40 to +93ºC).

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).

2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.

3. Service Temperature: -50 to +250ºF (-45 to +121ºC).

G. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).

2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.

3. Service Temperature: -67 to +500ºF (-55 to +260ºC).

2.08 Duct accessory hardware:

1. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

2. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - Execution

3.01 Examination:

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

  1. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel Install steel volume dampers in steel ducts.

C. Set dampers to fully open position before testing, adjusting, and balancing.

D. Install test holes at fan inlets and outlets and elsewhere as indicated.

E. Install fire and smoke dampers according to UL listing.

F. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

  1. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.

  2. Control devices requiring inspection.

  3. Elsewhere as indicated.

G. Install access doors with swing against duct static pressure.

H. Access Door Sizes:

  1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).

  2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).

  3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).

  4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).

  5. Body Access: 25 by 14 inches (635 by 355 mm).

6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).

I. Label access doors according to Section 230553 - Identification for HVAC Piping and Equipment to indicate the purpose of access door.

J. Install flexible connectors to connect ducts to equipment.

K. For fans developing static pressures of 5-inch w.g. (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

L. Connect terminal units to supply ducts directly or with maximum 12-inch (300-mm) lengths of flexible duct. Do not use flexible ducts to change directions.

M. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch (1500 mm) lengths of flexible duct clamped or strapped in place.

N. Connect flexible ducts to metal ducts with liquid adhesive plus tape.

O. Install duct test holes where required for testing and balancing purposes.

3.02 Field quality control:

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.

2. Inspect locations of access doors and verify that purpose of access door can be performed.

3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.

4. Inspect turning vanes for proper and secure installation.

5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section includes: For each product.

1. Fiberglass Backward Curved centrifugal fans.

1.03 Reference Standards

A. Air Movement and Control Association International, Inc. (AMCA):

1. AMCA 99 - Standards Handbook.
2. AMCA 300 - Reverberant Room Method for Sound Testing of Fans (ANSI).
3. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data (ANSI).

B. Air Movement and Control Association International, Inc./American Society of Heating, Refrigerating and Air-Conditioning Engineers (AMCA/ASHRAE):

1. AMCA 210/ASHRAE 51 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating (ANSI).

C. American Bearing Manufacturers Association (ABMA):

1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

D. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1. ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality.

E. NFPA:

1. NFPA 70 - National Electrical Code.

1.04 Submittals

A. Product Data:

1. Include rated capacities, furnished specialties, and accessories for each fan.
2. Certified fan performance curves with system operating conditions indicated.
3. Certified fan sound-power ratings.
4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
5. Material thickness and finishes, including color charts.
6. Dampers, including housings, linkages, and operators.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

D. Field quality control reports.

E. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.05 Maintenance

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Belts: One set for each belt-driven unit.

PART 2 - Products

2.01 Performance Requirements

A. AMCA Compliance:

1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.

2. Operating Limits: Classify according to AMCA 99.

B. Unusual Service Conditions: Refer to Fan Schedule on Drawings.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Capacities and Characteristics: Refer to Fan Schedule on Drawings.

2.02 Backward-Inclined Centrifugal Fans

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hartzell Air Movement

2. Aerovent; a Twin City Fan company.

3. Loren Cook Company

4. Engineer Approved Equal

B. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt-drive Fiberglass Backward Curved Centrifugal fan consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.

2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.

3. Factory-installed and -wired disconnect switch.

C. Housings:

1. Formed panels to make curved-scroll housings with shaped cutoff.

2. Panel Bracing: Steel angle member supports for mounting and supporting fan scroll, wheel, motor, and accessories.

3. Horizontally split, bolted-flange housing.

4. Solid fiberglass inlet cone and flange.

5. Outlet flange.

D. Backward-Inclined Wheels:

1. Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, back plate, backward cr blades, and fastened to shaft with set screws.

2. Welded or riveted to flange and back plate; cast-iron or cast-steel hub riveted to back plate.

E. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.

2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.

3. Designed to operate at no more than 70% of first critical speed at top of fan's speed range.

F. Prelubricated and Sealed Shaft Bearings:

1. Self-aligning, pillow-block-type ball bearings.

2. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.

3. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

G. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

2. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.

3. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

H. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.

2. Service Factor Based on Fan Motor Size: 1.5.

3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.

4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.

5. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.

6. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

7. Motor Mount: Adjustable for belt tensioning.

I. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.

2. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.

3. Companion Flanges: Rolled flanges for duct connections of same material as housing.

4. Inlet Screens: Grid screen of same material as housing.

5. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.

6. Spark-Resistant Construction: AMCA 99.

7. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

8. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

2.03 Motors

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 - Common Motor Requirements for HVAC Equipment.

2.04 Source Quality Control

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."

PART 3 - Execution

3.01 Installation

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting: Install centrifugal fans on cast-in-place concrete equipment base(s) using elastomeric pads. Comply with requirements for equipment bases specified in Division 03. Comply with requirements for vibration isolation devices specified in Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.

1. Minimum Deflection: 1/4 inch (6 mm).

2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.

4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.

5. Place and secure anchorage devices. Use setting Drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

6. Install anchor bolts to elevations required for proper attachment to supported equipment.

E. Install units with clearances for service and maintenance.

F. Label fans according to requirements specified in Section 23 05 53 - Identification for HVAC Piping and Equipment.

3.02 Connections

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00 - Air Duct Accessories.

B. Install ducts adjacent to fans to allow service and maintenance.

3.03 Field Quality Control

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.

5. Adjust belt tension.

6. Adjust damper linkages for proper damper operation.

7. Verify lubrication for bearings and other moving parts.

8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

9. See Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC for testing, adjusting, and balancing procedures.

10. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.04 Demonstration

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION

PART 1 - General

1.01 Related documents:

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

1.02 Summary:

A. This Section includes:

1. Axial roof ventilators.
2. Propeller fans.

1.03 Reference standards:

A. American Bearing Manufacturers Association (ABMA):

1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings (ANSI).

B. Air Movement and Control Association International, Inc. (AMCA):

1. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data (ANSI).

C. Air Movement and Control Association International, Inc./American Society of Heating, Refrigerating and Air-Conditioning Engineers (AMCA/ASHRAE):

1. AMCA 210/ASHRAE 51 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating (ANSI).

D. NFPA:

1. NFPA 70 - National Electrical Code.

1.04 Performance requirements:

A. Project Altitude: Base fan-performance ratings on actual Project Site elevations.

1.05 Submittals:

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:

1. Certified fan performance curves with system operating conditions indicated.

2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers.

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

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.06 Quality assurance:

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

1.07 Coordination:

A. Coordinate size and location of structural-steel support members.

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

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.08 Maintenance:

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set for each belt-driven unit.

PART 2 - Products

2.01 Axial roof ventilators:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Aerovent; a division of Twin City Fan Companies, Ltd.
2. Greenheck Fan Corporation.
3. Loren Cook Company.

B. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, hinged, aluminum base.

1. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheel: Aluminum hub and blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Pulleys: Cast-iron, adjustable-pitch motor pulley.

E. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.

F. Capacities and Characteristics: Refer to Fan Schedule on Drawings.

2.02 Propeller fans:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Aerovent; a division of Twin City Fan Companies, Ltd.
2. Greenheck Fan Corporation.
3. Loren Cook Company.

B. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.

C. Fan Wheel: Replaceable, cast aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

D. Fan Drive: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

E. Fan Drive:

1. Resiliently mounted to housing.
2. Statically and dynamically balanced.
3. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
4. Extend grease fitting to accessible location outside of unit.
5. Service Factor Based on Fan Motor Size: 1.4.
6. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
7. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
    a. Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
8. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
9. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
10. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
11. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

F. Accessories:

1. Motor-Side Back Guard: ½” Aluminum, complying with OSHA Specifications, removable for maintenance.
2. Wall Sleeve: Galvanized steel to match fan and accessory size.
3. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

G. Capacities and Characteristics: Refer to Fan Schedule on Drawings.

2.03 Motors:

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 - Common Motor Requirements for HVAC Equipment.

   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

   2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

2.04 Source quality control:

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - Execution

3.01 Installation:

A. Install power ventilators level and plumb.

B. Install floor-mounted units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Secure fans to structurally provided roof curb per drawings..

D. Install units with clearances for service and maintenance.

E. Label units according to requirements specified in Section 23 05 53 - Identification for HVAC Piping and Equipment.

3.02 Connections:

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00 - Air Duct Accessories.

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26.

D. Connect wiring according to Division 26.

3.03 Field quality control:

A. Perform tests and inspections.

B. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.

5. Adjust belt tension.

6. Adjust damper linkages for proper damper operation.

7. Verify lubrication for bearings and other moving parts.

8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.

10. Shut unit down and reconnect automatic temperature-control operators.

11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.04 Adjusting:

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION

PART 1 - General

1.01 Related documents:

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

1.02 Summary:

A. This Section includes:

1. Rectangular and square ceiling diffusers.
2. Adjustable bar registers and grilles.
3. .Fixed face registers and grilles.

1.03 Related requirements:

A. DIVISION 08 for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.

B. Section 23 33 00 - Air Duct Accessories for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.04 Reference standards:

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

B. Applicable Standards (Latest Edition):

1. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
    a. ASHRAE 70 - Method of Testing for Rating the Performance of Air Outlets and Inlets (ANSI).

1.05 Submittals:

A. Action Submittals:

1. Product Data: For each type of product indicated, include the following:
    a. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.

   b. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

2. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

3. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

B. Informational Submittals:

1. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

   a. Ceiling suspension assembly members.

   b. Method of attaching hangers to building structure.

   c. Size and location of initial access modules for acoustical tile.

   d. Duct access panels.

2. Source quality-control reports.

PART 2 - Products

2.01 Diffusers, registers, and grilles:

A. For all diffusers, registers, and grilles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Krueger.

   b. Price Industries.

   c. Titus.

2. All products shall conform to the schedules.

2.02 Source quality control:

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - Execution

3.01 Examination:

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.02 Installation:

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.03 Adjusting:

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

PART 1 - General

1.01 Related documents:

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

1.02 Summary:

A. This Section includes:

1. Odor control systems using activated carbon.

1.03 Related requirements:

A. Section 23 34 16 - Centrifugal HVAC Fans for customized fan and filter units.

1.04 Reference standards:

A. Applicable Standards (Latest Edition):

1. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

    a. ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality.

2. NFPA:

    a. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

1.05 Submittals:

A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.

1. Show assembly, dimensions, materials, and methods of assembly of components.

2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

C. Field quality-control reports.

D. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

E. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

  1. Provide one complete 100% refill supply for each filter requiring loose-fill media.

PART 2 - Products

2.01 Carbon Adsorber Tank systems:

A. Description: Odor control system consisting of tank

  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Carbtrol.

    b. Integrity Municipal Systems.

    c. ECS Environmental Solutions.

B. Media: Carbon-filled fibrous material.

C. Fill Media: Approximately 8000 lbs of highly active carbon per canister.

  1. Type: Granular

  2. H2S capacity: 0.20 g H2S/cc carbon minimum

  3. Density: 0.40 g/cc.

  4. Mesh Size: 4 by 8 US Sieve.

D. Capacities and Characteristics: Refer to equipment schedule on Contract Drawings.

PART 3 - Execution

3.01 Installation:

A. Do not operate fan system until particulate filter media (temporary or permanent) is in place. Replace temporary media used during construction and testing with new media.

B. Coordinate filter installations with duct and air-handling unit installations.

3.02 Field quality control:

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installation, including connections.

B. Tests and Inspections:

1. Test for leakage of unfiltered air while system is operating.

C. Air filter will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.03 Cleaning:

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new particulate filter media.

END OF SECTION

PART 1 - General

1.01 Related documents:

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

1.02 Summary:

A. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:

1. Electric-heating coils.
2. Economizer outdoor- and return-air damper section.
3. Integral, space temperature controls.
4. Roof curbs.

B. Related Sections include the following:

1.03 References:

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

B. Air-Conditioning, Heating & Refrigeration Institute (AHRI):

1. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
2. AHRI 270 - Sound Performance Rating of Outdoor Unitary Equipment.
3. AHRI 340/360 - Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.
4. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.
5. AHRI 430 - Performance Rating of Central Station Air-Handling Units
6. AHRI Guideline B - Guidelines for Roof Mounted Outdoor Air-Conditioning Installations.

C. Air Movement and Control Association (AMCA)

1. AMCA 210 - Laboratory Methods of Testing Fans for Rating.

2. AMCA 300 - Reverberant Room Methods for Sound Testing of Fans.
3. AMCA 301 - Methods for Calculating Fan Sound Ratings From Laboratory Test Data.
4. AMCA 99 - Standards Handbook.
5. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating.

D. American Bearing Manufacturers Association (ABMA):

1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

E. American Gas Association (AGA):

1. AGA FUN - Fundamentals of Gas Appliances.

F. American National Standards Institute (ANSI):

1. ANSI Z21.47/CSA 2.3 - Standard for Gas-Fired Central Furnaces.
2. ANSI Z83.4/CSA 3.7 - Non-Recirculating Direct Gas-Fired Industrial Air Heaters.
3. ANSI Z83.18 Recirculating Direct Gas-Fired Industrial Air Heaters.

G. American Society of Civil Engineers (ASCE):

1. ASCE 7-10 - Minimum Design Loads for Buildings and Other Structures.

H. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1. ASHRAE 15 & 34 - Safety Standard for Refrigeration Systems.ASHRAE 33 - Methods of Testing Forced Circulation Air Cooling and Air Heating Coils.
2. ASHRAE 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
3. ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality.
4. ASHRAE 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks.

I. American Society of Heating, Refrigerating and Air-Conditioning Engineers/Illuminating Engineering Society of North America (ASHRAE/IESNA):

1. ASHRAE/IESNA 90.1 - Energy Standard for Buildings except Low-Rise Residential Buildings.

J. American Society of Mechanical Engineers (ASME)

1. ASME B31.5 - Refrigeration Piping and Heat Transfer Components.

K. ASTM International (ASTM):

1. ASTM B88 - Standard Specification for Seamless Copper Water Tube.
2. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric).
3. ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
4. ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation.
5. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound-Absorbing Material).
6. ASTM D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
7. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

L. Code of Federal Regulations (CFR):

1. 40 CFR, Part 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings (EPA).
2. 29 CFR, Part 1910, Subpart O - Machinery and Machine Guarding (OSHA).

M. International Electrotechnical Commission (IEC):

1. IEC 60947-4-1 - Low-Voltage Switchgear and Controlgear - Part 4-1 - Contactors and Motor-Starters-Electromechanical Contactors and Motor-Starters.

N. National Electrical Manufacturers Association (NEMA):

1. NEMA 250 - Enclosures for Electrical Equipment (1,000V Maximum).
2. NEMA KS 1 - Heavy Duty Enclosed and Dead Front Switches (600V Maximum).

O. National Roofing Contractors Association (NRCA):

1. NRCA 0423 - The NRCA Roofing Manual: Membrane Roof Systems.
2. NRCA ROOFMAN14 - The NRCA Roofing Manual.

P. National Fire Protection Association (NFPA):

1. NFPA 54 - National Fuel Gas Code.
2. NFPA 70 - National Electrical Code.
3. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

4. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

Q. Underwriters Laboratories, Inc. (UL):

1. UL 489 - UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.

2. UL 723 - UL Standard for Safety Test for Surface Burning Characteristics of Building Materials.

3. UL 900 - UL Standard for Safety Air Filter Units.

4. UL 1995 - UL Standard for Safety Heating and Cooling Equipment.

1.04 Definitions:

A. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations [and to absorb heat during heating operations]. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

B. Outdoor-Air Refrigerant-Coil Fan: The outdoor-air refrigerant-coil fan in RTUs. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

C. RTU: Rooftop unit. As used in this Section, this abbreviation means [packaged,] outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

D. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

E. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

1.05 Action submittals:

A. Product Data: Include manufacturer's technical data for each AHU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

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

1. Wiring Diagrams: Power, signal, and control wiring.

1.06 Informational submittals:

1.07 Closeout submittals:

A. Operation and Maintenance Data: For AHUs to include in emergency, operation, and maintenance manuals.

1.08 Maintenance material submittals:

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: One set for each belt-driven fan.

2. Filters: One set of filters for each unit.

1.09 Quality assurance:

A. AMCA Compliance:

1. Comply with AMCA 99 for fabrication quality.

2. Comply with AMCA 210 for fan performance ratings.

3. Comply with AMCA 301 and test as described in AMCA 300 for sound ratings.

B. AHRI Compliance:

1. Comply with AHRI 210/240 and AHRI 340/360 for testing and rating energy efficiencies for RTUs.

2. Comply with AHRI 270 for testing and rating sound performance for RTUs.

3. Comply with AHRI 410 to certify air coil capacity, pressure drop and selection.

4. Comply with AHRI 430 for fabrication quality.

C. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.

2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.

D. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. The air handling unit shall be a product of manufacturer regularly engaged in the production of air handling equipment.

1.10 Warranty:

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Equipment start-up or as specified in Section 01 43 33.

2. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Equipment start-up or as specified in Section 01 43 33.

PART 2 - Products

2.01 Manufacturers:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carrier Corporation.

2. York.

3. Engineer Approved Equal

2.02 Performance/design criteria:

A. General Fabrication Requirements: Comply with requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and System Start-up."

B. Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Capacities and Characteristics: As scheduled.

2.03 Cabinet:

A. Construction: Double wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Exterior Casing Material: Minimum 16 gauge galvanized steel with factory-painted finish.

C. Interior Casing Material: Minimum 20 gauge galvanized or stainless steel.

D. Lifting and Handling Provisions: Factory-installed shipping skids and lifting lugs.

E. Base Rails: Galvanized-steel rails for mounting on pad as indicated.

F. Cabinet Insulation:

1. Type: Fibrous-glass duct lining complying with ASTM C1071, Type II or flexible elastomeric insulation complying with ASTM C534, Type II, sheet materials.
2. Thickness: 1 inch (25 mm).
3. Insulation Adhesive: Comply with ASTM C916, Type I.
4. Flame Spread: Maximum 25 flame spread, 50 fuel contribution or 50 smoke generation when tested under ASTM E84 and UL 723.
5. Mechanical Fasteners: Suitable for adhesive, mechanical, or welding attachment to casing without damaging liner and without causing air leakage when applied as recommended by manufacturer.

G. Finish:

1. Seal fixed joints with flexible weathertight sealer.
2. Seal removable joints with closed cell foam gasket.

H. Condensate Drain Pans:

1. Slope in at least two planes to direct water toward drain connection.
2. Size: Large enough to collect condensate from cooling coils including coil piping connections, coil headers, and return bends.
3. Material: Stainless steel.
4. Drain Connection:
   a. Terminated with threaded nipple.

2.04 Supply fan:

A. Forward-Curved Fan Type: Centrifugal; statically and dynamically balanced with OSHA belt guard and inlet screen.

1. Fan Wheel Material: Galvanized or Painted steel, mounted on solid-steel shaft.
2. Bearings: Self-aligning, permanently lubricated.

B. Motors:

  1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 - Common Motor Requirements for HVAC Equipment.

C. Mounting:

  1. Fan wheel, motor, and drives shall be mounted to fan casing with restrained elastomeric isolators on a welded steel base coated with air dried epoxy finish.

  2. Factory mount motor on adjustable slide rails.

  3. Provide access to motor, drive, and bearings through hinged access doors.

2.05 Cooling coils:

A. Coil Casing Material: Manufacturer's standard material.

B. Tube Material: Copper

C. Fin Material: Aluminum.

D. Fin and Tube Joints: Mechanical bond.

E. Leak Test: Coils shall be leak tested with air underwater.

F. Coating: Provide phenolic epoxy corrosion-protection coating.

G. Provide coil section with coils and access to both sides of coil.

  1. Enclose coils with headers and return bends fully contained within casing.

  2. Slide coils into casing through removable end panel.

  3. Provide with blank off sheets and sealing collar at connection penetrations.

2.06 Refrigeration system:

A. Comply with requirements in ASHRAE 15, "Safety Standard for Refrigeration Systems."

B. Refrigerant Charge: Factory charged with refrigerant and filled with oil.

C. Compressors: Scroll compressors with integral vibration isolators, internal overcurrent and over-temperature protection, internal pressure relief.

D. Refrigerant: R-410A.

  1. Classified as Safety Group A1 according to ASHRAE 34.

2. Provide unit with operating charge of refrigerant.

E. Refrigeration System Specialties:

   1. Expansion valve with replaceable thermostatic element.
   2. Refrigerant dryer.
   3. High-pressure switch.
   4. Low-pressure switch.
   5. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
   6. Brass service valves installed in discharge and liquid lines.
   7. Provide alternate row circuiting for units 7.5 tons cooling capacity and larger.

F. Capacity Control:

   1. Hot-gas bypass refrigerant control for capacity control with continuous dehumidification on a single compressor.
   2. Patented, Rawal APR control with zero to 100% modulating capacity control using hot-gas bypass. Evaporator coil shall be continuously active for dehumidification.
   3. Single compressor with evaporator and condenser coil within the refrigerant section to provide initial pre-cooling and to reheat for humidity control.
   4. Heat-pipe heat exchanger wrapped around the evaporator coil to pre-cool the air entering the evaporator coil and reheat the air leaving the evaporator coil to control humidity.

G. Coating: Provide phenolic epoxy corrosion-protection coating on evaporator coils.

2.07 Electric-resistance heating coil:

A. UL Compliance: Comply with requirements in UL 1995.

B. Electric-Resistance Heating Elements:

   1. Open-Coil Resistance Wire: 80% nickel and 20% chromium.
   2. Supports and Insulation: Floating ceramic bushings recessed into casing openings; fastened to supporting brackets and mounted in galvanized-steel frame.

3. Heating Capacity: Low density 35 W per inch² (54 kW per m²), factory wired for single-point wiring connection; with time delay for element staging and overcurrent- and overheat-protection devices.

4. Safety Controls:

    a. Blower-motor interlock, air-pressure switch.

    b. Quiet mercury contactors.

    c. Time delay between steps.

    d. Integral, nonfused power disconnect switch.

2.08 Outdoor-air intake hood:

A. Type: Manufacturer's standard hood or louver.

B. Materials: Match cabinet.

C. Bird Screen: Comply with requirements in ASHRAE 62.1.

D. Configuration:

1. Designed to inhibit wind-driven rain and snow from entering unit.

2. Fabricate intake louvers of aluminum with frame matching cabinet.

3. Depth: Six inches with plenum.

4. Provide aluminum bird screen, removable for cleaning from outside.

5. Delrin bearings on intake damper if provided.

2.09 Filters:

A. Extended-Surface, Disposable Panel Filters:

1. Comply with NFPA 90A.

2. Factory-fabricated, dry, extended-surface type.

3. Thickness: 4 inches (100 mm).

4. Minimum Merv: 7, according to ASHRAE 52.2.

5. Media: Water-resistant, fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.

B. Mounting Frames:

1. Extended surface filters arranged for flat orientation, removable from access plenum.

2. Provide factory mounted differential pressure on cabinet exterior for each filter bank.

2.10 Electrical power connections:

A. General Electrical Power Connection Requirements: Factory-installed and -wired switches, motor controllers, transformers, and other necessary electrical devices shall provide a single-point field power connection to unit.

B. Enclosure: NEMA 250, Type 4X, mounted in unit with hinged access door in unit cabinet having a lock and key or padlock and key,

C. Wiring: Numbered and color-coded to match wiring diagram.

D. Wiring Location: Install factory wiring outside an enclosure in a raceway.

E. Factory-Mounted, Overcurrent-Protection Service: For each motor.

F. Transformer: Factory mounted with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

G. Controls: Factory wire unit-mounted controls where indicated.

H. Lights: Factory wire unit-mounted lights.

I. Receptacle: Factory wire unit-mounted, ground fault interrupt (GFI) duplex receptacle.

J. Control Relays: Auxiliary and adjustable time-delay relays.

2.11 Controls:

A. Control Wiring: Factory wire connection for controls power supply.

B. Control Devices: Sensors, transmitters, relays, switches, detectors, operators, actuators, and valves shall be manufacturer's standard items to accomplish indicated control functions.

C. Unit-Mounted Status Panel:

   1. Cooling/Off/Heating Controls: Control operational mode.

   2. Damper Position: Indicate position of outdoor-air dampers in terms of percentage of outdoor air.

   3. Status Lights:

      a. Filter dirty.

b. Fan operating.

c. Cooling operating.

d. Heating operating.

e. Smoke alarm.

f. General alarm.

4. Digital Numeric Display:

a. Outdoor airflow.

b. Supply airflow.

c. Outdoor dry-bulb temperature.

d. Outdoor dew point temperature.

e. Space temperature.

f. Supply temperature.

g. Space relative humidity.

h. Space carbon dioxide level.

D. Control Dampers:

1. Damper Location: Factory installed inside unit for ease of blade axle and bushing service. Arrange dampers located in a mixing box to achieve convergent airflow to minimize stratification.

2. Damper Leakage: Comply with requirements in AMCA 500-D. Leakage shall not exceed 6.5 cfm per ft.^{2} (33 L/s per m^2) at a static-pressure differential of 4.0 inches water column (1000 Pa) when a torque of 5 inch lbs. per ft.^{2} (30.1 Newton m per m^2) is applied to the damper jackshaft.

3. Damper Rating: Rated for close-off pressure equal to the fan shutoff pressure.

4. Damper Label: Bear the AMCA seal for both air leakage and performance.

5. Blade Configuration: Use parallel blade configuration for two-position control and equipment isolation service. Use opposed blade configuration for modulating control when mixing two airstreams.

6. Damper Frame Material: Extruded aluminum, galvanized steel, or stainless steel.

7. Blade Type: Single-thickness metal reinforced with multiple V-grooves or hollow-shaped airfoil.

8. Blade Material: Extruded aluminum, galvanized steel, or stainless steel.

9. Maximum Blade Width: 6 inches (150 mm).

10. Maximum Blade Length: 48 inches (1200 mm).

11. Airflow Measurement:

    a. Monitoring System: Complete and functioning system of airflow monitoring as an integral part of the damper assembly where indicated.

    b. Remote Monitoring Signal: 0 to 10V or 4-20 mA scaled signal.

    c. Accuracy of flow measurement: Within 10% of the actual flow rate between the range of the scheduled minimum and maximum airflow. For units with a large range between minimum and maximum airflow, configure the damper sections and flow measurement assembly as necessary to comply with accuracy.

    d. Straightening Device: Integral to the flow measurement assembly if required to achieve the specified accuracy as installed.

    e. Flow measuring device: Suitable for operation in untreated and unfiltered outdoor air. If necessary, include temperature and altitude compensation and correction to maintain the accuracy.

E. Damper Operators:

1. Factory-installed 24V electric operator with gear train sealed in oil for each damper assembly with one operator for each damper assembly mounted to the damper frame.

2. Operator capable of shutoff against fan pressure and able to operate the damper with sufficient reserve power to achieve smooth modulating action and proper speed of response at the velocity and pressure conditions to which the damper is subjected.

3. Maximum Operating Time: Open or close damper 90 degrees in 60 seconds.

4. Adjustable Stops: For both maximum and minimum positions.

5. Position Indicator and Graduated Scale: Factory installed on each actuator with words "OPEN" and "CLOSED," or similar identification, at travel limits.

6. Spring-return operator to fail-safe on units 7.5 tons or larger; either closed or open as required by application.

7. Operator Type: Direct coupled, designed for minimum 60,000 full-stroke cycles at rated torque.

8. Position feedback Signal: For remote monitoring of damper position.

9. Coupling: V-bolt and V-shaped, toothed cradle.

10. Circuitry: Electronic overload or digital rotation-sensing circuitry.

F. Electric-Resistance Heat Controls:

1. Factory-mounted sensor in unit discharge with sensor adjustment located in control panel to control electric coil to maintain temperature.

2. Wall-mounted, space-temperature sensor with temperature adjustment to control electric coil to maintain temperature.

3. Capacity Controls: On/off .

G. Damper Controls: Space pressure sensor modulates outdoor- and return-air dampers to maintain a positive pressure in space at a minimum of 0.05 inch w.g. (12.4 Pa) with respect to outdoor reference.

H. Barometric Relief Dampers: Gravity damper shall open to relieve positive pressure in the return air section when required building pressurization achieved.

I. Integral Smoke Alarm: Smoke detector installed in return air.

2.12 Accessories:

A. Service Lights and Switch: Factory installed in each accessible section with weatherproof cover. Factory wire lights to a single-point field connection.

B. Duplex Receptacle: Factory mounted in unit supply-fan section, with 20 amp 120V GFI duplex receptacle and weatherproof cover.

C. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

1. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.

2. Fan-speed selection including auto setting.

PART 3 - Execution

3.01 Examination:

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Examine roof curbs and equipment supports for suitable conditions where units will be installed.

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

3.02 Installation:

A. Comply with manufacturer's rigging and installation instructions for unloading units and moving to final locations.

B. Comply with manufacturer’s installation instructions and AHRI Guideline B.

C. Restrained Curb Support: Install restrained vibration isolation roof-curb rails on roof structure according to "The NRCA Roofing Manual."

1. Restrained isolation roof-curb rails are specified in Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.

2. Install and secure units on curbs and coordinate roof penetrations and flashing with roof construction.

3. Install flexible duct connectors. Comply with requirements in Section 23 33 00 - Air Duct Accessories for flexible duct connectors.

4. Install vibration isolation and seismic-control devices. Comply with requirements in Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment for vibration isolation and seismic-control devices.

5. Coordinate size, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07.

6. Coordinate size, location, and installation of unit manufacturer's roof curbs and equipment supports with roof Installer.

D. Equipment Mounting: Install floor or on-grade mounted units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases specified in Division 03.

1. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch (450 mm) centers around the full perimeter of concrete base.

3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use setting Drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

5. Install anchor bolts to elevations required for proper attachment to supported equipment.

6. Install on concrete base designed to withstand, without damage to equipment, seismic force required by code.

E. Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.

1. Drain Piping: Schedule 40 PVC pipe complying with ASTM D1785, with solvent-welded fittings.

2. Pipe Size: Same size as condensate drain pan connection.

3.03 Connections:

A. Where installing piping adjacent to units, allow space for service and maintenance.

B. Duct Connections:

1. Comply with requirements in Section 23 31 13 - Metal Ducts.

2. Drawings indicate the general arrangement of ducts.

3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 23 33 00 - Air Duct Accessories.

C. Electrical Connections: Comply with requirements for power wiring, switches, and motor controls in Division 26 Sections.

1. Install electrical devices furnished by unit manufacturer but not factory mounted.

3.04 Startup service:

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Do not operate unit without Owner’s authorization, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

3. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

a. High-limit heat exchanger.

b. Alarms.

4. Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.

5. Start refrigeration system when outdoor-air temperature is within normal operating limits and measure and record the following:

   a. Cooling coil leaving-air, dry- and wet-bulb temperatures.

   b. Cooling coil entering-air, dry- and wet-bulb temperatures.

   c. Condenser coil entering-air dry-bulb temperature.

   d. Condenser coil leaving-air dry-bulb temperature.

6. Simulate maximum cooling demand and inspect the following:

   a. Compressor refrigerant suction and hot-gas pressures.

   b. Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.

7. Inspect casing insulation for integrity, moisture content, and adhesion.

8. Verify that clearances have been provided for servicing.

9. Verify that controls are connected and operable.

10. Verify that filters are installed.

11. Clean coils and inspect for construction debris.

12. Verify bearing lubrication.

13. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.

14. Adjust fan belts to proper alignment and tension.

15. Start unit.

16. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.

17. Operate unit for run-in period.

18. Calibrate controls.

19. Adjust and inspect high-temperature limits.

20. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.

21. Verify operational sequence of controls.

22. Measure and record the following airflows. Plot fan volumes on fan curve.

    a. Supply-air volume.

    b. Return-air flow.

    c. Outdoor-air flow.

B. After startup, change filters, verify bearing lubrication, and adjust belt tension.

C. Remove and replace components that do not properly operate and repeat startup procedures as specified above.

D. Prepare written report of the results of startup services.

3.05 Adjusting:

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.06 Demonstration:

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION

PART 1 - General

1.01 Related documents:

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

1.02 Summary:

A. This Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.03 Related requirements:

A. Section 23 05 13 - Common Motor Requirements for HVAC Equipment.

1.04 Reference standards:

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

B. Air-Conditioning Heating & Refrigeration Institute (AHRI):

1. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1. ASHRAE 15 - Safety Standard for Refrigeration Systems (ANSI).
2. ASHRAE 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size (ANSI).
3. ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality (ANSI).

D. American Society of Heating, Refrigerating and Air-Conditioning Engineers/Illuminating Engineering Society of North America (ASHRAE/IESNA):

1. ASHRAE/IESNA 90.1 - Energy Standard for Buildings except Low-Rise Residential Buildings (ANSI).

E. NFPA:

1. NFPA 70 - National Electrical Code.
2. NFPA 90A - Installation of Air-Conditioning and Ventilating Systems.

1.05 Submittals:

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

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

  1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

  2. Wiring Diagrams: For power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Field quality-control reports.

E. Warranty: Sample of special warranty.

F. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

G. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

  1. Filters: One set for each air-handling unit.

  2. Fan Belts: One set for each air-handling unit fan.

1.06 Quality assurance:

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

  1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

1.07 Coordination:

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in DIVISION 03.

1.08 Warranty:

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

    a. For Compressor: Five years from date of Equipment start-up or as specified in Section 01 43 33.

    b. For Parts & Labor: One year from date of Equipment start-up or as specified in Section 01 43 33.

PART 2 - Products

2.01 Manufacturers:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carrier Corporation; Home Comfort and HVAC Building & Industrial Systems.

2. YORK; a Johnson Controls company.

3. Engineer Approved Equal

2.02 Indoor units (6 tons (21 kw) or more):

A. Concealed Evaporator-Fan Components:

1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.

2. Insulation: Faced, glass-fiber duct liner.

3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with AHRI 210/240.

4. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.

5. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.

6. Fan Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 23 05 13 - Common Motor Requirements for HVAC Equipment.

b. Multitapped, multispeed with internal thermal protection and permanent lubrication.

c. Three-phase, permanently lubricated, ball-bearing motors with built-in thermal-overload protection.

d. Wiring Terminations: Connect motor to chassis wiring with plug connection.

e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in DIVISION 26 Sections.

f. Enclosure Type: Totally enclosed, fan cooled.

g. Mount unit-mounted disconnect switches on exterior of unit.

7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

8. Air Filtration Section:

a. General Requirements for Air Filtration Section:

(1) Comply with NFPA 90A.

(2) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

b. Disposable Panel Filters:

(1) Thickness: See Schedule.

(2) Resistance: See Schedule for initial and dirty filter values.

(3) MERV according to ASHRAE 52.2: See Schedule.

(4) Media: Fibrous material formed into deep-V-shaped pleats held by self-supporting wire grid permanent, cleanable and antimicrobial agent.

(5) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

9. Condensate Drain Pans:

a. Fabricated with 1% slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.

        - (1) Length: Extend drain pan downstream from leaving face by one half the vertical dimension of the refrigerant coil.
        - (2) Depth: A minimum of 2 inches (50 mm) deep.
    - b. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
    - c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
        - (1) Minimum Connection Size: NPS 1 (DN 25).
    - d. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.03 Outdoor units (6 tons (21 kw) or more):

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gauge ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
    - a. Compressor Type: Scroll.
    - b. Compressors shall be specifically selected to match related evaporator coil.
    - c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with AHRI 210/240. Provide Phenolic epoxy corrosion-protection coating after assembly.
3. Fan: Aluminum-propeller type, directly connected to motor.
4. Motor: Permanently lubricated, with integral thermal-overload protection.
5. Low Ambient Kit: Permits operation down to 45ºF (7ºC).
6. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
    - a. Compressor Type: Scroll.
    - b. Compressors shall be specifically selected to match related evaporator coil.

7. Heat Exchanger: Copper tubes in copper tube or in steel shell, with water-temperature-actuated, water-regulating valve.

2.04 Accessories:

A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

  1. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.

  2. Fan-speed selection including auto setting.

B. Automatic-reset timer to prevent rapid cycling of compressor.

C. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

D. Drain Hose: For condensate.

2.05 Capacities and characteristics:

A. Cooling Capacity:

  1. See Schedule.

B. Heating Capacity:

  1. See Schedule.

C. Indoor Unit:

  1. See Schedule.

D. Outdoor Unit:

  1. Type: Air cooled.

  2. See Schedule.

PART 3 - Execution

3.01 Installation:

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install ground-mounted, compressor-condenser components on 2-inch grout pad that is 4 inches larger, on each side, than unit. See DIV 03 for grout requirements.

D. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch (25 mm).

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.02 Connections:

A. Piping installation requirements are specified in other DIVISION 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Duct Connections: Duct installation requirements are specified in Section 23 31 13 - Metal Ducts. Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 23 33 00 - Air Duct Accessories.

3.03 Field quality control:

A. Perform tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

END OF SECTION

PART 1 - General

1.01 Related Documents

A. This Section specifies general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 01:

1. Submittals.
2. Coordination drawings.
3. Record documents.
4. Maintenance manuals.
5. Rough-ins.
6. Electrical installations.
7. Cutting and patching.
8. Electrical Demolition.
9. Touch-up Painting.

1.02 Summary

A. This Contract includes, but is not limited to, the following systems:

1. 208Y/120 V, 3 phase, 60 hertz, 4 wire lighting, convenience power, and small power system.
2. 480Y/277 V, 3 phase, 60 hertz, 4 wire power system.
3. 480V, 3 phase, 60 hertz, 3 wire power system.
4. Grounding systems.
5. Control systems.
6. Underground conduit system, including handholes.
7. Temporary lighting and convenience power facilities during construction.
8. Underground duct banks, including handholes and manholes.
9. Instrumentation systems.

B. Furnish and install (including supports) the following equipment as per the Drawings and Specifications.

C. Install and support the following equipment furnished by others:

1. Grinder control panels.
2. Sump Pump control panel.

1.03 Related Requirements

A. Division 31 for excavation for electrical installations within the building boundaries and from building to utility connections.

B. Section 01 73 29 - Cutting and Patching.

C. Section 01 78 00 - Contract Closeout.

D. Section 08 31 00 - Metal Access Doors for access doors.

E. Section 09 90 00 - Protective Coatings for surface coatings.

F. Section 23 05 13 - Common Motors Requirements for HVAC Equipment for factory-installed motors, controllers, accessories, and connections.

G. Section 46 05 13 – Common Motor Requirements for Water and Wastewater Equipment.

1.04 Reference Standards

A. Publication Dates: Comply with standards in effect as of the date of the Contract Documents unless otherwise indicated.

B. National Electrical Contractors Association (NECA).

C. National Electrical Installation Standards (NEIS): Except where the NEIS requirements specifically deviate from specific requirements of the NEC, the NEC shall take precedence.

D. National Fire Protection Association (NFPA):

1. NFPA 70 – National Electrical Code (NEC).

E. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C2 – National Electrical Safety Code (NESC).

F. Underwriters Laboratories (UL).

1.05 Definitions

A. EPA: Environmental Protection Agency.

B. PCB: Polychlorinated biphenyl.

C. PVC: Polyvinyl Chloride.

1.06 Submittals

A. Submit as specified in Division 01.

B. Refer to each Section of this Division for specific Submittal requirements.

C. Provide Conforming to Construction Records schematic diagrams and wiring diagrams.

D. Provide product data on electrical material and products.

E. Prepare coordination drawings in accordance with Division 01, for equipment rooms, and other congested areas to a scale of 1/4 inch=1 foot-0 inch or larger if required. Detail major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Drawings shall be prepared on 30-by-42-inch sheets. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of major raceway systems, equipment, and materials.

2. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.

3. Exterior wall and foundation penetrations.

4. Fire-rated wall and floor penetrations.

5. Equipment connections and support details.

6. Sizes and location of required concrete pads and bases.

7. Support details.

8. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

9. Prepare floor plans, elevations, and appropriate details to indicate penetrations in floors, walls, and ceilings, and their relationship to other penetrations and installations.

10. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets, air inlets, light fixtures, communications systems' components, sprinklers, heat detectors, smoke detectors, motion detectors, speakers, and other ceiling-mounted devices.

11. Coordinate chases, slots, inserts, sleeves, and openings with general construction work.

F. Prepare record documents in accordance with the requirements in Section 01 78 00 - Contract Closeout. In addition to the requirements specified in Division 01, indicate installed conditions for:

    1. Major raceway systems, size and location for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; fuse sizes, circuit breaker sizes and arrangements.

    2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.

    3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

G. Engage the services of a licensed Land Surveyor or licensed Professional Engineer registered in the state in which the Project is located to record the locations and invert elevations of underground installations.

H. Prepare operation and maintenance manuals in accordance with Section 01 78 00 - Contract Closeout. In addition to the requirements specified in Division 01, include the following information for equipment items:

    1. Description of function, normal operating characteristics and limitations, performance curves, engineering data, tests, and complete nomenclature and commercial numbers of replacement parts.

    2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; lockout/tagout procedures; and summer and winter operating instructions.

    3. Maintenance procedures for routine preventive maintenance and troubleshooting; disassembly, repair, reassembly; aligning and adjusting instructions.

    4. Servicing instructions, lubrication charts and schedules.

    5. "Conforming to Construction Records" schematic and wiring diagrams.

1.07 Delivery, Storage, and Handling

A. Deliver products to the Project Site properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

1.08 Project Site Conditions

A. Altitude = 689 feet above mean sea level.

B. Maximum Outdoor Ambient Temperature = 95 degrees F.

C. Minimum Outdoor Ambient Temperature = 19 degrees F.

D. Maximum Outdoor Relative Humidity = 100 percent.

1.09 Warranty

A. Provide a minimum one-year warranty on all electrical equipment. Warranty period shall begin when equipment is permanently energized or started unless specified otherwise in Section 01 43 33. Contractor shall provide written notification to Owner's Representative prior to this warranty start date.

PART 2 - Products

2.01 Products

A. Unless indicated otherwise, all equipment and material shall be new, undamaged and meet the requirements of Underwriters Laboratories, Inc. (UL). Where UL requirements are not applicable, equipment and material shall be identified as such by Contractor and approved by Owner before purchase and installation.

2.02 Electronic Equipment Compliance

A. Contractor warrants that all equipment, devices, items, systems, software, hardware, or firmware provided shall properly, appropriately, and consistently function and accurately process date and time data (including without limitation: calculating, comparing, and sequencing). This warranty supersedes anything in the Specifications or other Contract Documents which might be construed inconsistently. This warranty is applicable whether the equipment, device, item, system, software, hardware, or firmware is specified with or without reference to a manufacturer's name, make, or model number.

2.03 Finishes

A. For equipment: Equipment manufacturer's paint selected to match installed equipment finish.

B. Galvanized surfaces: Zinc-rich paint recommended by item manufacturer.

C. Provide finishes in accordance with Section 09 90 00 - Protective Coatings.

PART 3 - Execution

3.01 Erection, Installation, Application

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. All electrical work and material shall comply with the following requirements:

1. NFPA 70 - The National Electrical Code (NEC).
2. IEEE C2, National Electrical Safety Code, Federal Information Processing Standards Publication (FIPS).
3. NECA National Electrical Installation Standards (NEIS) (all except Table 1 of NECA 1).
4. Coordinate electrical systems, equipment, and materials installation with other building components. Equipment motor horsepower sizes and kilowatt sizes shown are approximate. If equipment of a different size is furnished by Contractor, Contractor shall furnish and install the proper support equipment, motor starter, switchgear, feeders, fuses, circuit breaker, disconnect switch, wire, and conduit required for the equipment furnished, at no additional cost to Owner.
5. Verify all existing dimensions by field measurements.
6. Arrange for chases, slots, and openings in other building components during progress of construction to allow for electrical installations.
7. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.
8. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building. Coordinate concrete pads, bases, roof curbs, and related items.
9. Coordinate with all other building trades.
10. Where mounting heights are not specifically detailed, specified, or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

11. Coordinate connection of electrical systems with exterior [underground] [and] [overhead] utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

12. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Should coordination requirements conflict with individual system requirements, refer conflict to Owner's Representative in writing.

13. Install systems, materials, and equipment level, plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

14. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting with minimum of interference with other installations.

15. Install access panel or doors where units are concealed behind finished surfaces. Access panels and doors are specified in Section 08 31 00 - Access Doors. The electrical Contractor shall be responsible for furnishing access panels required for electrical equipment in accordance with Division 08. Access panels shall be installed by Contractor.

16. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

17. All equipment conductor termination provisions shall be UL listed for 75ºC conductors.

18. All electrical equipment and installations shall be of adequate strength to withstand, without failure, forces encountered in defined Seismic conditions.

19. Install raceways, cables, wireways, cable trays and busways clear of obstructions and clear of the required working space of equipment.

C. Refer to each section of this Division for specific performance requirements.

D. Disposal of existing fluorescent lamps shall be by Contractor shipping the lamps to an EPA approved recycler for recycling. All shipping and disposal costs will be paid by Contractor at no additional expense to Owner.

E. Existing pre-1980 fluorescent lamp ballasts and ballasts not marked "no PCBs" (or are not dated with manufacturing date) shall be assumed to contain PCBs. Contractor shall dispose of PCB fluorescent ballasts by shipping the ballasts to an EPA approved PCB incineration facility. All shipping and disposal costs will be paid by Contractor at no additional expense to Owner.

3.02 Work On Existing Equipment

A. Do not remove any equipment from service without obtaining permission from Owner and Engineer.

B. Perform work that requires taking equipment out of service at times designated by Owner so as to cause minimum interruption in pump station operation.

C. Continue work with as many workmen as can be efficiently utilized from the time any equipment is removed from service until equipment is tested and back in service.

D. Connect electrical Equipment to provide same phasing as existing equipment, unless otherwise specified or indicated.

3.03 Testing

A. Test all electrical Equipment upon completion of installation to ensure that the Equipment operates satisfactorily and conforms to Contract Documents.

B. Furnish temporary power sources of proper type for testing purposes when normal supply is not available at the time of testing.

3.04 Demolition

A. Protect existing electrical equipment and installations indicated to remain. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.

B. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.

C. Abandoned Work: Cut and remove buried raceway and wiring indicated to be abandoned in place, 2 inches below surface of adjacent construction. Cap raceways and patch surface to match existing surface finish.

D. Remove demolished material from Project Site.

E. Remove, store, clean, re-install, reconnect and make operational components indicated for relocation.

3.05 Cutting and Patching

A. General: Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of the trades involved. Perform cutting and patching in accordance with Section 01 73 29 - Cutting and Patching. In addition to the requirements specified in Division 01, the following requirements apply:

1. Perform cutting and patching for electrical equipment and materials required to:

    a. Uncover work to provide for installation of ill-timed work.

    b. Remove and replace defective work.

    c. Remove and replace work not conforming to requirements of the Contract Documents.

    d. Remove samples of installed work as specified for testing.

    e. Install equipment and materials in existing structures.

    f. Upon written instructions from Engineer, uncover and restore work to provide for Engineer's observation of concealed work if installed without using the proper specified procedures.

B. For work in existing installations, the Contractor shall cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including, but not limited to, removal of electrical items indicated to be removed and items made obsolete by the new work.

C. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

D. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

E. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

F. All penetrations through fire-rated walls, ceilings and floors shall be sealed with a UL listed and FM Global approved sealant system that matches the fire rating of the surface penetrated.

G. Patch existing finished surfaces and building components that must be cut for the electrical installation or are damaged by Contractor using new materials matching existing materials.

H. All cutting, patching, and repairing shall be subject to the supervision and the approval of Owner's Representative.

I. Repair and re-finish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fire proofing where existing fireproofing has been disturbed. Repair and re-finish materials and other surfaces by skilled mechanics of trades involved.

3.06 Finishes

A. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit degree of damage at each location.

B. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.

C. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

D. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

E. Repair damage to protective coatings in accordance with Section 09 90 00 - Protective Coatings.

3.07 Cleaning

A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.

3.08 Protection

A. Protect equipment and installations and maintain conditions to ensure that coatings, finishes and cabinets are without damage or deterioration at time of Substantial Completion.

3.09 Closeout

A. Instructions, training, and manufacturer’s service representative:

1. Provide on-site instructions and training of Owner's personnel as specified.
2. Provide on-site services of a manufacturer's authorized service representative as specified.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section includes the requirements for furnishing and installing (including terminations) all low-voltage electrical conductors, cable, and accessories.

B. This Section includes an attached schedule of cables with circuit numbers as indicated on the Contract Documents.

1.03 Related Requirements

A. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

B. Section 26 05 33 – Raceways, Boxes, Seals and Fittings for Electrical Systems.

C. Section 26 05 53 – Electrical Identification.

D. Section 26 50 00 – Lighting.

1.04 Reference Standards

A. Publication Dates: Comply with standards in effect as of the date of the Contract Documents unless otherwise indicated.

B. American Society for Testing and Materials (ASTM):

1. ASTM B3 – Standard Specification for Soft or Annealed Copper Wire.
2. ASTM B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
3. ASTM B33 – Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
4. ASTM B172 – Rope-Lay Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors.

C. Insulated Cable Engineers Association (ICEA):

1. ANSI/ICEA S-81-570 – 600Volt Rated Cables of Ruggedized Design for Direct Burial Installations as Single Conductors or Assemblies of Single Conductors.

2. ANSI/ICEA S-105-692 – 600Volt Single Layer Thermoset Insulated Utility Underground Distribution Cables.

3. ICEA T-29-520 – Vertical Cable Tray Flame Tests at 210,000 Btu.

D. Institute of Electrical and Electronics Engineers (IEEE):

   1. IEEE 1202 – Flame-Propagation Testing of Wire and Cable.

E. International Electrical Testing Association (NETA):

   1. ANSI/NETA ATS – Acceptance Testing Specifications for Electrical Power Equipment and Systems.

F. National Electric Manufacturers Association (NEMA) and Insulated Cable Engineers Association (ICEA):

   1. NEMA WC57/ ICEA S-73-532 – Standard for Control, Thermocouple Extension, and Instrumentation Cables.

   2. NEMA WC70/ ICEA S-95-658 – Power Cables Rates 2000 V or Less For The Distribution of Electrical Energy.

G. National Fire Protection Association (NFPA):

   1. NFPA 70 – National Electrical Code (NEC).

H. Underwriters Laboratories, Inc. (UL):

   1. UL 44 – Thermoset Insulated Wires and Cables.

   2. UL 83 – Thermoplastic-Insulated Wires and Cables.

   3. UL 854 – Service Entrance Cables.

   4. UL 1277 – Standard for Electrical Power and Control Tray Cables with Optional Optical Fiber Members.

1.05 Definitions

A. Burns & McDonnell type designations, such as SEV1, CEV1, and BC2 indicated or specified, are for identification purposes only and are not intended to correspond to any trade designation. Burns & McDonnell type designations are defined by the Wire and Cable Specification Sheets located at the end of this section.

1.06 Submittals

A. Product Data: For each type of product including:

1. Data sheets for each wire and cable type specified.
2. Data sheets for wire and cable accessories.
3. Cable manufacturer's approval of splicing and terminating materials.
4. Cable manufacturer's approval of pulling compounds.
5. Cable manufacturer's installation requirements such as maximum pulling tensions, sidewall pressures, minimum bending radii, and other considerations.
6. Other Equipment and Materials to be used.

1.07 Delivery, Storage, And Handling

A. Packing and shipping: Cable shall be shipped on reels such that it is protected from mechanical injury. Each end of each length of cable shall be hermetically sealed with manufacturer’s end caps and securely attached to the reel. Cable reels shall be delivered vertically to allow for easy unloading. There shall be a minimum of six (6) inches between the top of the cable and the edge of the reel. Any cable reels that are not shipped vertically may be rejected upon delivery.

B. Storage and protection: Cable stored and/or cut on site shall have the ends turned down, and sealed with cable manufacturer’s standard cable end seals, or field-installed heat-shrink cable end seals.

C. Cable shall be stored on-site in a fashion that will prevent mechanical damage to the cable. Cable shall be stored away from areas that may have splashing or airborne debris. If necessary, cable shall be protected from hazards by visqueen, tarps, or similar materials.

PART 2 - Products

2.01 Manufacturers

A. Wire and Cable: Acceptable manufacturers for each wire and cable type will be manufacturers that have been manufacturing the specified cable for a minimum of five years and meet all the requirements listed on the Wire and Cable Specification Sheets.

B. Cable Connectors for Control and Instrument Cable:

1. TE Connectivity Ltd.

2. Hollingsworth Solderless Terminal Company.
3. Panduit Corporation.
4. 3M Company.
5. Thomas and Betts Company, Inc.

C. Cable Connectors for Power Cable:
    1. TE Connectivity Ltd.
    2. Thomas and Betts Company, Inc.
    3. 3M Company.
    4. Panduit Corporation.

D. Termination and Splice Kits:
    1. 3M Company.
    2. Raychem.

E. VFD Cable Termination Kits:
    1. Service Wire Company.
    2. Engineer approved equal.

F. Tape and Insulation Putty:
    1. 3M Company.

G. Cable Ties:
    1. TE Connectivity Ltd.
    2. Avery-Dennison Corporation.
    3. Panduit Corporation.
    4. 3M Company.
    5. Thomas and Betts Company, Inc.

H. Cable Supports:
    1. Emerson - O. Z./ Gedney Company.
    2. Hubbell, Kellems Grips.

I. Sealed Wall Cable Transition System:

1. Roxtec, Inc.
2. Engineer approved equal.

J. Terminal Blocks:

1. Allen Bradley.
2. Buchanan.
3. Phoenix Contact.
4. Square D Company.
5. Weidmuller.
6. Automation Direct.

K. Cable Identification Tags:

1. Allen Marking Products.
2. Panduit.
3. Specialty Products Company.
4. Thomas and Betts.

L. Cable Fire and Smoke Stop Fittings:

1. Crouse Hinds.
2. Nelson Electric.
3. Emerson –O. Z./Gedney Company.

2.02 Wire and Cable

A. Wire and cable shall be furnished in accordance with the specification sheets at the end of this Section.

2.03 Connectors

A. General Requirements:

1. Designed and sized for specific cable being connected.

2. Solderless, pressure type connectors constructed of non-corrodible tin plated copper.

3. Application tooling for connectors shall contain die or piston stops to prevent over crimping and cycling or pressure relief to prevent under crimping. Dies of all application tooling shall provide dot or wire size coding for quality control verification. All tooling shall be manufactured by the connector manufacturer.

B. Power Connectors (10 AWG and Smaller) 600V and Below:

1. "Scotchlok" pre-insulated spring wire connectors.

2. Buchanan open end copper splicing caps, applied with "Lok Seal" tool, with nylon snap on insulators.

C. Power Connectors (sizes 8 to 4 AWG) 600V and Below:

1. Non-insulated ring tongue type.

2. Ring tongue sized to match terminal stud size.

3. Brazed barrel seam.

4. Application tooling designed to crimp the wire barrel (conductor grip) with a one-step crimp.

D. Power Connectors (sizes 2 AWG to 750 MCM) 600V and Below:

1. Non-insulated one hole rectangular tongue for sizes 2 AWG through 3/0 AWG and two hole rectangular tongue for 4/0 AWG through 750 MCM.

2. Acceptable manufacturers' cross reference chart is listed at end of this Section.

E. Power Connectors (sizes 2 AWG to 750 MCM) above 600V:

1. Non-insulated one hole rectangular tongue for sizes 2 AWG through 3/0 AWG and two hole rectangular tongue for 4/0 AWG through 750 MCM.

2. Voltage rating equal or greater than that of the cable being used.

3. Application tooling shall be hydraulically operated.

F. Control, Instrument, and Specialty Cable Connectors:

1. Tin plated copper.

2. Vinyl or nylon pre-insulated ring tongue type. Spade lugs will not be permitted.

3. Sized to match terminal stud size.

4. Have insulation grip sleeve to firmly hold to cable insulation.

5. Insulation grip sleeve shall be funneled to facilitate wire insertion and prevent turned back strands.

6. Application tooling designed to crimp the wire barrel (conductor grip) and the insulation grip sleeve with a one-step crimp.

2.04 Motor Lead Termination/Splice (Low Voltage, 600 V and Below, Power Cable)

A. Splices shall be made using compression type connectors bolted together. The compression type connectors shall be properly sized for the cables. Reference acceptable connector manufacturer's cross reference chart.

B. Splice to be covered with heat shrinkable tubing connector insulators or slip-on rubber boot or sleeve.

C. Splicing shall be done in accordance with the instructions provided with the Raychem brand MCK Motor Connector Kit or 3M Company 5300 Series Motor Lead Splice Kit.

2.05 VFD Cable Termination Kits

A. Provide termination kit designed for terminating VFD cable shield.

B. Termination kit shall be designed for use with VFD cable and approved by the cable manufacturer.

2.06 Cable Supports

A. Cable supports for cables in vertical conduit risers shall be Emerson – O.Z. Gedney Type "R" wedging plug type or approved equal.

B. Kellems stainless steel basket type wire mesh grip for cables where indicated.

C. Stainless steel cable clamps in non-horizontal ladder type cable tray.

2.07 Sealed Wall Cable Transition System

A. Transition system shall be an assembly consisting of a metal frame, a compression mechanism, and insert modules with peelable layers for a variety of diameters of cable.

B. Design shall be water and gas tight to 14.5psi.

C. Provide stainless steel or coated galvanized steel frame suitable for concrete block wall installation.

D. Provide modules as indicated.

E. Provide a solid core for all spare modules installed under this contract.

F. Provide cable transition system by Roxtec, Inc. or equal.

2.08 Cable Ties

A. Nylon self-locking type.

B. Have a normal service temperature range of 40°C to 85°C.

C. Be weather resistant type for outdoor use.

D. TE Connectivity "AMP TY," Avery-Dennison "BAR LOK," Panduit Corporation "PAN TY," Thomas & Betts "TY RAP," or 3M Brand cable ties.

2.09 Terminal Blocks

A. For mounting in terminal boxes (TBs):

1. Designed and sized for the cables being terminated.

2. Block rated 600V.

3. Binding screw type terminals for power cables and strap screw or tubular clamp terminals for control and instrument cables.

4. Rated current carrying capacity equal to or greater than the cable being terminated.

5. Marking strip.

B. For Mounting in Cabinets, Panels, Control Boards, etc.:

1. Designed and sized for the cables being terminated.

2. Block rated 600V.

3. Binding screw type terminals for power cables and current transformer circuits and strap screw or tubular clamp terminals for control and instrument cables.

4. Rated current carrying capacity equal to or greater than the cable being terminated.

5. Marking strip on blocks for power cables and control and instrument cables.

6. Short circuit strips with one shorting screw for each terminal for current transformer circuits.

7. Shorting type terminal blocks rated for 10 AWG shall be used for all cables connected to current transformers (CTs).

2.10 Cable Identification Tags

A. Designed to provide a permanent wire and cable identification system.

B. Show complete cable number. Cable numbers are defined in the Cable Schedule and/or Contract Drawings.

C. Cable numbers may be typed or printed, and shall be legible and permanent.

D. Character size for cable numbers shall be a minimum of 1/8 inch.

E. Material shall be vinyl-cloth or other non-metallic material, and shall be impervious to moisture.

F. Be securely attached to cables and accessible for inspection.

G. Cable identification tags, marking and attachment methods shall be subject to approval of Engineer.

H. For cable sizes smaller than 1/0 AWG, heat shrinkable labels, as manufactured by Raychem or equivalent shall be used. The label shall not be shrunk to the wire. For cable sizes larger than 1/0 AWG,

PART 3 - Execution

3.01 Installation

A. General Requirements:

1. Install in conduit, tray, duct system, or direct burial as indicated.

2. Cable shall not be subjected to pulling tensions or sidewall pressures in excess of the manufacturer's recommendations.

3. Attach pulling grips over the cable sheath to prevent slipping of the insulation.

4. Do not subject cable to bending radius less than those recommended by the cable manufacturer or as noted below (whichever is greater) during or after installation:

   a. Eight times the cable outside diameter for 600V or lower rated cables.

5. Install intermediate pull boxes as indicated or as required to avoid subjecting cable to excessive pulling tension or sidewall pressures.

6. Support cables at connections or termination points such that any strain on cable will not be transmitted to the connection or termination.

7. Install cable supports in vertical runs of tray or conduit, at boxes and at terminations in equipment, and as required to meet intermediate support requirements of National Electrical Code (NEC).

8. All pulling compounds shall be approved by wire and cable manufacturer as being compatible with cable materials.

9. Attach a cable identification tag to each cable at all termination or end points.

10. Install fire and smoke stop fittings at all cable penetrations of fire rated walls, floors, and ceilings.

B. Power (600V and Below), Control, Instrument, and Specialty Cable:

1. Install metallic barrier in all tray and boxes to separate power, control, and instrumentation from low level signal (50V or less) instrumentation circuits where run in the same tray or box.

2. Secure with cable ties in cable tray risers at intervals not to exceed 3 feet.

3. Tie together with cable ties all single conductor cable on each individual circuit in each junction box, equipment or manhole, and in cable tray, at intervals not to exceed 6 feet.

4. Attach a cable identification tag to each cable.

    a. At each terminal to identify the circuit and cable.

    b. Attach fiber tags with cable ties.

    c. Use nylon ties and identification tabs color coded as follows:

        (1) 480V circuits – Red.

        (2) 277, 240, or 208Vac circuits – Orange.

        (3) 120V circuits – White.

        (4) Control cables – Natural Nylon.

5. Insulation Color Coding for Phase Identification:

    a. Color code 600-volt insulated, service entrance, feeder, and branch circuit conductors with factory-applied colored insulation for No. 8 AWG and smaller (except: No. 6 AWG and smaller for green ground wire); 1-inch band of colored tape at all splices and terminations for No. 6 AWG and larger (except: No. 4 AWG and larger for green ground wire) as follows:

Phase	208Y/120 Volts	480Y/277 Volts
A	Black	Brown
B	Red	Purple
C	Blue	Yellow
Neutral	White	Gray
Ground	Green	Green

b. Tag each individual conductor or wire with wire markers as follows:

    (1) With terminal designation indicated on schematic diagrams or given on manufacturer's equipment drawings.

    (2) At each terminal.

    (3) In addition to specified circuit tags.

c. Terminate and ground, control, instrument, and specialty cable shields as indicated and recommended by the manufacturer of the equipment being connected. In general, ground the shields at the control panels.

d. Terminate shields for VFD cables at both the source and load using VFD cable termination kit.

e. Intermediate cable splices shall not be allowed when installing power, control, and instrument wiring except when spicing to lead wires provided with the equipment or device, or unless approved by the Engineer prior to cable installation.

f. Control and instrument and thermocouple cable splices shall be as follows:

    (1) Made only in junction or terminal boxes.

    (2) Made on terminal blocks with marking strips.

(3) Conductor color coding shall be maintained.

(4) For shielded cables, shield continuity and isolation shall be maintained.

(5) Thermocouple cable splices to be made only on terminal blocks which correspond to thermocouple type used.

g. Power cable (600V or below) splices and motor terminations shall be as follows:

(1) Made only in junction or terminal boxes.

(2) Splices shall be made using compression type connectors bolted together.

(3) Splice to be covered with a heat shrinkable connector insulator.

h. High-Temperature Wiring:

(1) Install from device to a terminal box for all devices which by their location have the body of the device or electrical connection subject to ambient temperatures in excess of 185°F. Typical locations are feed water heaters, burner fronts, boiler penthouse, and deaerator.

(2) Locate terminal box far enough from the source of heat so that the temperature does not exceed 175°F. This distance generally is between 3 and 5 feet.

(3) Replace with high-temperature wire any wiring installed by this Contract that is damaged by excessive heat.

6. Lighting Cable: Install as specified in Division 26.

7. Ground Cable: Install as specified in Division 26.

8. Control and Instrument Cable: Install as specified this Section and in Division 40.

9. Communications Cable: Install as specified in this Section.

C. Cable Connections and Terminations:

1. Make up clean and tight to assure a low-resistance joint.

2. Make only in terminal boxes, equipment or other accepted enclosures and not in conduit or cable tray.

3. Install all connectors with tooling manufactured by the connector manufacturer and as specified.

3.02 Field Quality Control

A. Perform tests and inspections and prepare test reports. Submit test reports as specified.

B. General Requirements:

1. Test all wire, cable, and electrical equipment installed or connected by Contractor to assure proper installation, setting, connection, and functioning as indicated or to conform to Contract Documents and manufacturer's instructions.
2. Conduct all tests except megger insulation testing in the presence of Engineer and/or Owner and under the supervision of Equipment manufacturer's field engineer.
3. Include all tests recommended by the Equipment manufacturer unless specifically waived by Engineer.
4. Include all additional tests issued by Engineer that he deems necessary because of field conditions to determine that Equipment and Material and systems meet requirements of Contract Documents.
5. Include all tests recommended by the NETA Acceptance Testing Specifications.
6. The contractor shall be responsible for all damage to Equipment or Material due to improper test procedures or test apparatus handling.

C. Cable Testing Requirements:

1. Megger all 600V insulated power cable with a 1000Vdc megger for one minute, and values must not be less than 50 megohms per NETA ATS 7.3. Determine the values with all switchboards, panelboards, fuse holders, switches, and overcurrent devices in place. Do not connect motors and transformers during meggering. Megger wire and cable after installation and not on the cable reel.
2. Cables with conductors failing this test shall be removed and replaced.
3. Provide all phasing tests and make all changes necessary to assure proper rotation of all motors, the correct phasing and phase sequence of all circuits susceptible to being paralleled, the proper polarity on all instrument transformer wiring, and such other phasing tests as may be required for the equipment being connected under this Contract.

D. 600V Control Cable:

1. Check all control cable for rightness of terminal contacts.

2. Megger the specific control cables selected by Resident Project Representative. The quantity of cables required to be meggered will not exceed 10% of the control cable installed by this Contract. Megger as described for 600V power cable after installation, but with cables disconnected from control panels and other equipment.

3. All control cables shall have a continuity check performed on each conductor to ensure the conductance of each wire before the wires are terminated.

4. Cables with conductors failing this test shall be removed and replaced.

E. 300V Instrument Cable:

1. Megger the specific instrument cables selected by Resident Project Representative. The quantity of cables required to be meggered will not exceed 10% of the instrument cable installed by this Contract. Insulation resistance shall be a minimum of 1,000 megohms per 1,000 feet.

2. All instrument cables shall have a continuity check performed on each conductor and shield to ensure the conductance of each wire and shield before the wires are terminated.

3. Cables with conductors or shields failing this test shall be removed and replaced.

F. Quality Assurance:

1. Test Reports:

    a. Submit as specified in Division 01.

    b. Maintain a written record of all tests showing date, personnel making tests, equipment used, Equipment or Material tested, tests performed, and results.

    c. Notify Engineer two weeks prior to commencement of all testing except for megger tests.

END OF SECTION

Burns & McDonnell Engineering Company **Engineers – Architects – Consultants** **Kansas City, Missouri**	**WIRE AND CABLE SPECIFICATION SHEET**	
	BC2 **B&McD TYPE:**	**NEC TYPE:**

BARE COPPER GROUND CABLE

GENERAL REQUIREMENTS:

Annealed, tin-coated, bare copper (ASTM B33)

SPECIFIC REQUIREMENTS:

1. Solid in sizes 4 AWG and smaller.
2. Class B stranded in sizes 2 AWG and larger (ASTM B8)

Burns & McDonnell Engineering Company
Engineers – Architects – Consultants
Kansas City, Missouri

WIRE AND CABLE SPECIFICATION SHEET

CEV2	**TC**
B&McD TYPE:	**NEC TYPE:**

600 VOLT – SHIELDED MULTI-CONDUCTOR CONTROL CABLE

GENERAL REQUIREMENTS:

CONDUCTOR: Class B or C stranded annealed copper (NEMA WC57/ICEA S-73-532 Section 2).

INSULATION: Cross-linked polyethylene “XLPE” (NEMA WC57/ICEA S-73-532 Section 3) and rated as Type XHHW-2. Color coding shall be Method 1 (NEMA WC57/ICEA S-73-532 Appendix E, Paragraph. E3.1) using color pigmented compounds with colors as designated by Table E-2 (K-2).

CABLE SHIELD: Aluminized mylar or polyester tape and tinned copper drain wire (NEMA WC57/ICEA S-73-532 Section 4.1).

CABLE JACKET: Polyvinyl chloride “PVC” (NEMA WC57/ICEA S-73-532 Section 4.2) and rated for outdoor use.

IDENTIFICATION: Surface printing on the cable shall show manufacturer’s name, cable type (TC), insulation type (XHHW-2), number and size of conductors, voltage rating, and Underwriters Laboratories label (UL).

SPECIFIC REQUIREMENTS:

TEMPERATURE RATING Cable shall be suitable for operation under the following maximum conductor temperatures:

90°C --- Continuous, wet or dry locations

CONDUCTOR SIZE: #14 AWG

INSULATION THICKNESS:

Conductor Size (AWG)	Insulation Thickness (Mils) (NEMA WC57 / ICEA S-73-532 Table 3-1)
14 - 11	30

JACKET THICKNESS:

Calculated Diameter Of Cable Under Jacket (inches)	Jacket Thickness (Mils) (NEMA WC57 / ICEA S-73-532 Table 4-1)
0.425 or less	45
0.426 - 0.700	60
0.701 - 1.500	80
1.501 - 2.500	110
2.501 or larger	140

FACTORY TESTS: All cable shall be tested in accordance with requirements of NEMA WC57/ICEA S-73-532 Section 6, ICEA 210,000 BTU flame test (ICEA T-29-520), and UL1277.

CERTIFICATION: Cables shall be certified to be in conformance with all applicable requirements of NEMA WC57/ICEA S-73-532, ICEA T-29-520, and UL1277.

Burns & McDonnell Engineering Company
Engineers – Architects – Consultants
Kansas City, Missouri

WIRE AND CABLE SPECIFICATION SHEET

SEV1	**TC**
B&McD TYPE:	**NEC TYPE:**

600 VOLT – MULTI-CONDUCTOR POWER CABLE

GENERAL REQUIREMENTS:

CONDUCTOR: Class B or C stranded annealed copper (NEMA WC70/ICEA S-95-658 Section 2).

GROUND CONDUCTOR: Class B stranded bare copper ground conductor sized in accordance with Table 5-2 NEMA WC70/ICEA S-95-658.

INSULATION: Cross-linked polyethylene “XLPE” (NEMA WC70/ICEA S-95-658 Section 3) and rated as Type XHHW-2. Color coding shall be Method 4 (NEMA WC57/ICEA S-73-532) using a neutral or single color compound with surface printing of numbers.

CABLE JACKET: Polyvinyl chloride “PVC” (NEMA WC70/ICEA S-95-658 Section 4) oil resistant jacket, rated for outdoor use.

IDENTIFICATION: Surface printing on the cable shall show manufacturer’s name, cable type (TC), insulation type (XHHW-2), conductor size, conductor type, voltage rating, and Underwriters Laboratories label (UL).

SPECIFIC REQUIREMENTS:

TEMPERATURE RATING Cable shall be suitable for operation under the following maximum conductor temperatures:

90°C --- Continuous, wet or dry locations

INSULATION THICKNESS:

Conductor Size (AWG or MCM)	Insulation Thickness (Mils) (NEMA WC70 / ICEA S-95-658 Table 3-4)
14 - 9	30
8 - 2	45
1 - 4/0	55
225 - 500	65
525 - 1000	80

JACKET THICKNESS:

Calculated Diameter Of Cable Under Jacket (inches)	Minimum Thickness (Mils) (NEMA WC70 / ICEA S-95-658 Table 4-5)	Nominal Thickness (Mils) (NEMA WC70 / ICEA S-95-658 Table 4-5)
0.425 or less	40	45
0.426 - 0.700	50	60
0.701 - 1.500	70	80
1.501 - 2.500	95	110
2.501 or larger	120	140

FACTORY TESTS: All cable shall be tested in accordance with requirements of NEMA WC70/ICEA S-95-658 Section 6, ICEA T-29-520 (210,000 BTU flame test), IEEE 1202 (70,000 BTU flame test), UL 1685 and UL1277.

CERTIFICATION: Cables shall be certified to be in conformance with all applicable requirements of NEMA WC70/ICEA S-95-658, ICEA T-29-520, IEEE 1202, UL 1685, UL1277, and UL44. Suitable for use in NEC Class 1, Division 2 locations.

Burns & McDonnell Engineering Company
Engineers - Architects - Consultants
Kansas City, Missouri

WIRE AND CABLE SPECIFICATION SHEET

B&McD TYPE: **SEV3**

NEC TYPE: **TC**

600 VOLT – SINGLE CONDUCTOR POWER CABLE

GENERAL REQUIREMENTS:

CONDUCTOR:	Class B or C stranded annealed copper (ICEA S-95-658, Section 2).
INSULATION:	Cross-linked polyethylene "XLPE" (ICEA S-95-658,9 Section 3) and rated as Type XHHW-2.
IDENTIFICATION:	Surface printing on the cable jacket shall show manufacturer's name, cable type (TC), insulation type (XHHW-2), size of conductor, voltage rating, Underwriters Laboratories label (UL), and sunlight resistant for CT use on size 1/0 AWG and larger.

SPECIFIC REQUIREMENTS:

TEMP. RATING: Cable shall be suitable for operation under the following maximum conductor temperatures:
90°C --- Continuous, wet or dry locations

INSULATION THICKNESS:

Conductor Size (AWG or MCM)	Insulation Thickness (Mils) (ICEA S-95-658 Table 3-4
14-9	30
8-2	45
1-4/0	55
225-500	65
525-1000	80
1025-2000	100

FLAME TEST COMPLIANCE:	UL 1685 for #1/0 AWG and larger
FACTORY TESTS:	All cable shall be tested in accordance with requirements of ICEA S-95-658 and UL1581.
CERTIFICATION:	Cables shall be certified to be in conformance with all applicable requirements of ICEA S-95-658 and UL1581. Sunlight-resistant for #1/0 AWG and larger.

3/2/01

Burns & McDonnell Engineering Company **Engineers – Architects – Consultants** **Kansas City, Missouri**	**WIRE AND CABLE SPECIFICATION SHEET**	
	SEV6 **B&McD TYPE:**	**TC** **NEC TYPE:**

600 VOLT (1000 VOLT UL) – SHIELDED MULTI-CONDUCTOR POWER (VFD) CABLE

GENERAL REQUIREMENTS:

CONDUCTOR: Three - stranded tinned-copper (NEMA WC70/ICEA S-95-658 Section 2).

GROUND CONDUCTOR: One full-sized tinned copper ground conductor with PVC-insulation, same AWG as conductors.

INSULATION: Cross-linked polyethylene “XLPE” (NEMA WC70/ICEA S-95-658 Section 3).

CABLE SHIELD: Overall polyester coated aluminum foil shield plus 85% tinned copper braid with full size tinned copper drain wire.

CABLE JACKET: Polyvinyl chloride “PVC” (NEMA WC70/ICEA S-95-658 Section 4) oil resistant jacket, rated for outdoor use.

IDENTIFICATION: Surface printing on the cable shall show manufacturer’s name, cable type (TC), insulation type (XHHW-2), conductor size, conductor type, voltage rating, and Underwriters Laboratories label (UL).

SPECIFIC REQUIREMENTS:

TEMPERATURE RATING Cable shall be suitable for operation under the following maximum conductor temperatures:

90°C --- Continuous, wet or dry locations

INSULATION THICKNESS:

Conductor Size (AWG or MCM)	Insulation Thickness (Mils) (NEMA WC70 / ICEA S-95-658 Table 3-4)
14 - 9	45
8 - 2	55
1 - 4/0	65
225 - 500	75

JACKET THICKNESS:

Calculated Diameter Of Cable Under Jacket (inches)	Minimum Thickness (Mils) (NEMA WC70 / ICEA S-95-658 Table 4-5)	Nominal Thickness (Mils) (NEMA WC70 / ICEA S-95-658 Table 4-5)
0.425 or less	40	45
0.426 - 0.700	50	60
0.701 - 1.500	70	80
1.501 - 2.500	95	110
2.501 or larger	120	140

FACTORY TESTS: All cable shall be tested in accordance with requirements of UL 1685 and IEEE 1202 Vertical Tray Flame Test (70,000 BTU/hr).

CERTIFICATION: Cables shall be certified to be in conformance with all applicable requirements of NEMA WC70/ICEA S-95-658. Suitable for use in NEC Class 1, Division 2 hazardous locations.

CABLE SCHEDULE

Issue	Date	Description	BY	CKD	APPD
			CAB	CSH	CSH

TERMINATION INFORMATION					CABLE						ROUTING						COMMENTS	
CABLE #	FROM TAG #	FROM	TO TAG #	TO:	CLASS	TYPE	# OF SETS	SIZE	GND	CONDUIT SIZE	segment 1	segment 2	segment 3	segment 4	segment 5	segment 6	Rev	Remarks
P-PS-XF1-01	XF-1	EXISTING SERVICE ENTRANCE TRANSFORMER	PS-SWG-010	PUMP STATION SWITCHGEAR	PWR	BMCD_SEV3	8	3-1/C #500 W/ #1/0 NEUT.		8-4"	PS-EDB-004	PS-EDB-001	AG CONDUIT					
P-PS-GEN090-01	PS-GEN-090	PUMP STATION GENERATOR	PS-SWG-010	PUMP STATION SWITCHGEAR	PWR	BMCD_SEV3	7	3-1/C #500 W/ #1/0 NEUT.	#500	7-4"	PS-EDB-002							EACH PARALLEL SET SHALL HAVE A DEDICATED FULLY SIZED EQUIPMENT GROUNDING CONDUCTOR
	XF-2	FUTURE SERVICE ENTRANCE TRANSFORMER	PS-SWG-010	PUMP STATION SWITCHGEAR						10-4"	PS-EDB-006							FUTURE UTILITY SERVICE (CAPPED BELOW GRADE)
P-PS-SWG010-01	PS-SWG-010	PUMP STATION SWITCHGEAR	SWBD	EXISTING PUMP STATION SWITCHBOARD	PWR	BMCD_SEV3	7	3-1/C #500	#500	7-4"	PS-EDB-001	PS-EDB-005	AG CONDUIT					EACH PARALLEL SET SHALL HAVE A DEDICATED FULLY SIZED EQUIPMENT GROUNDING CONDUCTOR
P-PS-SWG010-02	PS-SWG-010	PUMP STATION SWITCHGEAR	PS-SWBD-020	PUMP STATION SWITCHBOARD	PWR	BMCD_SEV3	7	3-1/C #500	#500	7-4"	PS-EDB-002	AG CONDUIT	PS-EDB-003	PS-CT-003	PS-RXT-001			EACH PARALLEL SET SHALL HAVE A DEDICATED FULLY SIZED EQUIPMENT GROUNDING CONDUCTOR
P-PS-SWG010-03	PS-SWG-010	PUMP STATION SWITCHGEAR	CSO-DSW-002	CSO EFFLUENT PS SERVICE (EXISTING 800A FUSED SWITCH)	PWR	BMCD_SEV3	3	3-1/C #500 W/ #1/0 NEUT.	#1/0	3-4"	PS-EDB-001	PS-EDB-004	AG CONDUIT					EACH PARALLEL SET SHALL HAVE A DEDICATED FULLY SIZED EQUIPMENT GROUNDING CONDUCTOR
P-PS-SWG010-04	PS-SWG-010	PUMP STATION SWITCHGEAR	CSO-DSW-001	CSO TREATMENT FACILITY MCC FEED	PWR	BMCD_SEV3	2	3-1/C #350 W/ #350 NEUT.	#1/0	2-4"	PS-EDB-001	PS-EDB-005	AG CONDUIT					EACH PARALLEL SET SHALL HAVE A DEDICATED FULLY SIZED EQUIPMENT GROUNDING CONDUCTOR
P-SWBD-01	SWBD	EXISTING PUMP STATION SWITCHBOARD	PS-ATS-040	MCC AUTO TRANSFER SWITCH	PWR	BMCD_SEV3	2	3-1/C #350	#1/0	2-3"	AG CONDUIT							EACH PARALLEL SET SHALL HAVE A DEDICATED FULLY SIZED EQUIPMENT GROUNDING CONDUCTOR
P-PS-ATS040-01	PS-ATS-040	MCC AUTO TRANSFER SWITCH	MCC	EXISTING PUMP STATION MCC	PWR	BMCD_SEV3	2	3-1/C #350	#1/0	2-3"	AG CONDUIT							EACH PARALLEL SET SHALL HAVE A DEDICATED FULLY SIZED EQUIPMENT GROUNDING CONDUCTOR
P-PS-SWBD020-01	PS-SWBD-020	PUMP STATION SWITCHBOARD	PS-ATS-040	MCC AUTO TRANSFER SWITCH	PWR	BMCD_SEV3	2	3-1/C #350	#1/0	2-3"	AG CONDUIT							EACH PARALLEL SET SHALL HAVE A DEDICATED FULLY SIZED EQUIPMENT GROUNDING CONDUCTOR
P-PS-SWBD020-02	PS-SWBD-020	PUMP STATION SWITCHBOARD	VFD 1	PUMP STATION PUMP P-1 VFD	PWR	BMCD_SEV3	2	3-1/C #500	#2/0	2-3"	AG CONDUIT							EACH PARALLEL SET SHALL HAVE A DEDICATED FULLY SIZED EQUIPMENT GROUNDING CONDUCTOR
P-PS-SWBD020-03	PS-SWBD-020	PUMP STATION SWITCHBOARD	OCS-STR-001	ODOR CONTROL SYSTEM EXHAUST FAN MOTOR STARTER	PWR	BMCD_SEV1	1	3/C #2 w/GND	#6	1 1/2"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT		
P-OCS-STR001-01	OCS-STR-001	ODOR CONTROL SYSTEM EXHAUST FAN MOTOR STARTER	OCS-EF-001	ODOR CONTROL SYSTEM EXHAUST FAN	PWR	BMCD_SEV1	1	3/C #2 w/GND	#6	1 1/2"	BG CONDUIT							FINAL TERMINATION TO FAN SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
P-PS-SWBD020-04	PS-SWBD-020	PUMP STATION SWITCHBOARD	EBPS-VFD-101	EBPS PUMP 101 VFD	PWR	BMCD_SEV3	1	3-1/C #350	#3	3"	AG CONDUIT							
P-EBPS-VFD101-01	EBPS-VFD-101	EBPS PUMP 101 VFD	EBPS-PJB-100	EBPS WET WELL PUMP JUNCTION BOX	PWR	BMCD_SEV6	1	3/C #350 w/GND	#3	3"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT		
P-EBPS-VFD101-01A	EBPS-PJB-100	EBPS WET WELL PUMP JUNCTION BOX	EBPS-P-101	EBPS PUMP 101	PWR	MANUFACTURER SUPPLIED CABLE				3"	BG CONDUIT							
P-PS-SWBD020-05	PS-SWBD-020	PUMP STATION SWITCHBOARD	EBPS-VFD-102	EBPS PUMP 102 VFD	PWR	BMCD_SEV6	1	3-1/C #350	#3	3"	AG CONDUIT							
P-EBPS-VFD102-01	EBPS-VFD-102	EBPS PUMP 102 VFD	EBPS-PJB-100	EBPS WET WELL PUMP JUNCTION BOX	PWR	BMCD_SEV6	1	3/C #350 w/GND	#3	3"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT		
P-EBPS-VFD102-01A	EBPS-PJB-100	EBPS WET WELL PUMP JUNCTION BOX	EBPS-P-102	EBPS PUMP 102	PWR	MANUFACTURER SUPPLIED CABLE				3"	BG CONDUIT							
P-PS-SWBD020-06	PS-SWBD-020	PUMP STATION SWITCHBOARD	PS-XF-040	480V-208Y/120V TRANSFORMER	PWR	BMCD_SEV1	1	3/C #10 w/GND	#10	1"	AG CONDUIT	PS-CT-001	AG CONDUIT					FINAL TERMINATION TO XFMR SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
P-PS-SWBD020-07	PS-SWBD-020	PUMP STATION SWITCHBOARD	EBPS-GRCP-101	GRINDER CONTROL PANEL 101	PWR	BMCD_SEV1	1	3/C #10 w/GND	#10	3/4"	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT				
P-PS-SWBD020-08	PS-SWBD-020	PUMP STATION SWITCHBOARD	EBPS-GRCP-102	GRINDER CONTROL PANEL 102	PWR	BMCD_SEV1	1	3/C #10 w/GND	#10	3/4"	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT				
P-PS-SWBD020-09	PS-SWBD-020	PUMP STATION SWITCHBOARD	EBPS-GRCP-103	GRINDER CONTROL PANEL 103	PWR	BMCD_SEV1	1	3/C #10 w/GND	#10	3/4"	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT				
P-PS-SWBD020-10	PS-SWBD-020	PUMP STATION SWITCHBOARD	EBPS-SG-001	EBPS SLIDE GATE 001	PWR	BMCD_SEV1	1	3/C #12 w/GND	#12	3/4"	PS-RXT-001	PS-CT-002	AG CONDUIT	BG CONDUIT				FINAL TERMINATION TO GATE ACTUATOR SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
P-PS-SWBD020-11	PS-SWBD-020	PUMP STATION SWITCHBOARD	EBPS-SG-002	EBPS SLIDE GATE 002	PWR	BMCD_SEV1	1	3/C #12 w/GND	#12	3/4"	PS-RXT-001	PS-CT-002	AG CONDUIT	BG CONDUIT				FINAL TERMINATION TO GATE ACTUATOR SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
P-PS-SWBD020-12	PS-SWBD-020	PUMP STATION SWITCHBOARD	EBPS-SG-003	EBPS SLIDE GATE 003	PWR	BMCD_SEV1	1	3/C #12 w/GND	#12	3/4"	PS-RXT-001	PS-CT-002	AG CONDUIT	BG CONDUIT				FINAL TERMINATION TO GATE ACTUATOR SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
P-PS-SWBD020-13	PS-SWBD-020	PUMP STATION SWITCHBOARD	EBPS-SG-004	EBPS SLIDE GATE 004	PWR	BMCD_SEV1	1	3/C #12 w/GND	#12	3/4"	PS-RXT-001	PS-CT-002	AG CONDUIT	BG CONDUIT				FINAL TERMINATION TO GATE ACTUATOR SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
P-PS-SWBD020-14	PS-SWBD-020	PUMP STATION SWITCHBOARD	EBPS-DS-101	BRIDGE CRANE DISCONNECT SWITCH	PWR	BMCD_SEV1	1	3/C #8 w/GND	#10	1"	PS-RXT-001	PS-CT-002	AG CONDUIT					

CABLE SCHEDULE

Issue	Date	Description	BY	CKD	APPD
			CAB	CSH	CSH

TERMINATION INFORMATION					CABLE						ROUTING						COMMENTS	
CABLE #	FROM TAG #	FROM	TO TAG #	TO:	CLASS	TYPE	# OF SETS	SIZE	GND	CONDUIT SIZE	segment 1	segment 2	segment 3	segment 4	segment 5	segment 6	Rev	Remarks
P-EBPS-DS101-01	EBPS-DS-101	BRIDGE CRANE DISCONNECT SWITCH	EBPS-BC-001	EBPS BRIDGE CRANE	PWR	BMCD_SEV3	1	3-1/C #8	#10	1"	AG CONDUIT							INSTALL 4-HOLE SERVICE HEAD ON CONDUIT. INSTALL CABLE THRU SERVICE HEAD TO BRIDGE CRANE.
P-PS-SWBD020-15	PS-SWBD-020	PUMP STATION SWITCHBOARD	EBPS-STR-001	EBPS WET WELL SUPPLY FAN STARTER	PWR	BMCD_SEV1	1	3/C #12 w/GND	#12	3/4"	PS-RXT-001	AG CONDUIT						
P-EBPS-STR001-01	EBPS-STR-001	EBPS WET WELL SUPPLY FAN STARTER	EBPS-SF-001	EBPS WET WELL SUPPLY FAN	PWR	BMCD_SEV3	1	3-1/C #12	#12	3/4"	BG CONDUIT							FINAL TERMINATION TO FAN SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
P-PS-SWBD020-16	PS-SWBD-020	PUMP STATION SWITCHBOARD	EBPS-STR-002	EBPS DIVERSION CHAMBER SUPPLY FAN STARTER	PWR	BMCD_SEV3	1	3-1/C #12	#12	3/4"	PS-RXT-001	PS-CT-002	AG CONDUIT					
P-EBPS-STR002-01	PS-STR-002	PUMP STATION WET WELL SUPPLY FAN STARTER	EBPS-SF-002	EBPS DIVERSION CHAMBER SUPPLY FAN	PWR	BMCD_SEV3	1	3-1/C #12	#12	3/4"	AG CONDUIT							FINAL TERMINATION TO FAN SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
P-PS-SWBD020-17	PS-SWBD-020	PUMP STATION SWITCHBOARD	PS-GEN-090	PUMP STATION GENERATOR	PWR	BMCD_SEV1	1	3/C #6 w/GND	#8	1"	PS-RXT-001	PS-CT-003	AG CONDUIT	PS-EDB-003				
P-PS-SWBD020-18	PS-SWBD-020	PUMP STATION SWITCHBOARD	EBPS-SPCP-101	EBPS SUMP PUMP CONTROL PANEL	PWR	BMCD_SEV1	1	3/C #12 w/GND	#12	1"	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT				
P-EBPS-SPCP101-01	EBPS-SPCP-101	EBPS SUMP PUMP CONTROL PANEL	EBPS-SP-101	EBPS WET WELL SUMP PUMP	PWR	MANUFACTURER SUPPLIED CABLE					BG CONDUIT							
P-PS-SWBD020-19	PS-SWBD-020	PUMP STATION SWITCHBOARD	EBPS-DS-102	PAC UNIT DISCONNECT SWITCH	PWR	BMCD_SEV1	1	3/C #8 w/GND	#10	1"	PS-RXT-001	PS-CT-003	AG CONDUIT					
P-EBPS-DS102-01	EBPS-DS-102	PAC UNIT DISCONNECT SWITCH	PS-PAC-001	PUMP STATION EQUIPMENT ROOM AC	PWR	BMCD_SEV3	1	3-1/C #8	#10	1"	AG CONDUIT							
P-PS-MCC-01	PS-MCC-010	PUMP STATION MOTOR CONTROL CENTER	PS-DS-101	PUMP STATION PS-AHU-001 DISCONNECT	PWR	BMCD_SEV3	1	3-1/C #6	#10	1"	AG CONDUIT							
P-PS-DS101-01	PS-DS-101	PUMP STATION PS-AHU-001 DISCONNECT	PS-AHU-001	PUMP STATION ELECTRICAL ROOM AIR HANDLER	PWR	BMCD_SEV3	1	3-1/C #6	#10	1"	AG CONDUIT							
P-PS-MCC-02	PS-MCC-010	PUMP STATION MOTOR CONTROL CENTER	PS-DS-102	PUMP STATION PS-CU-001 DISCONNECT	PWR	BMCD_SEV3	1	3-1/C #6	#10	1"	AG CONDUIT							
P-PS-DS102-01	PS-DS-102	PUMP STATION PS-CU-001 DISCONNECT	PS-CU-001	PUMP STATION ELECTRICAL ROOM CONDENSING UNIT	PWR	BMCD_SEV3	1	3-1/C #6	#10	1"	AG CONDUIT							FINAL TERMINATION TO CONDENSING UNIT SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
P-PS-MCC-03	PS-MCC-010	PUMP STATION MOTOR CONTROL CENTER	PS-STR-002	PUMP STATION SUPPLY FAN MOTOR STARTER	PWR	BMCD_SEV3	1	3-1/C #12	#12	3/4"	AG CONDUIT							
P-PS-STR002-01	PS-STR-002	PUMP STATON SUPPLY FAN MOTOR STARTER	PS-SF-002	PUMP STATION SUPPLY FAN	PWR	BMCD_SEV3	1	3-1/C #12	#12	3/4"	AG CONDUIT							FINAL TERMINATION TO FAN SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
P-PS-XF040-01	PS-XF-040	480V-208Y/120V TRANSFORMER	PS-PNL-040	PUMP STATION LIGHTING PANEL	PWR	BMCD_SEV3	1	3-1/C #6 W/ #6 NEUT.	#8	1"	AG CONDUIT							
P-PS-PNL040-01	PS-PNL-040	PUMP STATION LIGHTING PANEL	EBPS-PLC-060	EBPS PLC CABINET	PWR	BMCD_SEV1	1	2/C #12 w/GND	#12	3/4"	AG CONDUIT	PS-CT-001	AG CONDUIT					
P-PS-PNL040-02	PS-PNL-040	PUMP STATION LIGHTING PANEL	PS-BACP-001	BUILDING ALARM CONTROL PANEL	PWR	BMCD_SEV1	1	2/C #12 w/GND	#12	3/4"	AG CONDUIT	PS-CT-001	AG CONDUIT					
P-PS-PNL040-03	PS-PNL-040	PUMP STATION LIGHTING PANEL		EQUIPMENT ROOM LIGHTS	PWR	BMCD_SEV3	1	2-1/C #12	#12	3/4"	AG CONDUIT							
P-PS-PNL040-04	PS-PNL-040	PUMP STATION LIGHTING PANEL		EQUIPMENT ROOM RECEPTACLES	PWR	BMCD_SEV3	1	2-1/C #12	#12	3/4"	AG CONDUIT							
P-PS-PNL040-05	PS-PNL-040	PUMP STATION LIGHTING PANEL		EBPS CANOPY LIGHTING	PWR	BMCD_SEV1	1	2/C #12 w/GND	#12	3/4"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	AG CONDUIT			
P-PS-PNL040-06	PS-PNL-040	PUMP STATION LIGHTING PANEL	PS-HVAC-CP-001	HVAC SYSTEMS ALARM PANEL	PWR	BMCD_SEV3	1	2-1/C #12	#12	3/4"	AG CONDUIT							
P-PS-PNL040-07	PS-PNL-040	PUMP STATION LIGHTING PANEL		EXTERIOR RECEPTACLES	PWR	BMCD_SEV3	1	2-1/C #12	#12	3/4"	AG CONDUIT							
P-EBPS-GRCP101-01	EBPS-GRCP-101	GRINDER CONTROL PANEL 101	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	PWR	BMCD_SEV1	1	3/C #12 w/GND	#12	3/4"	AG CONDUIT	PS-CT-004	AG CONDUIT					DRUM MOTOR
P-EBPS-GRCP101-02	EBPS-GRCP-101	GRINDER CONTROL PANEL 101	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	PWR	BMCD_SEV1	1	3/C #10 w/GND	#10	3/4"	AG CONDUIT	PS-CT-004	AG CONDUIT					GRINDER MOTOR
P-EBPS-GRCP101-03	EBPS-GRCP-101	GRINDER CONTROL PANEL 101	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	PWR	BMCD_SEV1	1	3/C #12 w/GND	#12	3/4"	AG CONDUIT	PS-CT-004	AG CONDUIT					DRUM MOTOR
P-EBPS-GRCP101-01A	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	EBPS-GR-101	EBPS GRINDER 101	PWR	MANUFACTURER SUPPLIED CABLE				1 1/2"	BG CONDUIT							DRUM MOTOR
P-EBPS-GRCP101-02A	EBPS-GRCP-101	GRINDER CONTROL PANEL 101	EBPS-GR-101	EBPS GRINDER 101	PWR	MANUFACTURER SUPPLIED CABLE				1 1/2"	BG CONDUIT							GRINDER MOTOR
P-EBPS-GRCP101-03A	EBPS-GRCP-101	GRINDER CONTROL PANEL 101	EBPS-GR-101	EBPS GRINDER 101	PWR	MANUFACTURER SUPPLIED CABLE				1 1/2"	BG CONDUIT							DRUM MOTOR
P-EBPS-GRCP102-01	EBPS-GRCP-102	GRINDER CONTROL PANEL 102	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	PWR	BMCD_SEV1	1	3/C #12 w/GND	#12	3/4"	AG CONDUIT	PS-CT-004	AG CONDUIT					DRUM MOTOR

CABLE SCHEDULE

Issue	Date	Description	BY	CKD	APPD
			CAB	CSH	CSH

TERMINATION INFORMATION					CABLE						ROUTING						COMMENTS	
CABLE #	FROM TAG #	FROM	TO TAG #	TO:	CLASS	TYPE	# OF SETS	SIZE	GND	CONDUIT SIZE	segment 1	segment 2	segment 3	segment 4	segment 5	segment 6	Rev	Remarks
P-EBPS-GRCP102-02	EBPS-GRCP-102	GRINDER CONTROL PANEL 102	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	PWR	BMCD_SEV1	1	3/C #10 w/GND	#10	3/4"	AG CONDUIT	PS-CT-004	AG CONDUIT					GRINDER MOTOR
P-EBPS-GRCP102-03	EBPS-GRCP-102	GRINDER CONTROL PANEL 102	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	PWR	BMCD_SEV1	1	3/C #12 w/GND	#12	3/4"	AG CONDUIT	PS-CT-004	AG CONDUIT					DRUM MOTOR
P-EBPS-GRCP102-01A	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	EBPS-GR-102	EBPS GRINDER 102	PWR	MANUFACTURER SUPPLIED CABLE				1 1/2"	BG CONDUIT							DRUM MOTOR
P-EBPS-GRCP102-02A	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	EBPS-GR-102	EBPS GRINDER 102	PWR	MANUFACTURER SUPPLIED CABLE				1 1/2"	BG CONDUIT							GRINDER MOTOR
P-EBPS-GRCP102-03A	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	EBPS-GR-102	EBPS GRINDER 102	PWR	MANUFACTURER SUPPLIED CABLE				1 1/2"	BG CONDUIT							DRUM MOTOR
P-EBPS-GRCP103-01	EBPS-GRCP-103	GRINDER CONTROL PANEL 103	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	PWR	BMCD_SEV1	1	3/C #12 w/GND	#12	3/4"	AG CONDUIT	PS-CT-004	AG CONDUIT					DRUM MOTOR
P-EBPS-GRCP103-02	EBPS-GRCP-103	GRINDER CONTROL PANEL 103	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	PWR	BMCD_SEV1	1	3/C #10 w/GND	#10	3/4"	AG CONDUIT	PS-CT-004	AG CONDUIT					GRINDER MOTOR
P-EBPS-GRCP103-03	EBPS-GRCP-103	GRINDER CONTROL PANEL 103	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	PWR	BMCD_SEV1	1	3/C #12 w/GND	#12	3/4"	AG CONDUIT	PS-CT-004	AG CONDUIT					DRUM MOTOR
P-EBPS-GRCP103-01A	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	EBPS-GR-103	EBPS GRINDER 103	PWR	MANUFACTURER SUPPLIED CABLE				1 1/2"	BG CONDUIT							DRUM MOTOR
P-EBPS-GRCP103-02A	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	EBPS-GR-103	EBPS GRINDER 103	PWR	MANUFACTURER SUPPLIED CABLE				1 1/2"	BG CONDUIT							GRINDER MOTOR
P-EBPS-GRCP103-03A	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	EBPS-GR-103	EBPS GRINDER 103	PWR	MANUFACTURER SUPPLIED CABLE				1 1/2"	BG CONDUIT							DRUM MOTOR
P-EBPS-VFD101-02	EBPS-VFD-101	EBPS PUMP 101 VFD	EBPS-IJB-100	PUMP JUNCTION BOX (PUMP MODULE)	PWR	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT		
P-EBPS-VFD102-02	EBPS-VFD-102	EBPS PUMP 102 VFD	EBPS-IJB-100	PUMP JUNCTION BOX (PUMP MODULE)	PWR	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT		
P-PS-IL1-01	PS-IL-1	H2S DETECTION ALARM INDICATION LIGHT NORTH ACCESS DOOR	PS-BACP-001	PUMP STATION BUILDING ALARM CONTROL PANEL	PWR	BMCD_SEV3	1	2-1/C #12	#12	1"	AG CONDUIT							
P-PS-IL2-01	PS-IL-2	COMBUSTIBLE GAS DETECTION ALARM INDICATION LIGHT NORTH ACCESS DOOR	PS-BACP-001	PUMP STATION BUILDING ALARM CONTROL PANEL	PWR	BMCD_SEV3	1	2-1/C #12										
P-PS-IL3-01	PS-IL-3	NO ALARM CONDITION PRESENT INDICATION LIGHT NORTH ACCESS DOOR	PS-BACP-001	PUMP STATION BUILDING ALARM CONTROL PANEL	PWR	BMCD_SEV3	1	2-1/C #12										
P-PS-IL4-01	PS-IL-4	H2S DETECTION ALARM INDICATION LIGHT SOUTH ACCESS DOOR	PS-BACP-001	PUMP STATION BUILDING ALARM CONTROL PANEL	PWR	BMCD_SEV3	1	2-1/C #12	#12	1"	AG CONDUIT							
P-PS-IL5-01	PS-IL-5	COMBUSTIBLE GAS DETECTION ALARM INDICATION LIGHT SOUTH ACCESS DOOR	PS-BACP-001	PUMP STATION BUILDING ALARM CONTROL PANEL	PWR	BMCD_SEV3	1	2-1/C #12										
P-PS-IL6-01	PS-IL-6	NO ALARM CONDITION PRESENT INDICATION LIGHT SOUTH ACCESS DOOR	PS-BACP-001	PUMP STATION BUILDING ALARM CONTROL PANEL	PWR	BMCD_SEV3	1	2-1/C #12										
C-EBPS-SG001-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-SG-001	EBPS SLIDE GATE 001	CNTRL	BMCD_CEV2	1	7/C #14		3/4"	BG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	AG CONDUIT	BG CONDUIT		FINAL TERMINATION TO GATE ACTUATOR SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
C-EBPS-SG002-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-SG-002	EBPS SLIDE GATE 002	CNTRL	BMCD_CEV2	1	7/C #14		3/4"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	AG CONDUIT	BG CONDUIT		FINAL TERMINATION TO GATE ACTUATOR SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
C-EBPS-SG003-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-SG-003	EBPS SLIDE GATE 003	CNTRL	BMCD_CEV2	1	7/C #14		3/4"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	AG CONDUIT	BG CONDUIT		FINAL TERMINATION TO GATE ACTUATOR SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
C-EBPS-SG004-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-SG-004	EBPS SLIDE GATE 004	CNTRL	BMCD_CEV2	1	7/C #14		3/4"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	AG CONDUIT	BG CONDUIT		FINAL TERMINATION TO GATE ACTUATOR SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
C-EBPS-GRCP101-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-GRCP-101	GRINDER CONTROL PANEL 101	CNTRL	BMCD_CEV2	1	12/C #14		1"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT		
C-EBPS-GRCP101-02	EBPS-GRCP-101	GRINDER CONTROL PANEL 101	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	CNTRL	BMCD_CEV2	1	9/C #14		1"	AG CONDUIT	PS-CT-004	AG CONDUIT					
C-EBPS-GRCP102-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-GRCP-102	GRINDER CONTROL PANEL 102	CNTRL	BMCD_CEV2	1	12/C #14		1"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT		
C-EBPS-GRCP102-02	EBPS-GRCP-102	GRINDER CONTROL PANEL 102	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	CNTRL	BMCD_CEV2	1	9/C #14		1"	AG CONDUIT	PS-CT-004	AG CONDUIT					
C-EBPS-GRCP103-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-GRCP-103	GRINDER CONTROL PANEL 103	CNTRL	BMCD_CEV2	1	12/C #14		1"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT		
C-EBPS-GRCP103-02	EBPS-GRCP-103	GRINDER CONTROL PANEL 103	EBPS-GRJB-101	EBPS GRINDER JUNCTION BOX	CNTRL	BMCD_CEV2	1	9/C #14		1"	AG CONDUIT	PS-CT-004	AG CONDUIT					
C-EBPS-JB001-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-JB-001	EBPS JUNCTION BOX	CNTRL	BMCD_CEV2	1	3/C #14		1"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT		
C-EBPS-LSH101-01	EBPS-JB-001	EBPS JUNCTION BOX	EBPS-LSH-101	EBPS DIVERSION CHAMBER HIGH LEVEL	CNTRL	MANUFACTURER SUPPLIED CABLE				1"	BG CONDUIT							
C-EBPS-LS110-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-PJB-100	EBPS WET WELL PUMP JUNCTION BOX	CNTRL	BMCD_CEV2	1	7/C #14		1"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT		
C-EBPS-LSH111-01	EBPS-PJB-100	EBPS WET WELL PUMP JUNCTION BOX	EBPS-LSH-111	EBPS WET WELL HIGH LEVEL	CNTRL	MANUFACTURER SUPPLIED CABLE				1 1/2"	BG CONDUIT							

CABLE SCHEDULE

Issue	Date	Description	BY	CKD	APPD
			CAB	CSH	CSH

BURNS McDONNELL

TERMINATION INFORMATION					CABLE						ROUTING						COMMENTS	
CABLE #	FROM TAG #	FROM	TO TAG #	TO:	CLASS	TYPE	# OF SETS	SIZE	GND	CONDUIT SIZE	segment 1	segment 2	segment 3	segment 4	segment 5	segment 6	Rev	Remarks
C-EBPS-LSL112-01	EBPS-PJB-100	EBPS WET WELL PUMP JUNCTION BOX	EBPS-LSL-112	EBPS WET WELL LOW LEVEL	CNTRL	MANUFACTURER SUPPLIED CABLE					BG CONDUIT							
C-EBPS-VFD101-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-VFD-101	EBPS PUMP 101 VFD	CNTRL	BMCD_CEV2	1	12/C #14			AG CONDUIT	PS-CT-001	AG CONDUIT					
C-EBPS-VFD101-02	EBPS-VFD-101	EBPS PUMP 101 VFD	EBPS-IJB-100	PUMP JUNCTION BOX (PUMP MODULE)	CNTRL	BMCD_CEV2	1	5/C #14			AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT		
C-EBPS-IJB100-01	EBPS-IJB-100	PUMP JUNCTION BOX (PUMP MODULE)	EBPS-PJB-100	EBPS WET WELL PUMP JUNCTION BOX	CNTRL	BMCD_CEV2	1	5/C #14			AG CONDUIT							
C-EBPS-VFD102-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-VFD-102	EBPS PUMP 102 VFD	CNTRL	BMCD_CEV2	1	12/C #14			AG CONDUIT	PS-CT-001	AG CONDUIT					
C-EBPS-VFD102-02	EBPS-VFD-102	EBPS PUMP 102 VFD	EBPS-IJB-100	PUMP JUNCTION BOX (PUMP MODULE)	CNTRL	BMCD_CEV2	1	5/C #14			AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT		
C-EBPS-IJB100-02	EBPS-IJB-100	PUMP JUNCTION BOX (PUMP MODULE)	EBPS-PJB-100	EBPS WET WELL PUMP JUNCTION BOX	CNTRL	BMCD_CEV2	1	5/C #14			AG CONDUIT							
C-EBPS-SPCP101-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-SPCP-101	EBPS SUMP PUMP CONTROL PANEL	CNTRL	BMCD_CEV2	1	5/C #14			AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	PS-CT-004	AG CONDUIT		
C-PS-GEN090-01	EBPS-PLC-060	EBPS PLC CABINET	PS-GEN-090	PUMP STATION GENERATOR	CNTRL	BMCD_CEV2	1	12/C #14			AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-003	AG CONDUIT	PS-EDB-003		
C-PS-GEN090-02	PS-SWG-010	PUMP STATION SWITCHGEAR	PS-GEN-090	PUMP STATION GENERATOR	CNTRL	BMCD_CEV2	1	5/C #14			PS-EDB-002							
C-PS-GEN090-03	PS-ES-090	PUMP STATION GENERATOR EMERGENCY STOP	PS-GEN-090	PUMP STATION GENERATOR	CNTRL	BMCD_CEV2	1	3/C #14			BG CONDUIT							
C-OCS-STR001-01	OCS-STR-001	OCS-EF-001 EXHAUST FAN MOTOR STARTER	EBPS-STR-001	EBPS WET WELL SUPPLY FAN STARTER	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT							
C-OCS-STR001-02	OCS-STR-001	OCS-EF-001 EXHAUST FAN MOTOR STARTER	EBPS-STR-002	EBPS DIVERSION CHAMBER SUPPLY FAN STARTER	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT							
C-OCS-STR001-03	OCS-STR-001	OCS-EF-001 EXHAUST FAN MOTOR STARTER	PS-STR-002	PUMP STATION WET WELL SUPPLY FAN STARTER	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT							
C-OCS-STR001-04	OCS-STR-001	OCS-EF-001 EXHAUST FAN MOTOR STARTER		SMOKE DAMPER	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	BG CONDUIT							FINAL CONNECTION SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
C-OCS-STR001-05	OCS-STR-001	OCS-EF-001 EXHAUST FAN MOTOR STARTER	EBPS-PLC-060	EBPS PLC CABINET	CNTRL	BMCD_CEV2	1	5/C #14		3/4"	BG CONDUIT	AG CONDUIT	PS-CT-002	PS-RXT-001	PS-CT-001	AG CONDUIT		
C-OCS-STR001-06	OCS-STR-001	OCS-EF-001 EXHAUST FAN MOTOR STARTER		DUCT SMOKE DETECTOR	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	BG CONDUIT							FINAL CONNECTION SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
C-OCS-STR001-07	OCS-STR-001	OCS-EF-001 EXHAUST FAN MOTOR STARTER	SS-OCS-EF-001	AIR FLOW SWITCH	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	BG CONDUIT							FINAL CONNECTION SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
C-EBPS-STR002-01	EBPS-STR-002	EBPS DIVERSION CHAMBER SUPPLY FAN STARTER	OCS-STR-001	OSC-EF-001 EXHAUST FAN MOTOR STARTER	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT							
C-PS-STR002-01	PS-STR-002	PUMP STATION WET WELL SUPPLY FAN STARTER	OCS-STR-001	OSC-EF-001 EXHAUST FAN MOTOR STARTER	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT							
C-EBPS-STR001-01	EBPS-STR-001	EBPS WET WELL SUPPLY FAN STARTER	OCS-STR-001	OSC-EF-001 EXHAUST FAN MOTOR STARTER	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT							
C-PS-HVACCP-01	PS-HVAC-CP-001	HVAC SYSTEMS ALARM PANEL	PS-AHU-001	PUMP STATION AIR HANDLING UNIT	CNTRL	BMCD_CEV2	1	5/C #14		3/4"	AG CONDUIT							
C-PS-HVACCP-02	PS-HVAC-CP-001	HVAC SYSTEMS ALARM PANEL	PS-PAC-001	PUMP STATION PACKAGED AIR HANDLING UNIT	CNTRL	BMCD_CEV2	1	5/C #14		3/4"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	AG CONDUIT			
C-PS-HVACCP-03	PS-HVAC-CP-001	HVAC SYSTEMS ALARM PANEL	EBPS-PLC-060	EBPS PLC CABINET	CNTRL	BMCD_CEV2	1	7/C #14		1"	AG CONDUIT	PS-CT-001	AG CONDUIT					
C-PS-HVACCP-04	PS-HVAC-CP-001	HVAC SYSTEMS ALARM PANEL		AHU SMOKE DETECTOR	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT							
C-PS-HVACCP-05	PS-HVAC-CP-001	HVAC SYSTEMS ALARM PANEL		PAC UNIT SMOKE DETECTOR	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	AG CONDUIT			
C-PS-HVACCP-06	PS-HVAC-CP-001	HVAC SYSTEMS ALARM PANEL		ELECTRICAL ROOM HIGH TEMP SWITCH	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT							
C-PS-HVACCP-07	PS-HVAC-CP-001	HVAC SYSTEMS ALARM PANEL		EQUIPMENT ROOM HIGH TEMP SWITCH	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT	PS-CT-001	AG CONDUIT					
P-PS-HAVACCP-08	PS-HVAC-CP-001	HVAC SYSTEMS ALARM PANEL		AHU UNIT SMOKE DAMPER	PWR	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT	PS-RXT-001	PS-CT-002	AG CONDUIT				
P-PS-HVACCP-09	PS-HVAC-CP-001	HVAC SYSTEMS ALARM PANEL		PAC UNIT SMOKE DAMPER	PWR	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT	PS-RXT-001	PS-CT-002	AG CONDUIT				
C-EBPS-STR001-02	EBPS-STR-001	EBPS WET WELL SUPPLY FAN		EBPS WET WELL SUPPLY FAN DUCT SMOKE DETECTOR	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT							FINAL CONNECTION SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
C-EBPS-STR001-03	EBPS-STR-001	EBPS WET WELL SUPPLY FAN		EBPS WET WELL SUPPLY FAN DUCT SMOKE DAMPER	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT							FINAL CONNECTION SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
C-PS-STR002-02	PS-SF-002	PUMP STATION WET WELL SUPPLY FAN		PUMP STATION WET WELL SUPPLY FAN DUCT SMOKE DETECTOR	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT							FINAL CONNECTION SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
C-PS-STR002-03	PS-SF-002	PUMP STATION WET WELL SUPPLY FAN		PUMP STATION WET WELL SUPPLY FAN DUCT SMOKE DAMPER	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT							FINAL CONNECTION SHALL BE MADE WITH LIQUID TIGHT FLEXIBLE CONDUIT
C-PS-BACP001-01	PS-BACP-001	BUILDING ALARM CONTROL PANEL	EBPS-PLC-060	EBPS PLC CABINET	CNTRL	BMCD_CEV2	1	5/C #14		3/4"	AG CONDUIT	PS-CT-001	AG CONDUIT					
C-PS-BACP001-02	PS-BACP-001	BUILDING ALARM CONTROL PANEL	EBPS-PLC-060	EBPS PLC CABINET	CNTRL	BMCD_CEV2	1	3/C #14		3/4"	AG CONDUIT	PS-CT-001	AG CONDUIT					

CABLE SCHEDULE

Issue	Date	Description	BY	CKD	APPD
			CAB	CSH	CSH

TERMINATION INFORMATION					CABLE						ROUTING						COMMENTS	
CABLE #	FROM TAG #	FROM	TO TAG #	TO:	CLASS	TYPE	# OF SETS	SIZE	GND	CONDUIT SIZE	segment 1	segment 2	segment 3	segment 4	segment 5	segment 6	Rev	Remarks
I-EBPS-LIT101-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-LIT-101	EBPS DIVERSION CHAMBER LEVEL	INST	BMCD_IVV1	1	1PR #16		1"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	AG CONDUIT			
I-EBPS-LIT111-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-LIT-111	EBPS WET WELL LEVEL	INST	BMCD_IVV1	1	1PR #16		1"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	AG CONDUIT			
I-EBPS-VFD101-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-VFD-101	EBPS PUMP 101 VFD	INST	BMCD_IVV1	1	1PR #16		3/4"	AG CONDUIT	PS-CT-001	AG CONDUIT					
I-EBPS-VFD101-02	EBPS-PLC-060	EBPS PLC CABINET	EBPS-VFD-101	EBPS PUMP 101 VFD	INST	BMCD_IVV1	1	1PR #16		3/4"	AG CONDUIT	PS-CT-001	AG CONDUIT					
I-EBPS-VFD102-01	EBPS-PLC-060	EBPS PLC CABINET	EBPS-VFD-102	EBPS PUMP 102 VFD	INST	BMCD_IVV1	1	1PR #16		3/4"	AG CONDUIT	PS-CT-001	AG CONDUIT					
I-EBPS-VFD102-02	EBPS-PLC-060	EBPS PLC CABINET	EBPS-VFD-102	EBPS PUMP 102 VFD	INST	BMCD_IVV1	1	1PR #16		3/4"	AG CONDUIT	PS-CT-001	AG CONDUIT					
I-PS-AIC301-01	PS-AE-1	PUMP STATION UPPER LEVEL SCREEN ROOM TOXIC GAS DETECTOR	PS-AIC-001	H2S GAS DETECTION CONTROLLER (CLASSIFIED AREAS)	INST	BELDEN CABLE 83606 (#20 AWG 6/C SHIELDED)				3/4"	AG CONDUIT							
I-PS-AIC301-02	PS-AE-2	PUMP STATION LOWER LEVEL SCREEN ROOM TOXIC GAS DETECTOR	PS-AIC-001	H2S GAS DETECTION CONTROLLER (CLASSIFIED AREAS)	INST	BELDEN CABLE 83606 (#20 AWG 6/C SHIELDED)				3/4"	AG CONDUIT							
I-PS-AIC302-01	PS-AE-3	PUMP STATION DRY WELL TOXIC GAS DETECTOR	PS-AIC-002	H2S GAS DETECTION CONTROLLER (UNCLASSIFIED AREAS)	INST	BELDEN CABLE 83606 (#20 AWG 6/C SHIELDED)				3/4"	AG CONDUIT							
I-PS-AIC302-02	PS-AE-4	PUMP STATION ELECTRICAL ROOM TOXIC GAS DETECTOR	PS-AIC-002	H2S GAS DETECTION CONTROLLER (UNCLASSIFIED AREAS)	INST	BELDEN CABLE 83606 (#20 AWG 6/C SHIELDED)				3/4"	AG CONDUIT							
I-PS-AIC302-02	PS-AE-5	PUMP STATION EQUIPMENT ROOM TOXIC GAS DETECTOR	PS-AIC-002	H2S GAS DETECTION CONTROLLER (UNCLASSIFIED AREAS)	INST	BELDEN CABLE 83606 (#20 AWG 6/C SHIELDED)				3/4"	AG CONDUIT							
I-PS-AIC302-02	PS-AE-6	PUMP STATION LOWER LEVEL SCREEN ROOM COMBUSTIBLE GAS DETECTOR	PS-AIC-003	COMBUSTIBLE GAS DETECTION (CLASSIFIED AREAS)	INST	BELDEN CABLE 63706 (#16 AWG 6/C SHIELDED)				3/4"	AG CONDUIT							
I-PS-AIC302-02	EBPS-AE-1	EBPS WET WELL COMBUSTIBLE GAS DETECTOR	PS-AIC-003	COMBUSTIBLE GAS DETECTION (CLASSIFIED AREAS)	INST	BELDEN CABLE 63706 (#16 AWG 6/C SHIELDED)				3/4"	AG CONDUIT	PS-CT-001	PS-RXT-001	PS-CT-002	AG CONDUIT	BG CONDUIT		
T-EBPS-PLC060-01	PS PLC	PUMP STATION MAIN PLC	EBPS-PLC-060	EBPS PLC CABINET	TC	ETHERNET	1	CAT-6		3/4"	AG CONDUIT							

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section specifies electrical grounding and bonding as indicated on Drawings and schedules and as specified herein. Grounding and bonding Work is defined to encompass systems, circuits, and equipment.

B. Type of electrical grounding and bonding Work specified in this Section includes the following:

1. Solidly grounded. Grounded through a ground connection in which no impedance has been intentionally inserted.

C. Applications of electrical grounding and bonding Work in this Section include the following:

1. Metal building frames.
2. Electrical power systems.
3. Grounding electrodes.
4. Counterpoise grounding loops.
5. Separately derived systems.
6. Raceways.
7. Service equipment.
8. Boxes and enclosures.
9. Equipment.
10. Cable tray.
11. Chain-link fences and gates.

D. Refer to other DIVISION 26 Sections for wires/cables, electrical raceways, boxes and fittings, and wiring devices which are required in conjunction with electrical grounding and bonding Work; not Work of this Section.

1.03 Related Requirements

A. Section 26 05 33 - Raceways, Boxes, and Supports for Electrical Systems.

B. Section 26 05 53 - Identification for Electrical Systems.

C. Section 26 43 13 - Surge Protection Devices for Low-Voltage Electrical Power Requirements.

D. Section 31 23 33 - Trenching and Backfilling for Utilities.

1.04 References

A. Applicable Standards:

1. American Society for Testing and Materials (ASTM):
    a. B3 - Soft or Annealed Copper Wire.
    b. B8 - Concentric Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
    c. B33 - Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
2. Institute of Electrical and Electronic Engineers (IEEE): Comply with applicable requirements and recommended installation practices of the following IEEE Standards pertaining to grounding and bonding of systems, circuits, and equipment:
    a. 81 - Guide for Measuring Ground Resistance, and Potential Gradient in the Earth.
    b. 141 - Recommended Practice for Electric Power Distribution for Industrial Plants.
    c. 142 - Recommended Practice for Grounding Industrial and Commercial Power Systems.
3. National Electrical Contractors Association (NECA) Installation Standards.
4. National Fire Protection Association (NFPA):
    a. 70 - National Electrical Code (NEC): Comply with applicable local electrical code requirements of the authority having jurisdiction, and NEC as applicable to electrical grounding and bonding, pertaining to systems, circuits, and equipment.
5. Underwriters Laboratories (UL): Comply with applicable requirements of the following standards. Provide grounding and bonding products which are UL-listed and labeled for their intended usage.

a. 467 - Electrical Grounding and Bonding Equipment.

b. 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors.

c. 869 - Electrical Service Equipment.

d. 891 - Switchboards.

1.05 Submittals

A. Refer to DIVISION 01 and Section 26 05 10 - Basic Electrical Requirements for administrative and procedural requirements for Submittals.

B. Includes, but not limited to, the following:

1. Product Data: Submit manufacturer's data on all grounding and bonding components and associated accessories.

2. Qualification Data: For Qualified Testing Agency and testing agency's field Supervisor.

3. All field test reports.

1.06 Quality Assurance

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - Products

2.01 Manufacturers

A. Subject to compliance with requirements, provide grounding and bonding products of one of the following (for each type of product):

1. Grounding Products:

a. Advanced Lightning Technology.

b. Anderson/Square D.

c. Burndy LLC.

d. Cadweld Div.; Erico Products Inc.

e. Crouse-Hinds Div.; Cooper Industries.

f. Erico-International Corporation.

g. Fushi-Copperweld Inc.

h. Harger Lightning and Grounding.

i. Ideal Industries, Inc.

j. Joslyn Corporation.

k. Myers Electric Products, Inc.

l. O. Z. Gedney Div.; General Signal Corp.

m. Preferred Lightning Protection.

n. Thomas and Betts Corp.

o. Engineer-approved equal.

2.02 Grounding And Bonding

A. Materials and Components:

1. General: Except as otherwise indicated, provide electrical grounding and bonding systems indicated; with assembly of materials, including, but not limited to, cables/wires, connectors, solderless lug terminals, grounding electrodes, bonding jumper braid, surge arresters, and additional accessories needed for a complete installation. Where more than one type component product meets indicated requirements, selection is Contractor's code-compliance option. Where materials or components are not indicated, provide products which comply with NEC, UL, and IEEE requirements and with established industry standards for those applications.

2. Conductors:

   a. Unless otherwise indicated, provide insulated electrical grounding conductors for equipment grounding conductor connections that match power supply wiring materials and as a minimum are sized according to the NEC.

   b. Provide annealed, tin-coated, bare copper cable for ground electrode conductors. Size as indicated.

   c. Provide annealed, tin-coated, bare copper cable for buried ground system conductors.

   d. Provide annealed, tin-coated, bare copper cable for exposed ground system conductors.

   e. Tin-coated ground conductors shall meet ASTM B8 and B33.

   f. Bare copper ground conductors shall meet ASTM B3 and B8.

3. Service Surge Protection: Refer to Section 26 43 13 - Surge Protection Devices for Low-Voltage Electrical Power Requirements. Ground according to manufacturer’s instructions.

4. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600V. Lexan or PVC, impulse tested at 5,000V.

5. Bonding Plates, Connectors, Terminals, and Clamps: Provide electrical bonding plates, connectors, terminals, lugs, and clamps as recommended by bonding plate, connector, terminal, and clamp manufacturers for indicated applications.

   a. Bolted Connectors for Conductors and Pipes: Copper or copper-alloy, pressure type with at least two silicon bronze or stainless-steel bolts and lock washers.

   b. Irreversible Compression Fittings: Pure wrought copper extrusion clamps and connectors, made to be held in the dies of an installation tool. Connectors must be factory filled with an oxide inhibitor.

   c. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

   d. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals and long-barrel, two-bolt connection to ground bus bar.

6. Ground Rods or Ground Electrodes:

   a. Ground Rods or Grounding Electrodes: Copper-clad steel or copper-alloy, sectional type rods. One end pointed to facilitate driving, 3/4-inch diameter by 10 feet.

7. Electrical Grounding Connection Accessories: Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials, bonding straps, as recommended by accessories manufacturers for type service required or indicated.

8. Mastic Coatings:

   a. Sonneborn-Sonoshield Mastics (BASF Construction Chemicals LLC).

   b. W.R. Meadows - Sealmastic.

PART 3 - Execution

3.01 Installation

A. Install electrical grounding and bonding systems as indicated, in accordance with manufacturer's instructions and applicable portions of NEC, NECA's "Standards of Installation," and in accordance with recognized industry practices to ensure that products comply with requirements.

B. A grounding electrode shall be installed at each building or structure as indicated.

1. Grounding electrodes shall consist of the following:
    a. Ground rod and cable system.
    b. Concrete-encased electrode.
    c. Grounded metal frame of the building or structure.
    d. Other systems or structures as indicated.

C. Ground Rods:

1. Install rods as indicated by driving and not by drilling or jetting.
2. Drive rods into unexcavated portion of the earth where possible.
3. Where rods must be installed in excavated areas, drive rods into earth after compaction of backfill is completed.
4. Drive to a depth such that top of rods will be approximately 18 inches below final grade or subgrade, and connect main grid ground cable thereto.
5. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
6. Separation between ground rods shall be equal to or greater than the length of the rods.
7. The ground electrode conductor shall not contain splices between the ground electrode and the service entrance equipment.

D. Grounding Conductors:

1. Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
2. Install using as few joints as possible. Route along shortest and straightest paths possible unless otherwise indicated or required by Code.

3. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage. Suitably protect cable against damage during construction.

4. Replace or suitably repair cable if damaged by anyone before final acceptance.

5. In Exposed Installations:

    a. Route runs as indicated.

    b. Route along the webs of columns and beams, and in corners where possible for maximum physical protection.

    c. Where physical protection is required, install in PVC conduit unless indicated otherwise.

    d. Support at intervals of 3 feet or less with nonmagnetic clamp-type supports.

6. In Buried Installations:

    a. Conductor sizes shall be as indicated for specific connections. For required connections not indicated, use conductor size not less than No. 3/0 AWG if buried in the earth or cast in concrete, or No. 6 AWG at other locations.

    b. Lay in bottom of trench or in other excavations at the depth of the top of the ground rod.

    c. Bury at least 30 inches (600 mm) below grade.

    d. Maintain clearance of at least 12 inches from all underground metal piping or structures, except where connections thereto are specifically indicated.

    e. Ground cable shall enter the bottom of electrical gear or panels sitting on a slab through a PVC sleeve.

7. Backfill as specified in DIVISION 31.

E. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

F. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.

2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

G. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors with silicon bronze or stainless-steel bolts and lock washers.

2. Underground Connections: Provide exothermic welded connections where grounding conductors connect to underground grounding conductors and underground grounding electrodes.

3. Connections to Structural Steel:

   a. Irreversible compression ground clamp with breakaway bolt head to building steel that cannot be altered.

4. Clean metal contact surfaces of clamp-on connectors to ensure electrical conductivity and circuit integrity.

5. Exothermic terminations:

   a. Conform to manufacturer’s instructions.

   b. Chemically degrease and dry completely before welding.

   c. Apply one coat of mastic coating to all exothermic-welded connections to be buried.

H. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 3/0 AWG for a grounding conductor.

1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.

2. Bond grounding conductor to reinforcing steel matte in at least four locations using compression fittings designed for the intended purpose.

3. The grounding connection to the supplemental electrode shall be bonded by either exothermic welding or irreversible compression fittings.

4. Extend grounding conductor below grade and connect to building's grounding grid.

5. Extend at least one Ufer ground to the grounding electrode external to the concrete.

6. Welding Ufer ground to the structural reinforcing steel is prohibited.

I. Grounding for Steel Building Structure:

1. Install a driven ground rod – part of the counterpoise system - at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

2. Extend a bonding conductor from the counterpoise system to the structural steel and exothermically weld or connect with an irreversible compression fitting to the hold-down bolts securing the structural steel column to the support footing or foundation.

3. Use an approved bonding plate or lug to connect the counterpoise system to the steel building column.

J. Grounding Manholes and Handholes:

1. Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor.

2. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall.

3. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete.

4. Seal floor opening with waterproof, non-shrink grout.

K. Grounding Connections to Manhole Components:

1. Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor.

2. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor.

3. Train conductors level or plumb around corners and fasten to manhole walls.

4. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

L. All grounding system components shall be bonded to form one continuous grounding electrode.

M. Ground electrical service system neutral at service entrance equipment to grounding electrodes.

N. Ground each separately derived system neutral to the main building ground system.

O. Bond the system neutral to service entrance equipment enclosures.

P. Ground all exposed noncurrent carrying metal parts of electrical equipment, metal raceway systems, grounding conductors in raceways and cables, receptacle ground conductors, and metallic plumbing systems.

Q. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torqueing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.

R. Apply mastic coating to field connections, buried metallic grounding and bonding products, and places where factory applied protective coatings have been destroyed, which are subjected to corrosive action.

3.02 Installation - Equipment Grounding

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Terminate feeder and branch circuit insulated equipment grounding conductors with grounding lug on substation, switchgear, switchboard, motor control center, or panelboard ground bus. When conduit enters from below and is not connected to the enclosure, ground equipment grounding conductor on conduit grounding bushing and then bond to ground bus (or grounded enclosure if there is no ground bus).

C. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway and power cords runs.
7. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

D. Ground wireway at least once and at 10-foot intervals.

E. Ground all continuous runs of metallic cable tray and all isolated sections of metallic cable tray at each end. Install NEC sized bare copper equipment ground conductor in all cable tray. Clamp equipment ground conductor to cable tray at 20-foot intervals.

F. Bond cable trays routed parallel to each other with an NEC sized, bare copper tray bonding jumper ground conductor (based on highest ampacity circuit) at 100 foot intervals.

G. Bonding Interior Metal Ducts: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120V and more, including air cleaners, heaters, blowers, fans, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping. Install tinned copper bonding jumper to bond across flexible duct connections to achieve continuity.

H. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

I. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

J. Ground fence enclosures at each post with Burndy Type GK and GAR connectors. Install flexible braid straps across all hinge points and gates for fence enclosures. Bond fence posts, gates, and fence material to ground where crossed above by a utility line.

K. Bond all motors with “identified” ground conductor. Route in conduit with phase conductors.

L. Enclosure Grounds: Bond all enclosures by direct copper connection to the grounding electrode system.

M. Building Grounding Conductors: Support at intervals not to exceed 3 feet on center or as indicated.

3.03 Labeling

A. Comply with requirements in Section 26 05 53 - Identification for Electrical Systems for instruction signs. The label or its text shall be green.

3.04 Inspection

A. Do not cover up connections before they are inspected by Engineer.

B. Compression-type connections shall be inspected for embossment of proper die index per manufacturer's instructions.

3.05 Field Quality Control

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. All compression-type connections shall be inspected for proper die index number.
4. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.
    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.

    b. Perform tests by fall-of-potential method according to IEEE 81 for the following:

        (1) Testing and commissioning of new grounds, not yet connected to the utility power supply.

        (2) Testing complex ground systems that include a metallic loop.

    c. A clamp-on ground tester may only be used if the Owner does not require strict adherence to IEEE 81 and for the following situations:

        (1) To test installed grounds without disconnecting them from the utility.

(2) To test a grounding electrode configuration where the return path includes the earth. (This does not include a ground system that includes a metallic loop.)

(3) To test the resistance of a single rod in a series or array.

(4) To check errant current flow to ground for operator safety.

5. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.

2. Power and Lighting Equipment or System with Capacity of 500 to 1,000 kVA: 5 ohms.

3. Power and Lighting Equipment or System with Capacity More Than 1,000 kVA: 3 ohms.

4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).

5. Manhole Grounds: 10 ohms.

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section specifies the following:

1. Conduit.
2. Wireway.
3. Outlet and device boxes.
4. Pull and junction boxes.
5. Fittings.
6. Bushings and ground bushings.
7. Locknuts.
8. Knockout closures.
9. Seal fittings.
10. Inground pull boxes.
11. Hangers, supports, anchors and accessories.
12. Grout.

1.03 Related Requirements

A. Division 31 - Trenching and Backfilling.

B. Section 26 05 10 - Basic Electrical Requirements.

C. Section 26 05 26 - Grounding and Bonding for Electrical Systems.

D. Section 26 05 43 - Underground Duct Banks and Manholes.

E. Section 26 05 53 - Identification for Electrical Systems.

1.04 Reference Standards

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

B. American Welding Society (AWS):

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

C. ASTM International:

1. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
2. ASTM A153/A153M. - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
3. ASTM A240/A240M - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
4. ASTM A780/A780M - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
5. ASTM B117 -Standard Practice for Operating Salt Spray (Fog) Apparatus.
6. ASTM C1107/C1107M REV A - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).

D. National Fire Protection Association (NFPA):

1. NFPA 70 - National Electrical Code (NEC).

E. National Electrical Manufacturers Association (NEMA):

1. NEMA C80.1 – Electrical Rigid Steel Conduit.
2. NEMA RN 1 - Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
3. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
4. NEMA OS 2 - Nonmetallic Outlet Boxes, Covers, and Box Supports.
5. NEMA 250 - Enclosures for Electrical Equipment (1,000V Maximum).

F. Society of Protective Coatings (SSPC):

1. SSPC-PA 1 - “Shop, Field and Maintenance Painting of Steel.”

2. SSPC-SP3 - Power Tool Cleaning.

G. Underwriters' Laboratories, Inc. (UL):

1. Provide all devices, components, and equipment that are UL listed and labeled.
2. UL 6 - UL Standard for Safety Electrical Rigid Metal Conduit – Steel - Fourteenth Edition.
3. UL 50 - UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations - Thirteenth Edition.
4. UL 50E - UL Standard for Safety Enclosures for Electrical Equipment, Environmental Considerations - Second Edition.
5. UL 360 - UL Standard for Safety Liquid-Tight Flexible Metal Conduit - Seventh Edition.
6. UL 514A - UL Standard for Safety Metallic Outlet Boxes - Eleventh Edition.
7. UL 514B - UL Standard for Safety Conduit, Tubing, and Cable Fittings - Sixth Edition.
8. UL 514C - UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers - Fourth Edition.
9. UL 1203 - UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations - Fifth Edition.

1.05 Submittals

A. Submit as specified in Division 01 and Section 26 05 10 - Basic Electrical Requirements for administrative and procedural requirements for submittals.

B. Submittals shall include, but not be limited to, the following:

1. Product Data:
   a. Submit manufacturer's technical product data, including specifications and installation instructions, for each type of product required. Include data substantiating that materials comply with requirements.
   b. Submit manufacturer's data on supporting devices including catalog cuts, specifications, and installation instructions, for each type of support, anchor, sleeve, and seal.

1.06 Quality Assurance

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

B. Comply with NFPA 70.

C. Installations shall follow standard practices of NECA NEIS 1.

1.07 Coordination

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified together with concrete specifications.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - Products

2.01 Acceptable Manufacturers

A. Rigid Galvanized-Steel Conduit (RGS):

1. Allied Tube and Conduit, Atkore International.
2. Western Tube and Conduit Corporation.
3. Wheatland Tube Company, JMC Steel Group.
4. Republic Conduit, Tenaris.

B. Fittings for Rigid Steel Conduit:

1. Heavy-Duty Cast Malleable Iron Fittings:
    a. Appleton, Emerson Electric Company.
    b. Crouse-Hinds, Eaton.
    c. Thomas & Betts, ABB Group.
2. Conduit Expansion and Deflection Fittings:
    a. O-Z/Gedney, Emerson Electric Company.
    b. Thomas & Betts, ABB Group.

C. Rigid Steel Conduit and Fittings with Bonded Polyvinyl Chloride (PVC) Jacket:

1. OCAL, Thomas & Betts, ABB Group.

2. Robroy Industries.

D. Liquid-Tight Flexible Metal Conduit:

1. AFC Cable Systems, Atkore International.
2. Anamet Electrical, Inc.
3. Electri-Flex Company.
4. Southwire Company, LLC.
5. Thomas & Betts, ABB Group.

E. Outlet and Device Boxes:

1. Appleton, Emerson Electric Company.
2. Crouse-Hinds, Eaton.
3. Killark, Division of Hubbell, Inc.
4. Leviton Manufacturing Company, Inc.
5. O-Z/Gedney, Emerson Electric Company.
6. Thomas & Betts, ABB Group.

F. Pull and Junction Boxes:

1. Metallic Indoor and Outdoor Boxes:
    a. B-Line, Eaton.
    b. Hoffman, Pentair.
    c. Wiegmann, Hubbell Inc.
2. Fiberglass Boxes:
    a. Crouse-Hinds, Eaton, Krydon type.
    b. Schneider Electric, Krydon type.
    c. Hoffman, Pentair.

G. Conduit Hubs and Bodies:

1. Appleton, Emerson Electric Company.
2. Myers Industries, Inc. (ITT).

3. Crouse-Hinds, Eaton.
4. O-Z/Gedney, Emerson Electric Company.
5. Thomas & Betts, ABB Group.

H. Wall Entrance Seals: O.Z./Gedney, Emerson Electric Company.

I. Fittings:
   1. Crouse-Hinds, Eaton.
   2. Appleton, Emerson Electric Company.
   3. Thomas & Betts, ABB Group.

J. Bushings, Grounding Bushings, and Locknuts:
   1. Arrow Hart, Eaton.
   2. Appleton, Emerson Electric Company.
   3. O-Z/Gedney, Emerson Electric Company.
   4. Raco, Hubbell, Inc.
   5. Steel City, Thomas & Betts , ABB Group.

K. Electrical Enclosures:
   1. Hoffman, Pentair.
   2. Wiegmann, Hubbell, Inc.

L. Anchor Manufacturers: Subject to compliance with requirements, provide anchors of one of the following manufacturers.
   1. Hilti, Inc.
   2. B-line, Eaton
   3. Ideal Industries, Inc.
   4. Joslyn Manufacturing Co., Inc.
   5. Unistrut, Atkore International.

M. Metal Channel System Manufacturers: Subject to compliance with requirements, provide channel system of one of the following manufacturers.
   1. B-line, Eaton

2. Erico International Corporation.
3. Kindorf, Thomas & Betts, ABB Group.
4. Power-Strut, Atkore International.
5. Superstrut, Thomas & Betts, ABB Group.
6. Unistrut, Atkore International.

N. Inground Pull Boxes:

1. Hubbell Power Systems.
2. Engineer-approved equal.

O. Duct Seal:

1. Ideal Industries, Inc.
2. 3M Company.
3. Engineer-approved equal.

2.02 Design Requirements

A. Conduit:

1. Each length of threaded conduit furnished with coupling on one end and metal or plastic thread protector on other end.
2. UL listed and labeled conduit, on each length, fittings, and accessories.
3. Sizes of conduit, fittings, and accessories as indicated, specified, or as required by Electrical Codes and Standards.

B. Supports:

1. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

2.03 Rigid Galvanized Steel Conduit

A. Raceway:

1. Conform to NEMA C80.1, and UL 6.
2. Mild ductile steel, circular in cross section with uniform wall thickness sufficiently accurate to cut clean threads.
3. Each length threaded on both ends with threads protected.
4. All scale, grease, dirt, burrs, and other foreign matter removed from inside and outside prior to application of coating materials.
5. Galvanized by the hot-dip process as follows:
    a. Interior and exterior surfaces coated with a solid, unbroken layer of 99% virgin zinc by dipping.
    b. Coating not to show fixed deposits of copper after four 1-minute immersions in a standard copper sulfate solution.
    c. One coat of zinc-chromate finish on inside and outside surfaces to prevent oxidation and white rust.
6. Couplings and elbows fabricated, coated and finished by the same process as conduit.

B. Fittings:

1. Heavy-Duty Cast Malleable Iron Fittings:
    a. Mogul type for conduit sizes 1-1/2 inches and larger.
    b. LBD or roller action type LB for right-angle fittings for conduit sizes 2 inches and larger.
    c. Full-threaded hubs and rubber-gasketed covers.
    d. Zinc, cadmium-plated, or bronze hardware bolts and screws for assembly.
    e. Finished with cadmium plating or galvanizing.
    f. Form 8 bodies and covers.
    g. Standard and junction fittings.
2. Conduit Expansion Fittings:
    a. Line of Conduit Type:
        (1) Galvanized expansion fittings for rigid conduit movement up to 4 inches.

(2) Insulated metal bushing on ends of the conduit, bonding jumper, and with expansion head sealed with a high-grade graphite packing.

(3) O-Z/Gedney, Type AX with Type AJ bonding jumper or Thomas & Betts, Type XJG.

b. End Type:

(1) For conduit terminating in a junction box.

(2) O-Z/Gedney, Type EXE with Type BJ-E bonding jumper.

3. Conduit Expansion and Deflection Fittings:

    a. Provide for movement of 3/4 inch from normal in all directions between two rigid conduits.

    b. Integral bonding jumper.

    c. O-Z/Gedney, Type DX.

4. Conform to NEMA Type 1 enclosure in all nonhazardous areas except as specified or indicated otherwise.

2.04 Rigid Steel Conduit And Fittings With Bonded Polyvinyl Chloride (PVC) Jacket

A. Raceway:

1. Conform to hot-dipped galvanized rigid steel conduit as specified in RIGID STEEL CONDUIT, this Section, and as follows. Shall comply with NEMA RN1.

2. PVC coating bonded to the conduit. Extruded PVC jackets are unacceptable.

3. Coated externally with PVC to a nominal 40 mils, 0.035 inch to 0.045 inch.

4. Uniformly coated around outside diameter and full length of the conduit.

5. Pre-threaded ends coated with a urethane coating having a nominal thickness of 2 mils (0.002 inch).

6. Interior surfaces of all conduits and feed-through fittings coated (except where prohibited by design) with a two-part, chemically cured, urethane coating having a nominal thickness of 2 mils (0.002 inch).

7. The bond between the metal and jacket must exceed the tensile strength of the coating.

B. Couplings, Elbows, and Fittings:

1. Couplings, elbows, and other conduit fittings, boxes, cover plates, supports, hardware, and related items shall be treated and coated with the same process as conduit.

2. Each coupling and fitting to include a PVC sleeve that overlaps the conduit.

3. Length of the overlapping sleeve equals diameter of the conduit or 2 inches, whichever is least.

4. Final cured PVC coating capable of withstanding a minimum electrical potential of 2,000V.

5. All conduit accessories, clamps, and hardware that are uncoated shall be stainless steel.

6. All fittings intended for wet, outdoor, or wash-down application shall carry a NEMA 4X rating.

7. Form 8 bodies and covers.

2.05 Liquid-Tight Flexible Metal Conduit

A. Liquid-tight conduit with flexible galvanized-steel core and a synthetic rubber, polyvinyl chloride, or thermoplastic covering.

B. Shall comply with UL 360.

C. Spiral encased copper bonding conductors for conduit in sizes 1-1/4 inches and smaller.

D. External grounding jumper as required.

E. Provide hot-dipped galvanized fittings for connections to rigid steel conduit, and aluminum- or PVC-coated fittings for connections to PVC-coated rigid steel conduit.

F. Fittings for flexible metal conduit shall comply with UL 514B.

2.06 Outlet and Device Boxes

A. Surface Mounted:

1. Cast hub device boxes for receptacles and switches.

2. Cast malleable iron. Metallic boxes shall meet UL 514A and NEMA OS 1.

3. PVC boxes for PVC conduit. PVC boxes shall meet UL 514C and NEMA OS 2.

4. FS or FD single or multiple gang boxes as required.

5. Outlet boxes intended for use in classified areas shall be UL 886 listed.

2.07 Pull and Junction Boxes

A. Steel Boxes - Indoors:

1. Hot-dipped galvanized steel.
2. Galvanized-steel covers.
3. Cadmium-plated screws and bolts.
4. For special boxes where it is not possible to provide hot-dip galvanizing, apply organic zinc-rich primer at 3-mils dry film thickness after SSPC-SP3 Power Tool Cleaning.
5. Minimum of 14-gage steel.
6. Conform to NEMA Type 1 enclosure in all nonhazardous areas except as specified or indicated otherwise.
7. Include piano-hinged, gasketed cover and interior mounting panel where oil-tight J.I.C boxes are used for enclosing terminal blocks and control relays.
8. Waterproof hubs in all unconditioned rooms and areas subject to moisture.

B. Steel Boxes - Outdoor:

1. Type 304 or 316 stainless steel with stainless-steel cover and stainless-steel clamps and screws.
2. Minimum 16 gage for boxes with no dimension exceeding 6 inches and minimum 14 gage for all other boxes.
3. Continuously welded seams shall be ground for a smooth finish.
4. Seamless gasket for cover.
5. Conform to NEMA Type 4X.
6. Provide continuous hinge, gasketed cover, and interior mounting plate when used for enclosing terminal blocks and control relays.
7. Provide rigid weatherproof conduit hubs for all boxes.

C. Metallic Barriers:

1. Designed not to separate phases of a power circuit.
2. Provide as indicated for the isolation of power circuits from other type circuits

D. Bushings: Provide threaded, nylon-insulated metallic bushings. Provide steel bushings for conduit sizes 1-1/2 inches and smaller. Provide malleable iron bushings for conduit sizes 2 inches and larger.

E. Grounding Bushings: Provided where indicated, specified and required by NEC. Provide threaded, insulated, malleable iron bushing with lay-in screw clamp lug.

F. Locknuts: Provide steel locknuts for conduit sizes 2 inches and smaller. Provide malleable iron for conduit sizes 2.5 inches and larger.

G. Sealing Hub: Provide watertight, threaded, insulated sealing hub connectors for all outdoor and indoor wet locations where conduit enters into enclosures. Sealing hub threaded lengths shall be adequate to allow installation of bushing.

H. Knockout Closures: Provide steel press-in knockout seals for all unused punched out knockouts 2 inches and smaller. Provide steel two-piece bolt on knockout seals for all unused punched out knockouts 2-1/2 inches and larger.

I. Fittings: Provide all threaded nipples, insulated short elbows, offset nipples, offset connectors, enlargers and reducers as required.

2.08 Conduit Wall Entrance Seals

A. Provide where required or indicated.

B. Use O-Z/Gedney Type FSK for new walls.

C. Use O-Z/Gedney Type CSM for penetration in existing walls.

2.09 Seal Fittings and Couplings For Rigid Steel and PVC-Jacketed Rigid Steel Conduit

A. Fittings:

1. Explosionproof.
2. Cast malleable iron.
3. Threaded cover to conform to NEC.
4. Full thread hubs.
5. Seal compound well for seal.
6. Drain seals as indicated or required to provide a continuous automatic drain of water.
7. "Chico" compound for all sealing fittings.
8. PVC jacketed in corrosive areas where PVC-jacketed conduit is used.

B. Couplings:

1. Explosionproof.

2. Flexible.

3. Conform to NEC.

4. Threaded steel end fittings securely fastened to the core and braided to ensure electrical continuity.

5. PVC jacketed in corrosive areas where PVC-jacketed conduit is used.

2.10 Steel Support System

A. General: Provide supporting devices which comply with manufacturer's standard materials, design, and construction in accordance with published product information, as required for complete installation, and as herein specified. All supports shall be designed for the support of the maximum number of conduits and their maximum conductor weights for maximum conduit loading. Where more than one type of supporting device meets indicated requirements, selection is Contractor's option. Do not use perforated metal straps for supports.

B. Fabricated from structural steel or manufactured framing members equal to "Unistrut" P-3000 (1-5/8 inch by 1-3/8 inch) series as manufactured by Unistrut Corporation, Kindorf B-995 (1-1/2 inch by 1-1/2 inch) series as manufactured by Thomas and Betts, or Superstrut A-1200 (1-5/8 inch by 1-5/8 inch) series as manufactured by Thomas and Betts.

C. Minimum 12 gage.

D. Construct as required to rigidly support all conduit runs, boxes, and equipment.

E. Stainless-Steel Supports:

1. Channel Type 304 stainless steel conforming to ASTM A240.

2. Stainless-steel conduit clamps and hangers, sized for the specific conduit diameter.

3. Provide stainless-steel rods, anchors, inserts, bolts, washers, nuts, and support hardware.

F. Anchors: Anchors of types, sizes, and materials indicated, with the following construction features.

1. Lead Expansion Anchors: 1/2, 5/8, or 3/4 inch as required.

2. Toggle Bolts: Springhead, 3/16 by 4 inch or larger size as required.

2.11 Inground Pull Boxes

A. Boxes and cover shall be made of polymer concrete.

B. Material shall be sunlight resistant, chemical resistant, moisture resistant, and non-conductive.

C. The boxes shall be stable type for extra depth.

D. The covers shall be heavy-duty and designed for 15,000 pounds over a 10-inch square with a minimum test load of 22,000 lbs. The covers shall be made of non-skid materials.

E. Shall be designed for outdoor inground installation.

F. Size shall be as required by the National Electrical Code. Minimum size shall be 12 inches wide by 24 inches deep by 12 inches high.

G. All mounting hardware shall be 316 stainless steel.

H. Install where indicated.

2.12 Duct Seal

A. Duct Seal:

1. Noncorrosive, permanently soft compound.
2. Nontoxic.
3. Provide flexible re-enterable and repairable seal around cables in conduits.
4. Prevent air movement and drafts through conduits.
5. Provide Ideal Industries Duct Seal, 3M® Moldable Putty, or Engineer-approved equal.

2.13 Grout

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5,000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - Execution

3.01 Preparation

A. Provide suitable protection for conduit risers against damage during construction.

B. Cap ends of all conduits before concrete is poured.

C. Cap all conduits after cleaning where conduits are to be left empty by this Contract.

D. Carefully ream ends of all conduit lengths after cutting to eliminate sharp burrs.

E. Clean out all conduits before pulling wire.

F. Clean out all conduits immediately after concrete work is finished.

3.02 Raceways and Box Installation

A. General Requirements:

1. Location:
    a. Install conduit as near as possible to the routing indicated.
    b. Shift locations as required to avoid interference with other equipment and piping being installed.
    c. Where routing of conduit is not indicated, such as for lighting home run circuits and other systems requiring small conduit runs, route conduit as specified subject to approval by Engineer.
2. Do not use conduit in sizes smaller than 3/4 inch, except 1/2 inch may be used for connections to control devices and thermocouples where necessary.
3. Holes and Sleeves:
    a. Provide through floors, walls, and roofs as necessary for conduit runs, including approved flashing and weather proofing at outside walls and on roofs.
    b. Install sleeves or forms for all openings in new Work.
    c. Provide the required inserts and holes, completely sleeved, bonded, curbed, flashed, and finished off in an approved manner, whether in concrete, steel grating, metal panels, or roofs.
    d. Core-drill all holes required in existing building work using a dustless method.
    e. Place nonshrinking grout or Dow Corning 3-6548 Silicone RTV or equivalent General Electric RTF 762 sealant as specified, in the following locations:

            (1) All holes in concrete, walls, floor, and roof slabs after installation of conduit.

            (2) All unused holes and sleeves as approved by Engineer.

        f. Install wall entrance seals where conduit enters the building or vaults from exterior underground.

4. Install duct seal in conduits around cables at all conduit terminations at control panels and boxes containing terminations and splices.

5. Make connections to boxes, panels, and other equipment as follows:

    a. Indoor Dry Locations: Double locknuts, one inside and one outside.

    b. Outdoor and Damp Locations: Rigid weatherproof conduit hubs.

    c. Bushings:

        (1) Threaded malleable iron or steel.

        (2) Insulated with Bakelite, molded and bonded into the bushing.

        (3) Placed on end of conduit in addition to locknuts.

        (4) Install with integral grounding connector and conductor where all conduits pass through multiple concentric panel knockouts and where the conduit must be bonded to equipment it is not attached to.

6. Running threads will not be permitted.

7. Coat all field cut threads in galvanized conduit with cold galvanizing paint.

8. Comply with applicable requirements of NEC pertaining to installation of conduit systems.

9. Place drainage fittings or weep holes at unavoidable low points where moisture can collect.

10. Install an entire conduit system that is electrically continuous with bonding jumpers provided as necessary to conform to NEC.

11. Install expansion fittings at all building expansion joints and every 100 feet of continuous conduit.

B. Rigid Steel Conduit:

1. Exposed:

    a. Install in building interior spaces where specified or indicated.

b. Install above grade outdoors.

c. Install horizontal runs as high above floor as possible, and in no case lower than 7 feet above floor, walkway, or platform in passage area.

d. Run conduit parallel or perpendicular to walls, ceiling, beams, and columns unless indicated otherwise.

e. Route to clear all doors, windows, access wells, and openings.

f. Group parallel runs in neatly aligned banks where possible with minimum of 1-inch clearance between conduits.

g. Maintain 6-inch clearance between conduit and coverings on all hot lines; steam, hot water, and the like.

h. Do not exceed a distance of 8 feet between supports on horizontal or vertical runs.

i. When terminating at cable tray, firmly attach conduit to tray and electrically bond conduit with ground wire to cable tray.

2. Concealed:

a. Conceal conduit for lighting, convenience outlets, and other circuits in walls, ceiling, and floors where possible.

b. Do not install conduit in concrete where conduit outside diameter exceeds one-third of concrete thickness.

c. Install parallel runs with a minimum spacing of three conduit diameters between conduits.

d. Use expansion and deflection fitting with bonding jumpers at all concrete expansion joints.

e. Tie securely in place to prevent movement when concrete is poured.

f. Install in floor slabs in as straight a run as possible. Conduit crossovers are not permitted unless conduit total outside diameter is one-third of the concrete thickness or less.

C. Rigid Steel Conduit PVC Jacketed:

1. Install in wetwells, screen rooms, and where indicated.

2. Coat field cut threads with manufacturer's standard product in accordance with manufacturer's recommendations.

3. Use bender one size larger for conduit sized 1 inch or less and conventional bender for conduit sized above 1 inch.

4. Use strap wrench to tighten conduit. Repair damaged coating with liquid patching compound recommended by conduit manufacturer.

5. Exposed:

    a. Group parallel runs in neatly aligned banks where possible with a minimum of 1-inch clearance between conduits.

    b. Run conduit parallel or perpendicular to walls, ceiling, beams, and columns unless indicated otherwise.

    c. Route to clear all doors, windows, access walls, and openings.

    d. Maintain 6-inch clearance between conduit and coverings on all hot lines; steam, hot water, and similar pipes.

    e. Do not exceed a distance of 8 feet between supports on horizontal or vertical runs.

    f. Install horizontal runs as high above floor as possible, and in no case lower than 7 feet above floor, walkway, or platform in passage area.

6. Buried:

    a. Install in as straight a run as possible between termination points of exact routing to be determined in the field and subject to approval by Engineer.

    b. Bury conduits a minimum of 30 inches below finish grade unless indicated otherwise.

    c. Slope conduit away from conduit risers where possible.

    d. Maintain 6-inch separation from underground piping.

    e. Use long radius elbows for all primary feeders unless indicated otherwise.

    f. Use for conduit risers where routed through concrete slabs.

    g. After trench bottom has been finished to grade, lay conduit. Backfilling shall be as specified in Division 31.

    h. Cap ends of all conduit risers before backfilling.

D. Liquid-Tight Flexible Metal Conduit.

1. Use between rigid conduit and motor terminal boxes except where conduit runs down from above and cannot be conveniently supported by a floor flange.

2. Place between rigid conduit or conduit box and control device cases where direct connection is not desirable for reasons of equipment movement, vibration, or for ease of maintenance.

3. Install at all points of connection to equipment mounted on supports to allow for expansion and contraction.

4. Conform to NEC with installation of conductors.

5. Install at locations where rigid conduit connections are impractical.

6. Use minimum length consistent with manufacturer's standard lengths, the acceptable bending radius, and with required movement of equipment.

7. Maximum length of 3 feet unless otherwise approved by Engineer.

8. Install an external bonding jumper to conform to NEC on conduit sized 1-1/2 inches and larger.

E. Conduit Fittings:

1. Installations of special fittings are indicated.

2. Use aluminum fittings for joining aluminum to steel conduit.

3. Install as required.

3.03 Boxes and Fittings

A. Install electrical boxes, bushings, locknuts, nipples, connectors, sealing hubs, and fittings as required, indicated, in accordance with applicable requirements of NEC and in accordance with recognized industry practices to fulfill Project requirements.

B. Coordinate installation of electrical boxes and fittings with wire/cable, wiring devices, and raceway installation work.

C. Provide weatherproof boxes for interior and exterior locations exposed to weather or moisture.

D. All boxes containing emergency power and lighting circuits shall be identified as specified in Section 26 05 53 - Electrical Identification.

E. Provide (oil-tight) knockout closures to cap unused knockout holes where blanks have been removed.

F. Install electrical boxes in only those locations which ensure ready accessibility to enclosed electrical wiring.

G. Maximum box size in a fire-rated wall shall be 4 inches by 4 inches square. Do not install boxes back-to-back in walls. In walls that are not fire-rated or acoustic-rated, provide not less than 6 inches horizontal separation between boxes installed in opposite sides of wall. Provide not less than 24 inches horizontal separation between boxes installed in opposite sides of fire-rated and acoustic-rated walls.

H. Do not install aluminum products in concrete.

I. Position recessed outlet boxes accurately to allow for surface finish thickness.

J. Set floor boxes level and flush with finish flooring material.

K. Fasten electrical boxes firmly and rigidly to the surfaces to which attached, structural surfaces to which attached, or solidly embed them in concrete or masonry.

L. Provide electrical connections for installed boxes.

M. Properly ground metallic electrical boxes in compliance with the NEC. Bond all non-isolated equipment grounding conductors to all electrical boxes.

N. Subsequent to installation of boxes, protect boxes from construction debris and damage.

O. Install special boxes as indicated of size required for conduits and cables entering and leaving box.

3.04 Supports

A. Construct with sufficient rigidity to hold all mounted equipment and material in permanent and neat alignment.

B. Design to provide 1/4-inch space between equipment housings and walls or columns upon which they are mounted.

C. Do not exceed load requirements in NEC and NEMA standards.

D. Use stainless-steel supports, clamps, and straps, and stainless-steel hardware to support steel conduit.

E. Use stainless-steel or PVC-coated conduit straps to support PVC-coated rigid steel conduit. Use stainless-steel clamps for supporting PVC coated rigid steel conduit on stainless-steel supports.

3.05 Concrete Bases

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3,000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 - Concrete.

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.06 Inground Pull Boxes

A. Install a minimum of 6 inches of compacted granular material below pull box.

B. Install top of pull box flush with finished grade.

C. Bring conduit up from below box or make conduit penetration in boxes per manufacturer's recommendations.

3.07 Seal Fittings

A. Install seal fittings in the rigid steel or PVC coated rigid steel conduit system as required by NEC.

B. Install necessary fittings where not indicated but required by code.

3.08 Painting

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION

PART 1 - General

1.01 Related documents:

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

1.02 Summary:

A. This Section includes:

1. Ladder cable trays.

1.01 Reference standards:

A. Applicable Standards (Latest Edition):

1. American National Standards Institute (ANSI):
    a. ANSI H35.1/H35.1M - Alloy and Temper Designation Systems for Aluminum.
2. American Society of Civil Engineers/Structural Engineering Institute.
    a. ASCE/SEI 7 - Minimum Design Loads for Buildings and Other Structures.
3. ASTM International:
    a. ASTM A123/A123M - Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
    b. ASTM A510/A510M - Standard Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel.
    c. ASTM A653/A653M - Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
    d. ASTM A1008/A1008M - Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
    e. ASTM A1011/A1011M - Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.

f. ASTM B633 - Specification for Electrodeposited Coatings of Zinc on Iron and Steel.

g. ASTM D769 - Specification for Black Synthetic Iron Oxide.

h. ASTM F593: Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

i. ASTM F594 - Specification for Stainless Steel Nuts.

j. ASTM F1136 - Specification for Zinc/Aluminum Corrosion Protective Coatings for Fasteners.

4. Master Painters Institute:

a. MPI# 77 - Epoxy, Gloss.

b. MPI# 101 - Primer, Epoxy, Anti-Corrosive, for Metal.

5. National Electrical Manufacturers Association:

a. NEMA VE 1 - Metal Cable Tray Systems.

b. NEMA VE 2 - Cable Tray Installation Guidelines.

6. NFPA:

a. NFPA 70 - National Electrical Code.

1.03 Submittals:

A. Product Data: For each type of product.

1. Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.

C. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.

2. Vertical and horizontal offsets and transitions.

3. Clearances for access above and to side of cable trays.

4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.

D. Field quality-control reports.

PART 2 - Products

2.01 Performance requirements:

A. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.

1. Temperature Change: 120ºF (67ºC), ambient; 180ºF (100ºC), material surfaces.

2.02 General requirements for cable trays:

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

1. Source Limitations: Obtain cable trays and components from single manufacturer.

B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Structural Performance: See articles on individual cable tray types for specific values for the following parameters:

1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.

2. Concentrated Load: A load applied at midpoint of span and centerline of tray.

3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.03 Ladder cable trays:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide Cooper B-Line or comparable product by one of the following:

1. Allied Tube & Conduit; a Tyco International Ltd. Co.

2. Chalfant Manufacturing Company.
3. Mono-Systems, Inc.
4. MP Husky.
5. Niedax-Kleinhuis USA, Inc.

C. Description:

1. Configuration: Two I-beam side rails with transverse rungs welded to side rails.
2. Rung Spacing: 6 inches (150 mm) o.c.
3. Radius-Fitting Rung Spacing: 9 inches (225 mm) at center of tray's width.
4. Minimum Cable-Bearing Surface for Rungs: 7/8-inch (22-mm) width with radius edges.
5. No portion of the rungs shall protrude below the bottom plane of side rails.
6. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
7. Minimum Usable Load Depth: 4 inches (100 mm).
8. Straight Section Lengths: 20 feet (6 m) except where shorter lengths are required to facilitate tray assembly.
9. Width: 36 inches (900 mm) unless otherwise indicated on Drawings.
10. Fitting Minimum Radius: 12 inches (300 mm).
11. Class Designation: Comply with NEMA VE 1, Class 20B or greater.
12. Splicing Assemblies: Bolted type using serrated flange locknuts.
13. Hardware and Fasteners: ASTM F593 and ASTM F594 stainless steel, Type 316.
14. Splice Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

2.04 Materials and finishes:

A. Aluminum:

1. Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 according to ANSI H35.1/H 35.1M for fabricated parts.

2. Hardware: Stainless steel, Type 316, ASTM F593 and ASTM F594.

3. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

2.05 Cable tray accessories:

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Barrier Strips: Same materials and finishes as for cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.06 Warning signs:

A. Lettering: 1-1/2-inch-high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

B. Comply with requirements for fasteners in SECTION 260553 – ELECTRICAL IDENTIFICATION.

2.07 Source quality control:

A. Testing: Test and inspect cable trays according to NEMA VE 1.

PART 3 - Execution

3.01 Cable tray installation:

A. Install cable trays according to NEMA VE 2.

B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

D. Remove burrs and sharp edges from cable trays.

E. Join aluminum cable tray with splice plates; use four square-neck carriage bolts and locknuts.

F. Fasten cable tray supports to building structure.

G. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb.

H. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

I. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

J. Support bus assembly to prevent twisting from eccentric loading.

K. Install center-hung supports for single-rail trays designed for 60 versus 40% eccentric loading condition, with a safety factor of 3.

L. Locate and install supports according to NEMA VE 2. Do not install more than one cable tray splice between supports.

M. Make changes in direction and elevation using manufacturer's recommended fittings.

N. Make cable tray connections using manufacturer's recommended fittings.

O. Install cable trays with enough workspace to permit access for installing cables.

P. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5,000, and 15,000V.

Q. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.02 Cable tray grounding:

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

B. Cable trays with electrical power conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. Cable trays with single-conductor power conductors shall be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72-inch (1800-mm) intervals. The grounding conductor shall be sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors," and Article 392, "Cable Trays."

D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding-bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

E. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.03 Cable installation:

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. Fasten cables on vertical runs to cable trays every 18 inches (450 mm).

D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches (1800 mm).

3.04 Connections:

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect raceways to cable trays according to requirements in NEMA VE 2.

3.05 Field quality control:

A. Perform the following tests and inspections:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.

2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.

3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.

4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.

5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.

6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.

7. Check for improperly sized or installed bonding jumpers.

8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.

9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.06 Protection:

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.

2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.

3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section includes the following:

1. Complete underground duct systems consisting of banks of nonmetallic ducts encased in reinforced concrete, and precast concrete handholes.
2. All necessary earth and rock excavation and backfill.
3. Removal and disposal of all excess excavation material.

1.03 Related Requirements

A. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

B. Earthwork: DIVISION 31.

C. Concrete: DIVISION 03.

1.04 Reference Standards

A. American Concrete Institute (ACI):

1. 318-14 – Building Code Requirements for Structural Concrete.

B. American Society for Testing and Materials (ASTM):

1. A48 – Standard Specification for Gray Iron Castings.
2. C857 – Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
3. C858 – Standard Specification for Underground Precast Concrete Utility Structures.
4. D4385 – Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products.
5. F512 – Standard Specification for Smooth Wall Polyvinyl Chloride (PVC) Conduit and Fittings for Underground Installation.

C. National Electrical Manufacturer's Association (NEMA):

1. TC 6 – PVC and ABS Plastic Utilities Duct for Underground Installation.

2. TC 8 – Extra Strength PVC Plastic Utilities Duct for Underground Installation.

D. Underwriters Laboratories, Inc. (UL):

1. 651 – Schedules 40, 80, Type EB and A Rigid PVC Conduit and Fittings

1.05 Submittals

A. Submit as specified in DIVISION 01.

B. Product Data: Submit the following for each type of product specified and included as minimum:

1. Data sheets for each product supplied.

C. Shop Drawings: Provide the following as minimum:

1. Submit shop drawings for fabrication and installation of pre-cast concrete structures and cast-in-place concrete structures including the following:

    a. Steel reinforcement drawings.

    b. Elevation showing openings, pulling irons, cable supports, sump, steps, covers, frames and other details.

D. Closeout Submittals: Final documentation shall include the following as minimum:

1. Certified “As-Built”/“As-Installed” drawings.

2. Copies of all approved Product Data.

1.06 Quality Assurance

A. Manufacturer Qualifications:

1. The manufacturer shall be by a company specializing in providing precast products and services normally associated with precast-concrete construction. Design of precast handholes shall be prepared by a professional engineer licensed in the state of Tennessee to conform to the procedures set forth in ACI 318 and applicable standards of this specification and of the size, shape, and details indicated or specified.

PART 2 - Products

2.01 Manufacturers

A. Ducts:

1. Carlon.
2. Certain-Teed.
3. Cantex.

B. Duct Spacers:

1. Carlon
2. CertainTeed.
3. Formex.

C. Concrete Inserts:

1. Unistrut Corporation.
2. B Line Systems, Inc.

D. Precast Handholes:

1. Barbour Concrete Co.
2. Champion Precast Inc.
3. Old Castle.
4. Engineer approved equal.

2.02 Ducts

A. Conduit Types for Concrete Encasement:

1. Type EB:
    a. Tested to Underwriters' Laboratories, Inc. (UL) Standard UL 651A.
    b. Type EB35, Heavy Wall, Thickness conforming to NEMA TC-8 and ASTM F512.

B. Rated for use with 90°C conductors.

C. Provide with all necessary end bells, couplings, offset couplings, elbows, plugs, and other fittings.

D. Sizes as indicated.

E. Install PVC coated rigid galvanized steel elbows for all duct termination risers and all non-sweeping 90 degree bends.

F. Provide prefabricated, interlocking type plastic duct spacers for duct spacing as indicated.

2.03 Reinforcing Steel

A. Provide as specified in DIVISION 03.

2.04 Concrete

A. Provide as specified in DIVISION 03.

2.05 Precast Handholes

A. Precast concrete handholes with precast concrete base and top slab shall conform to ASTM C857 and C858, except as noted below:

1. Concrete, reinforcing steel and formwork shall conform to applicable sections of DIVISION 03.

2. Top Slab Superimposed Live Load: A-16 (HS20-44 per AASHTO).

3. Equivalent Fluid Soil Density: 90 pcf.

4. Unit Weight of Soil: 120 pcf.

5. Net Allowable Soil Bearing Pressure: 1500 psf for the top 2 feet and 1000 psf below 2 feet.

6. Required Dimensions:

    a. Minimum dimensions shall conform to Drawings.

B. Units shall be constructed monolithically or of assembled sections with tongue-and-groove joints.

C. Concrete top cover shall be removable with recessed galvanized steel lifting inserts. Lifting inserts shall conform to ASTM C857.

D. Provide a flush mounted 30-inch manhole frame and cover shall be cast in the center of the cover.

E. Provide flush mounted plastic coated pulling irons in the walls located opposite of each set of duct openings.

F. Provide duct terminators to accommodate ducts entering as indicated.

G. Provide 8-inch sump hole through base slab.

H. Provide galvanized cable rack supports in each wall.

I. Provide submittal for precast reinforced concrete handholes prior to installation. The submittal shall be sealed by a professional engineer licensed in the state of Tennessee.

2.06 Castings

A. Manhole Frames and Covers:

1. ASTM A48, Class 30B. Cover shall be marked with “Electric.”

2. Watertight bolt-down type with drop handles.

3. Machine-bearing surfaces to provide an even seating.

4. Coat with coal-tar pitch varnish.

2.07 Warning Tape

A. Standard detectable warning tape, 4-mil 3 inch wide tape, red with black letters imprinted with "CAUTION BURIED ELECTRIC CABLE BELOW".

2.08 "Pulling in" rope:

A. Nylon or nylon equivalent composite.

B. Minimum average breaking strength: 2000 pounds.

PART 3 - Execution

3.01 Excavation and Trenching for Duct Banks and Handholes

A. Perform as specified in DIVISION 31.

B. Work with extreme care near existing underground utilities to avoid damaging them.

C. Pitch the trench uniformly toward handholes or both ways from high points between handholes for required drainage.

D. Notify the Owner's representative for inspection prior to any duct bank installation and prior to concrete placement.

3.02 Installation

A. Duct Banks:

1. Ducts:

        a. Assemble as follows:

            (1) On spacers to maintain horizontal and vertical separation indicated.

            (2) With joints in adjacent ducts staggered.

            (3) All joints watertight by application of joint sealer compound furnished by duct manufacturer.

            (4) No reinforcing steel or other ferrous material between individual ducts.

        b. Securely tie overall at 5 foot or closer intervals as required.

        c. Secure to anchors after assembling to prevent flotation when placing concrete.

        d. Slope towards handholes with a minimum continuous slope of 1/2 percent.

        e. Align ducts for each 100 feet not greater than 4 inches horizontal.

        f. All risers and non-sweeping bends shall be PVC coated rigid galvanized steel as specified.

        g. Install end bells flush with face of concrete at each handhole and termination point unless indicated otherwise.

        h. Immediately after cleaning, install a "pulling in" rope in each duct, and plug each end of all ducts.

    2. Install warning tape along the entire length of duct banks at a minimum depth of 12 inches below grade or as indicated on drawings.

    3. Reinforcing: Place as specified in DIVISION 03.

    4. Concrete:

        a. Do not place prior to inspection and approval of duct and reinforcing installation by Engineer.

        b. Place as specified in DIVISION 03.

B. Precast Handholes:

    1. Install a minimum of 6 inches of compacted granular material on undisturbed soil below handhole.

    2. Place at location and alignment as indicated.

    3. Top slab and handhole shall be set flush with finished grade.

    4. Install conduits as indicated.

C. Duct and Conduit Sealing:

1. Seal the ducts and conduits at building entrances and at outdoor equipment with a suitable non-hardening compound to prevent the entrance of moisture and gases.

3.03 Backfilling

A. Provide backfill and compaction as specified in DIVISION 31.

3.04 Adjusting and Cleaning

A. Rod and clean all ducts with suitable cleaners, swabs and mandrels after completion of the duct bank.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section specifies electrical identification work including the following:

1. Buried cable and duct bank warnings.
2. Electrical power, control, and communication conductors (and raceways).
3. Operational instructions and warnings.
4. Danger, caution and warning signs.
5. Equipment/system identification nameplates.

1.03 Reference Standards

A. Applicable Standards: Comply with the applicable requirements of the following standards.

1. American National Standards Institute (ANSI):
    a. Z53.1-1979 - Safety Color Code for Marking Physical Hazards.
2. National Fire Protection Association (NFPA):
    a. 70 - National Electrical Code (NEC), as applicable to installation of identifying labels and markers for wiring and equipment.
    b. 72 – National Electric Safety Code (NESC) – IEEE C2.
3. Occupational Safety and Health Administration (OSHA):
    a. 29 CFR 1910.144 – Safety Color Code for Marking Physical Hazards.
    b. 29 CFR 1910.145 - Specifications for Accident Prevention Signs and Tags.
4. Underwriters Laboratories (UL), pertaining to electrical identification systems:
    a. 969-1991 – Standards for Marking and Labeling Systems.

1.04 Submittals

A. Refer to DIVISION 01 and Section 26 05 10 - Basic Electrical Requirements for administrative and procedural requirements for submittals.

B. Includes, but not limited to, the following:

1. Product Data: Submit manufacturer's data on electrical identification materials and products.

2. Samples: Submit samples of each color, lettering style, and other graphic representation required for each identification material or system.

1.05 Quality Assurance

A. Comply with ANSI A13.1.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.06 Coordination

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - Products

2.01 Manufacturers

A. Subject to compliance with requirements, provide electrical identification products of one of the following (for each type marker):

1. Brady Worldwide, Inc.

2. Panduit Corp.

3. Seton Identification Products.

4. Thomas & Betts Corp.

2.02 Electrical Identification Materials

A. General: Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for an application, selection is Installer's option; but provide single selection for each application.

B. Arc Flash Hazard labeling in accordance with NEC Article 110.16.

C. Orange "Emergency" and "( )-VOLT" Conduit, Equipment, Box, and Cable Tray Markers:

   1. General: Self-adhesive vinyl tape marker not less than 3 mils thick. Provide 1-1/8 inch wide by 4-1/2 inch long marker for 2 inch and smaller conduit. Provide 2-1/4 inch wide by 9 inch long marker for 2-1/2 inch and larger conduit and all cable tray. Except as otherwise indicated, provide black lettering which indicates highest voltage of cables(s) in conduit or cable tray. Provide black lettering that indicates "Emergency" power circuit is in conduit or cable tray.

   2. Colors: Unless otherwise indicated or required by governing regulations, provide orange background tape marker.

D. Underground Type Plastic Line Marker:

   1. General: Permanent, bright-colored, continuous-printed plastic tape marker, intended for direct-burial service; not less than 6 inches wide by 4 mils thick. Provide tape marker with printing which most accurately indicates type of service of buried cable or duct bank. Provide embedded continuous metallic strip or core.

E. Wire/Cable Identification Bands:

   1. General: Vinyl-cloth self-adhesive cable/conductor markers of wrap-around type, either prenumbered plastic coated type or write-on type with clear plastic self-adhesive cover flap; numbered to show circuit identification number indicated on Drawings or Shop Drawings.

F. Self-Adhesive Plastic Signs:

   1. General: Self-adhesive or pressure-sensitive, preprinted, flexible vinyl signs for operational instructions or warnings; of sizes suitable for application areas and adequate for visibility, with proper wording for each application, e.g., "EXHAUST FAN."

a. Colors: Unless otherwise indicated or required by governing regulations, provide white signs with black lettering.

G. Baked Enamel "Danger" Signs:

1. "DANGER" signs of baked enamel finish on 20-gauge steel (unless specified otherwise); of standard safety red, safety black, and safety white as defined by ANSI Z535.1; 14 inches by 10 inches size, except where 10 inches by 7 inches is the largest size which can be applied where needed, and except where larger size is needed for adequate vision; with recognized standard explanation wording, e.g., "_____VOLTS, KEEP AWAY." Sign shall conform to OSHA and ANSI Z535.1.

H. Baked Enamel "Caution" Signs:

1. "CAUTION" signs of baked enamel finish on 20 gauge steel (unless specified otherwise); of standard safety yellow with safety black letters; 14 inches by 10 inches size, except where 10 inches by 7 inches is the largest size which can be applied where needed, and except where larger size is needed for adequate vision; with recognized standard explanation wording, e.g., "Caution for Ear Protection Required in this Area."

I. Based Enamel "WARNING" Signs:

1. "WARNING" signs of baked enamel finish on 20 gauge steel (unless specified otherwise); of standard safety orange with safety black letters; 14 inches by 10 inches size, except where 10 inches by 7 inches is largest size that can be applied where needed and except where larger size is needed for adequate vision; with recognized standard explanation wording. Sign shall conform to OSHA and ANSI Z535.1.

J. Engraved Plastic-Laminate Nameplates:

1. General: Engraving stock melamine plastic laminate nameplates, in sizes (minimum height of characters shall be 1/8 inch) and thicknesses specified or indicated, engraved with engraver's standard letter style of sizes and wording indicated, white face and black core plies (letter color) except as otherwise indicated, specified or required. Colors shall comply with OSHA and ANSI Z535.1. Nameplate shall be punched for mechanical fastening except where adhesive mounting is necessary because of surface it is mounted to.

   a. Thickness: 1/16-inch, for units up to 20 square inches or 8 inch length; 1/8-inch for larger units.

   b. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate surface it is mounted to.

2. Lettering and Graphics:

a. Coordinate names, abbreviations, and other designations used in electric identification work with corresponding designations shown, specified, or scheduled. Provide numbers, lettering, and wording as indicated or, if not otherwise indicated, as recommended by manufacturer or as required for proper identification and operation/maintenance of electrical systems and equipment. Comply with ANSI A13.1 pertaining to minimum sizes for letters and numbers. Comply with OSHA requirements. Comply with color requirements of ANSI Z535.1.

PART 3 - Execution

3.01 Application and Installation

A. General Installation Requirements:

1. Install electrical identification products as indicated, in accordance with manufacturer's written instructions and requirements of NEC.

2. Coordination: Where identification is to be applied to surfaces which require finish painting, install identification after completion of painting.

3. Regulations: Comply with governing regulations and requests of governing authorities for identification of electrical work.

B. Underground Cable, Conduit, and Duct Bank Identification Marker:

1. General: During back-filling/top-soiling of each exterior underground direct buried electrical, signal or communication cable, conduit and duct bank, install continuous underground-type plastic line marker, located directly over the direct buried cable, conduit or duct bank at 12 inches below finished grade. Where multiple small direct buried cables are buried in a common trench and do not exceed an overall width of 16 inches, install a single line marker.

2. Install line marker for every cable below grade, regardless of whether direct-buried, protected in conduit, or conduit in duct bank.

C. Wire/Cable Identification Bands:

1. General: Apply cable/conductor identification bands, including circuit number, on each wire/cable in each box/enclosure/cabinet where wires of more than one circuit or communication/signal system are present. Match identification with marking system used in panelboards, shop drawings, contract documents, and similar previously established identification for project's electrical work.

D. Operational Identification and Warning Plasticized Tags and Metal Signs and Plastic Signs:

1. General: Wherever reasonably required to ensure safe and efficient operation and maintenance of electrical systems, and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of

electrical facilities by unauthorized personnel, install signs with instruction or warnings. When signs are installed on switches, outlets, controls, devices and covers of electrical enclosures they may be self-adhesive vinyl or plastic. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for intended purposes.

2. Arc Flash Hazard warning signs per NEC 110.16.

3. Identification of Service Entrance available fault current at each service entrance per NEC 110.24.

E. Danger Signs:

1. General: In addition to installation of danger signs specified, indicated, and required by governing regulations and authorities, install appropriate danger signs at locations indicated and at locations subsequently identified by Installer of electrical work as constituting similar dangers for persons in or about Project.

2. XXXX Volts: Install danger signs (with actual circuit voltage) on all building doors, substations, switchgear, switchboards, panelboards switches, circuit breakers, etc., wherever it is possible (under any circumstances) for persons to come into contact with electrical voltages to ground greater than 277V.

3. Critical Switches/Controls: Install danger signs on switches and similar controls, regardless of whether concealed or locked up, where untimely or inadvertent operation (by anyone) could result in significant danger to persons or damage to or loss of property.

4. Provide the following danger sign on the equipment indicated:

   a. "Danger This Machine Starts Automatically" on all fire pumps, air compressors and emergency generators.

5. Provide the following danger signs on the doors leading to the equipment indicated:

   a. "Danger Hearing Protection Required" on all emergency generator room doors.

   b. "Danger: No Smoking, Matches or Open Flames" on all emergency generator room doors (, personnel doors opening into aircraft hangar,) and battery room doors.

F. Warning Signs:

1. Provide an orange background sign with black letters reading "WARNING: LOAD SIDE OF SWITCH MAY BE ENERGIZED BY BACKFEED" on all tie switches and tie circuit breakers.

2. Provide cable tray warning signs with 1-1/2-inch high black letters on an orange background that reads: "Warning! Not to be used as a walkway, ladder or

support for ladders for personnel." Provide on each side of cable tray at 10-foot intervals, visible from the floor below.

G. Caution Signs:

1. Provide yellow background caution signs with black letters on the doors leading to the equipment indicated:

    a. "Caution Ear Protection Required in this Area" on all emergency generator room doors.

2. Provide the following yellow background caution sign with black letters on all panelboards, substations, switches, circuit breakers, and switchboards where turning off a circuit will automatically start an emergency generator:

    a. "Caution Turning Off this Circuit will Automatically Start Emergency Generator XX"

3. Provide the following yellow background caution sign with black letters on all automatic transfer switches, switches, circuit breakers, equipment, and emergency panelboards that are energized by the emergency power system:

    a. "Caution Automatically Energized by the Emergency Power System."

H. Equipment/System Identification Nameplates:

1. General: Install engraved plastic-laminated nameplates on each major unit of electrical equipment in the building; including central or master unit of each electrical system including communication/control/signal/alarm systems, unless unit is specified with its own self-explanatory identification or signal system. Except as otherwise indicated, provide single line of text, 1/2-inch high lettering on 1-1/2-inch high sign (2 inches high were two lines are required), black lettering on white field. Provide text matching terminology and numbering of the contract documents and shop drawings. Nameplate shall include unit designation, normal source circuit number ("Fed from..."), circuit voltage, and other data specifically indicated. Nameplate shall indicate normal source circuit number ("Fed from..."), and emergency source circuit number ("Fed from..."), when the equipment is a transfer switch or fed directly from a transfer switch. Provide nameplates for each unit of the following categories of electrical work:

    a. Switchboards, panelboards, electrical cabinets, and enclosures. (Include main bus ampacity on the nameplate.)

    b. Major electrical switchgear (Include main bus ampacity on the nameplate.)

    c. Disconnect switch.

    d. Push buttons, selector switches, indicating lights. (Circuit number and voltage not required on nameplate).

    e. Power transfer equipment: Contactors and transfer switches.

f. Transformers (Include primary voltage, secondary voltage, number of phases, feeder, and panelboards or equipment supplied by the secondary.)

g. Power generating units.

h. Provide "EMERGENCY" conduit markers on all conduit and pullboxes that contain emergency power conductors.

i. Switchboard main switches and circuit breakers.

2. Install markers, tags, nameplates, and signs at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment. Secure the identification with fasteners, except use adhesive where fasteners should not or cannot penetrate surface.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section includes computer-based fault-current, arc flash hazard analysis, and overcurrent protective device coordination studies.

B. The study shall be provided for the electrical distribution system and include all power sources (normal and emergency) down to the branch circuit overcurrent protective device and equipment.

C. The study shall be performed for the power system supplying the Citico Pump Station and including all new distribution equipment and the main protective and feeder devices for the existing Citico Pump Station Switchboard, and the main devices for the CSO Treatment Facility and CSO Effluent Pump Station as supplied from the main switchgear specified in Section 26 23 00 – Low Voltage Switchgear.

1.03 Related Requirements

A. Section 26 05 53 – Identification for Electrical Systems.

B. Section 26 23 00 – Low Voltage Switchgear.

C. Section 26 24 13 – Switchboards.

D. Section 26 32 13 – Engine Generator Sets.

1.04 Reference Standards

A. The study shall be completed in accordance with the latest edition of the following standards:

1. IEEE Standard 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book).

2. IEEE 399 – Recommended Practice for Industrial and Commercial Power Systems Analysis (Brown Book).

B. The arc flash hazard analysis shall be completed in accordance with latest editions of the following standards:

1. IEEE Standard 1584 – Guide for Performing Arc-Flash Hazard Calculations.

2. NFPA70E – Standard for Electrical Safety Requirements for Employee Workplaces.

1.05 Performance/Design Criteria

A. The study shall calculate the available short-circuit current at each point in the electrical distribution system. The overcurrent protective devices shall have an interrupting rating equal to or greater than the available short-circuit current at the point of application.

B. The study shall examine proper protection of electrical system components and utilization equipment such that the equipment has a sufficient short-circuit current rating.

C. The overcurrent protective devices shall be analyzed for selective coordination. This analysis shall identify any potential selective coordination problems up to the available short-circuit current. Any areas where the overcurrent protective devices are not selectively coordinated shall be explicitly noted and recommendations shall be made to achieve selective coordination.

D. The study shall include an arc flash hazard analysis for electrical distribution equipment. The analysis shall determine the flash protection boundary, incident energy, and required level of personal protective equipment (PPE) for workers at the electrical distribution equipment. The electrical distribution equipment shall be labeled with this information in accordance with codes and standards.

1.06 Submittals

A. Submit as specified in Division 01.

B. Product Data: Submit computer analysis software to be used for the specified studies.

C. The results of the studies shall be summarized in report format with explanation of how to interpret the data.

D. As a minimum the report shall include the following:

1. Short Circuit Study:

    a. A printout of input data, calculated results and an explanation of how to interpret the data.

    b. A one-line diagram identifying all bus locations and the maximum available three-phase and line-to-ground short-circuit currents at each bus.

    c. A bus-to-bus listing of the maximum available short-circuit current expressed in RMS symmetrical amperes and the X over R ratio of that fault current.

    d. A table of specified equipment short-circuit ratings versus calculated short-circuit current values with notations of locations where are specified equipment short-circuit ratings are less or greater than required at the point of application.

e. An analysis of the results in which any overrating or inadequacies shall be called to the attention of the Engineer and recommendations made for improvements.

2. Protective Device Coordination Study:

    a. Time-current characteristic curve drawings on log-log printouts which illustrate:

        (1) The recommended settings for all adjustable relays, overcurrent protective devices and ground fault protective devices provided for the project.

        (2) The key or limiting overcurrent device characteristics, load characteristics, and protection requirements affecting the settings or ratings of the overcurrent protective devices supplied.

        (3) The degree of selective coordination achieved with the overcurrent protective devices supplied.

    b. A tabulation of the recommended settings for all adjustable relays, overcurrent protective devices and ground fault protective devices and type selections for fuse protective devices supplied.

    c. An analysis of the results in which any inadequacies related to selective coordination shall be called to the attention of the Engineer with recommendations for improved coordination.

3. Arc Flash Hazard Analysis Study:

    a. The following for each piece of switchgear, switchboard, motor control center, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker, disconnect switch, and equipment control panel installed on the project:

        (1) Minimum Arc Fault Current, Arc Flash Boundary and Arc Fault Incident Energy Level (cal/cm2).

        (2) Risk of personnel injury as a result of exposure to incident energy released during an arc flash event.

        (3) Appropriate ratings of personal protective equipment (PPE).

        (4) The Flash Protection Boundary (approach limit distance).

        (5) Information for equipment specific arc-flash hazard warning labels.

    b. Recommendations and methods to mitigate the hazard risk, where applicable, in order to reduce PPE requirements.

4. Cut sheets and submittal information on the Arc Flash warning labels being provided. Coordinate with Section 26 05 53 – Identification for Electrical Systems.

1.07 Quality Assurance

A. The company and individual(s) performing the study shall have a minimum 5 years documented experience in power system analysis and completed projects of similar size and scope. The individual(s) performing the study shall be a registered Professional Engineer in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of Engineer.

B. The company performing the study shall have the capability and experience to provide assistance during system start up.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

D. Comply with IEEE 399 for general study procedures.

E. Comply with IEEE 1584 or NFPA 70E for arc flash hazard analysis.

1.08 Sequencing and Scheduling

A. The selection of the company and the individual performing the study shall be submitted and approved by the design Engineer prior to the start of the study.

B. The study shall be completed and submitted and approved prior to the facility startup.

PART 2 - Products

2.01 General

A. The short circuit, protective device coordination, and flash hazard analysis study shall be completed with the aid of a computer software program such as SKM Power Tools.

B. The Contractor shall provide all lengths of cable for use in the studies.

C. All equipment ratings, make, and model information shall be obtained by the Contractor from the equipment manufacturers and/or suppliers and provided for use in the studies.

D. Information on the electrical service including available fault current, transformer impedance, primary fuse ratings, primary cable size, and any other required information shall be obtained from the local utility for inclusion in the studies.

E. The study shall be inclusive of the entire electrical distribution system from all power sources (normal and emergency) down to the branch circuit overcurrent protective device and equipment.

F. Separate calculations shall be performed for both the normal and emergency sources. Device settings shall be based upon the normal source study.

G. The Arc Flash Study shall be based on the study that results in the highest incident energy.

2.02 Short Circuit Coordination Study

A. The short circuit study shall as minimum include the following:

1. A schematic one-line drawing of the entire electrical system included in the study, from the power company system including the point of delivery, to each primary transformer, and including all main secondary buses of each transformer included in the study. Secondary buses shall include multiple secondary transformations within the scope of the study. Each device shall be identified using project assigned identification labels. Each motor 10 hp and larger shall be shown and identified. Each bus shall be assigned an identification number.

2. Source voltage and impedance data shall be given in the analysis, including reactance and resistance in OHMS to the source, and available symmetrical and asymmetrical short circuit amperes at the point of delivery of electrical power. Short circuit amperes shall be based on an assumed bolted three-phase and line-to-ground short circuits.

3. At each bus, including buses of all primary protective and switching devices, primary and secondary of all transformers, all secondary main and feeder breakers, and all secondary devices and panelboards within the scope of the study, the following shall be calculated:

    a. Symmetrical RMS short circuit amperes, calculated using total source and motor contribution reactance and resistance values.

    b. Asymmetrical average 3 phase RMS amperes at 1/2 cycle, calculated using actual total source and motor contribution X/R ratio.

    c. Reactance ("X") and Resistance ("R") in OHMS at the voltage of the device being examined, including both The Power Company source and all motor contributions.

4. Calculation sheets for cable sections shall indicate voltage, wire size, cable length, reactance and resistance of the section in OHMS and total "X" and "R" to the source.

5. Calculation sheets for transformer sections shall indicate transformer kVA, secondary voltage, percent impedance, percent reactance, percent resistance, and total "X" and "R" value in OHMS at the secondary voltage to source, including The Power Company source impedance plus any primary motor contribution.

6. Calculation sheets for busway and miscellaneous devices shall provide all pertinent parameters including operating voltage, section "X" and "R" values in

OHMS, and total "X" and "R" values in OHMS to the source, based on source impedance plus any motor contribution.

7. Bus summary sheets shall be provided giving consecutive bus numbers, description, voltage, "X" and "R" values in OHMS including The Power Company plus all motor contributions, symmetrical and asymmetrical short circuit amperes, X/R ration, and asymmetrical factor.

8. Motor summary sheets shall provide motor description and all pertinent motor data including subtransient reactance for each motor 10 hp and larger. Symmetrical short circuit amperes shall be given for each motor at the motor terminals.

2.03 Protective Device Coordination Study

A. The protective device coordination study shall as a minimum include the following:

1. Time-current coordination plots shall be made on log-log software generated plots and shall graphically indicate the coordination proposed for all of the key systems. The plots shall include complete titles, one-line diagram and legend.

2. The Power Company's relay, fuse, or protective device shall be plotted with all load protective devices at the same voltage.

3. Transformer primary protective device, transformer magnetic inrush, transformer ANSI withstand points, secondary voltage fuse or circuit breaker and largest feeder fuse or circuit breaker shall be plotted at the secondary voltage. Circuit breaker curves shall include complete operating bands, terminating with the appropriate available short circuit current. Fuse curves shall be identified as either total clearing time or damage time as applicable.

4. Low voltage circuit breakers shall have instantaneous, short delay, long-time pick-up and ground fault trip settings and ground fault ampere and time delay settings identified as plotted. Sensor or monitor rating shall be stated for each circuit breaker. All regions of the circuit breaker curve shall be identified.

5. The coordination plots shall include significant motor starting characteristics and large motor protective devices.

6. Feeder circuit breakers shall have the time-damage curve of the feeder conductors plotted to indicate protection of the conductor insulation at the total clearing time of the circuit breaker or fuse. The time-damage point shall be calculated for the specific parameters of conductor insulation used, with average 3 phase RMS asymmetrical amperes as 1/2 cycle calculated using actual resistance and reactance values of the source plus all motor contributions which exist at the load end of the feeder conductors.

7. A determination of settings or ratings for the overcurrent and ground fault protective devices supplied. Where necessary, an appropriate compromise shall be made between selective coordination and service continuity with selective coordination considered more important than system service continuity. The

time-current coordination analysis shall be performed with the aid appropriate software.

8. A summary tabulation shall be provided listing manufacturer and type for all overcurrent protective devices and all recommended settings of each adjustable band included in each device.

9. Settings of protective devices shall minimize the arc flash hazard while maintaining selective coordination.

2.04 Arc Flash Hazard Analysis Study

A. The arc flash hazard analysis study shall as minimum include the following:

1. Calculate incident energy levels and flash protection boundaries at all relevant equipment busses based on available short-circuit current, protective device clearing time and other applicable one-line diagram information.

2. As a minimum, the following shall be calculated for each piece of switchgear, switchboard, motor control center, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker, disconnect switch, and equipment control panel to be installed on the project:

   a. Minimum Arc Fault Current, Arc Flash Boundary and Arc Fault Rating (cal/cm2).

   b. Risk of personnel injury as a result of exposure to incident energy released during an arc flash event.

   c. The appropriate ratings of personal protective equipment (PPE).

   d. The Flash Protection Boundary (approach limit distance) as required by NFPA 70E.

3. Provide equipment specific arc-flash hazard warning label requirements per NEC Section 110.16, including all information specified to be provided on individual equipment warning labels.

4. Provide recommendations and incorporate with the protective coordination study methods to mitigate the hazard risk, where applicable, in order to reduce PPE requirements.

PART 3 - Execution

3.01 Examination

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are as indicated on Drawings.

B. Proceed with coordination study only after relevant equipment submittals have been approved and assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.02 Protective Device Selection and Settings

A. Prior to project Substantial Completion, the Contractor shall set all relays, overcurrent devices and ground fault protection devices and confirm selection of fuse overcurrent devices as follows:

1. Relays: Reset all adjustable relay settings from the factory default settings to the settings recommended in the studies specified in this Section.

2. Circuit Breakers and Motor Circuit Protectors: Reset all adjustable trip settings from the factory default settings to the settings recommended in the studies specified in this Section.

3. Ground Fault Protection Devices: Reset all adjustable device settings from the factory default settings to the settings recommended in the studies specified in this Section.

4. Fuses: Confirm that fuse types installed on the project are as recommended in the studies specified in this Section.

B. Certification: Prior to project Substantial Completion, the Contractor shall submit a document certifying that the Contractor has completed the settings and selection scope specified to the Engineer.

3.03 Installation

A. Install arc flash and available fault current labels on equipment as specified in Section 26 05 53 – Identification for Electrical Systems.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section specifies transformer work as indicated by Drawings and Schedules.

B. Types of transformers specified in this Section include the following:

   1. Dry-type transformers.

1.03 Related Requirements

A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cable.

B. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

C. Section 26 05 53 – Electrical Identification.

1.04 Reference Standards

A. Code of Federal Regulations (CFR):

   1. 10 CRF Part 429 – Certification, Compliance, and Enforcement for Consumer Products and Commercial and Industrial Equipment.

      a. 429.47 – Distribution Transformers.

   2. 10 CFR Part 431 – Energy Efficiency program For Certain Commercial and Industrial Equipment, Subpart K – Distribution Transformers.

      a. 431.193 – Test procedures for measuring energy consumption of distribution transformers.

      b. 431.196 – Energy Conservation Standards.

B. Institute of Electrical and Electronics Engineers (IEEE):

   1. IEEE C2 – National Electric Safety Code.

   2. IEEE C57.12.01 – General Requirements for Dry-Type Distribution and Power Transformers.

3. IEEE C57.12.50 - Requirements for Ventilated Dry-Type Distribution Transformers 1 to 500 kVA, Single-Phase, and 15 to 500 kVA, Three-Phase with High-Voltage 601 to 34,500V, Low Voltage 120-600V.

4. IEEE C57.12.91 - Test Code for Dry-Type Distribution and Power Transformers.

C. National Electrical Manufacturers Association (NEMA):

1. NEMA ST 20 - Dry-type Transformers for General Applications.

2. NEMA TR 1 - Transformers, Regulators, and Reactors. (Supplements IEEE C57 - Series Standards.)

3. NEMA 250 - Enclosures for Electrical Equipment.

D. National Fire Protection Association (NFPA):

1. NFPA 70 - National Electrical Code (NEC). Comply with NEC as applicable to installation and construction of electrical power/distribution transformers.

E. Underwriters Laboratories (UL):

1. Comply with applicable requirements of UL 506 Safety Standard for Specialty Transformers. Provide transformers and components which are UL-listed and labeled.

2. UL 1561 - Large General Purpose Transformers.

1.05 Submittals

A. Refer to Division 01 and Section 26 05 10 – Basic Electrical Requirements - for administrative and procedural requirements for submittals.

B. Product Data: Submit for each type of product specified and included, with the following as a minimum:

1. Technical product data: Includes, but not limited to, rated kVA, frequency, primary and secondary voltages, wiring diagram, percent taps, polarity, impedance and certification of transformer performance efficiency at 100% load, percentage voltage regulation at 100% load at 75ºC, full-load losses in watts, percent impedance at 75ºC, hot-spot and average temperature rise above 40ºC ambient temperature, sound level in decibels, and standard published data.

C. Shop Drawings: Submit the following as a minimum:

1. Manufacturer's drawings indicating dimensions and weight loadings for transformers and wall brackets.

2. Transformer nameplate data.

3. Wiring Diagrams: Submit wiring and control diagrams for transformers. Clearly differentiate between portions of wiring that are manufacturer factory installed and portions to be field-installed.

D. Submit all field test data.

E. Closeout Submittals: Final documentation shall include:

1. Operation and Maintenance manuals.

2. Certified “As-Built” drawings.

3. Copies of all approved Product Data.

4. Copies of all approved Test Reports.

5. Warranty information.

1.06 Quality Assurance

A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with IEEE C2, National Electric Safety Code.

D. Comply with IEEE C57.12.91, Test Code for Dry-Type Distribution and Power Transformers.

E. Testing procedures shall comply with 10 CFR 429.47 – Distribution Transformers and 10 CFR 431.193 – Test procedures for measuring energy consumption of distribution transformers.

1.07 Delivery, Storage, and Handling

A. Transformers shall be stored according to the manufacturer’s instructions and in a conditioned space to avoid condensation, dust, and other environmental contaminants.

B. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.08 Warranty

A. All equipment furnished under this Section shall be warranted by the Contractor and the equipment manufacturer(s) for a minimum period of one year[s] after the date of Equipment start-up or as specified in Section 01 43 33.

B. Warranty shall include all parts, labor, and expenses to perform necessary work.

1.09 Coordination

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - Products

2.01 Manufacturers

C. Subject to compliance with requirements, provide products of one of the following (for each type of transformer):

1. Eaton.
2. General Electric Company.
3. Sola/Hevi-Duty.
4. Siemens Energy and Automation.
5. Square D, Schneider Electric.

1.01 Transformers

A. General:

1. Except as otherwise specified or indicated, provide manufacturer's standard materials and components as indicated by published product information, designed and constructed as recommended by manufacturer, and as required for complete installation.

2. Comply with DOE energy efficiency standards as defined by 10 CFR Part 431.196 – Energy Conservation Standards for all transformers 15 kVA and larger.

3. Core material shall be grain-oriented, non-aging silicon steel. Coils shall be continuous windings without splices except for taps. Internal coil connections shall be brazed or pressure type.

4. Comply with NEMA 250 – Enclosures for Electrical Equipment.

B. Dry-Type Transformers (45 kVA or less):

1. Factory-assembled and tested, general-purpose, air-cooled, dry-type transformers; of sizes, characteristics, and rated capacities indicated.

2. Three-phase transformer:

   a. 480V delta connected primary and 208/120V wye-connected secondary with grounded neutral, 60-hertz, 30 kV BIL.

   b. Aluminum primary and secondary windings. Manufacturer’s standard impedance.

   c. Provide primary winding with 4 full-capacity taps; two 2-1/2% increments below and above full-rated voltage for de-energized tap-changing operation.

   d. Insulate with 220ºC, UL-component-recognized insulation system with a maximum of 115ºC rise above 40ºC ambient temperature.

   e. Rate transformer for continuous operation at rated kVA.

   f. Limit transformer surface temperature rise to maximum of 65ºC.

   g. Provide terminal enclosure, with cover, to accommodate primary and secondary winding connections and raceway connectors.

   h. Equip terminal leads with connectors installed. Limit terminal compartment temperature to 75ºC when transformer is operating continuously at rated load with ambient temperature of 40ºC. Provide wiring connectors suitable for copper wiring.

   i. Cushion-mount transformers with external vibration isolation supports.

   j. Sound-level ratings shall not exceed IEEE/NEMA standards. Conform to NEMA ST 20.

   k. Electrically ground core and coils to transformer enclosure by means of flexible metal grounding strap.

   l. Provide transformers with ventilated or fully enclosed sheet steel enclosures. Apply manufacturer's standard light gray indoor enamel over cleaned and phosphatized steel enclosure.

   m. Provide wall mounting brackets for wall- or column-mounted transformers.

3. Must comply with IEEE C57.12.01 and/or IEEE C57.12.50.
4. Must comply with UL 1561.

C. Equipment/System Identification: Provide equipment/system identification nameplates complying with Section 26 05 53 – "Identification for Electrical Systems."

D. Finishes: Coat interior and exterior surfaces of transformer, including bolted joints, with manufacturer's standard color baked-on enamel.

PART 3 - Execution

3.01 Examination

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 26 05 26 – Grounding and Bonding for Electrical Systems have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

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

3.02 Installation

A. Install transformers as indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NESC, NEMA, and IEEE standards in accordance with recognized industry practices to ensure that products fulfill requirements. Arrange equipment to provide adequate space for access and for cooling air circulation.

B. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A.

C. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer. Wall brackets shall meet the environmental requirements of the transformer installation for each location.

D. Construct concrete bases and anchor floor-mounted transformers according to manufacturer's written instructions.

3.03 Connections

A. Provide equipment grounding connections for transformers as specified, indicated, and as required. Tighten connections to comply with tightening torques specified in UL 486A to assure permanent and effective grounding. Provide grounding in accordance with Section 26 05 26 – "Grounding and Bonding for Electrical Systems."

3.04 Identification

A. Provide identification of transformers as specified in Section 26 05 53 – Electrical Identification.

B. Nameplates: Label each transformer with a nameplate complying with requirements for identification specified in Section 26 05 53 – Electrical Identification.

3.05 Field Quality Control

A. Tests and Inspections:

1. Prior to energization of transformers, check all accessible connections for compliance with manufacturer's torque tightening specifications. Clean out any dust and dirt.

2. Prior to energization, check circuitry for electrical continuity and for short circuits.

3. Perform insulation resistance test: Megger between high-voltage winding to low-voltage winding, low-voltage winding to ground, and high-voltage winding to ground. Record and submit test results. If readings are below 50 megohms (at 77°F), notify Engineer before energizing transformer.

4. Perform transformer turns ratio test (TTR) on the full winding and all taps. Record and submit test results.

5. Check cooling fans and controls, where provided, for proper operation.

6. Upon completion of installation of transformers and testing, energize primary circuitry at rated voltage and frequency from normal power source, and test transformers, including, but not limited to, audible sound levels, to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at the Site then retest to demonstrate compliance; otherwise, remove and replace with new units or components and proceed with retesting.

7. Adjust transformer primary taps for nominal system voltage at initial installation and again when the transformer reaches its designed "full" load condition after occupancy by the Owner. Schedule all required electrical outages with the Owner.

3.06 Finishes

A. Equipment coatings shall be free from scratches, rust, or other defects.

B. All damaged or defective coatings shall be repaired prior to final acceptance.

C. Field Painting:

1. Touch Up:

   a. Contractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.

   b. Field painting shall be performed based on manufacturer’s recommended procedures.

   c. Transformer manufacturer shall furnish Contractor with an adequate quantity of touch-up paint to match the factory applied finish.

3.07 Adjusting and Cleaning

A. Upon completion of installation, clean interior and exterior of transformers. Remove paint splatters, spots, dirt and debris.

3.08 Protection

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until unit is placed into service.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section includes metal-enclosed, low-voltage power circuit-breaker switchgear rated 1,000V and less for use in AC systems.

1.03 Reference Standards

A. American National Standards Institute (ANSI):

1. C37.13 - Low-Voltage AC Power Circuit Breakers Used in Enclosures.
2. IEEE C37.16 - Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage AC (635V and below) and DC (3200V and below) Power Circuit Breakers.
3. IEEE C37.17 - Trip Systems for Low-Voltage (1000V and below) AC and General Purpose (1500V and below) DC Power Circuit Breakers.
4. C37.20.1 - Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.
5. C37.35 - Application, Installation, Operation, and Maintenance of High-Voltage Air Disconnecting and Load Interrupter Switches.
6. C39.1 - Requirement for Electrical Analog Indicating Instruments.
7. C37.90- Relays and Relay Systems Associated with Electric Power Apparatus.
8. IEEE C37.100 - Standard Definitions for Power Switchgear.
9. C57.13 - Standard for Requirements for Instrument Transformers.
10. C62.11 - Metal-Oxide Surge Arresters for Alternating Current Power Circuits.

B. American Society for Testing and Materials (ASTM):

1. D877 - Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
2. D923 - Method for Sampling Electrical Insulating Liquids.

C. Institute of Electrical and Electronic Engineers (IEEE):

1. IEEE C2 - National Safety Code.
2. 141 - Recommended Practice for Electric Power Distribution for Industrial Plants.
3. 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
4. 241 - Recommended Practice for Electric Power Systems in Commercial Buildings.

D. National Electrical Manufacturers' Association (NEMA):

1. FU 1 - Low Voltage Cartridge Fuses.
2. NEMA C37.50 - Switchgear - Low Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures.
3. LA 1 - Surge Arresters.
4. NEMA SG 5 - Power Switchgear Assemblies.

E. National Fire Protection Association (NFPA):

1. NFPA 70 - National Electrical Code (NEC).
2. NFPA 70E – Standard for Electrical Safety in the Workplace.

F. National Electrical Contractors Association (NECA):

1. 400-98 - Recommended Practice for Installing and Maintaining Switchboards.

G. National Electrical Testing Association (NETA):

1. ATS-1999 - Acceptance Testing Specifications for Electrical Power Distribution Equipment.

H. Underwriters Laboratories (UL): Provide equipment and components which are UL - listed and labeled.

1. UL 467 - Grounding and Bonding Equipment.
2. UL 489 - Molded-Case Circuit-Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
3. UL 512 - Standard for Fuseholders.
4. UL 1558 - Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear.

1.04 Definitions

A. ATS: Acceptance testing service.

B. GFCI: Ground-fault circuit interrupter.

1.05 Submittals

A. Product Data: For each type of switchgear, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each type of switchgear and related equipment.

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:

    a. Tabulation of installed devices with features and ratings.

    b. Enclosure types and details.

    c. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.

    d. Bus configuration with size and number of conductors in each bus run, including phase, neutral, and ground conductors of main and branch buses.

    e. Current rating of buses.

    f. Short-time and short-circuit current rating of switchgear assembly.

    g. Nameplate legends.

    h. Mimic-bus diagram.

    i. UL listing for series rating of installed devices.

    j. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Power, signal, and control wiring.

    a. One-line diagram.

    b. AC three-line diagram.

    a. Wiring diagrams, including external connections terminals. Separate schematic and wiring drawings shall be submitted for each breaker. "Typical" drawings covering several breakers will not be acceptable.

2. Transfer Control System:

    a. Wiring diagram.

b. System control descriptions.

c. Electronic copy of software development after testing and acceptance.

C. Instrument transformer performance curves and data.

D. Protective device coordination curves on full-size (9-1/2 inch by 11-1/16 inch) log-log graph paper (similar to K&E No. 48-5258).

E. Communications protocol information for all data communication devices and systems.

F. Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.

G. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear. Show support locations, type of support, and weight on each support. Indicate field measurements.

H. Field quality-control test reports.

I. Updated mimic-bus diagram reflecting field changes after final switchgear load connections have been made, for record.

J. Operation and Maintenance Data: For switchgear and components to include in emergency, operation, and maintenance manuals. In addition to items specified in DIVISION 01, Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.06 Maintenance Material Submittals

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Six of each type and rating used. Include spares for potential transformer fuses, control power fuses, and fuses and fusible devices for fused circuit breakers.

2. Indicating Lights: Six of each type installed.

3. Touchup Paint: 3 containers of paint matching enclosure finish, each 0.5 pint (250 mL).

1.07 Quality Assurance

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain switchgear through one source from a single manufacturer.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on manufacturer’s preliminary layout. Contractor shall provide switchgear that meets space allocation indicated and available based on project conditions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NFPA 70.

1.08 Delivery, Storage, and Handling

A. Deliver switchgear in sections of length, width and height that can be moved past obstructions in delivery path. All necessary hardware for reconnecting shipping splits shall be provided.

B. If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

1.09 Project Conditions

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Owner no fewer than five days in advance of proposed interruption of electric service.

2. Do not proceed with interruption of electric service without Owner's written permission.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear, and adjacent surfaces and other items. Comply with indicated maximum dimensions. Furnish equipment with shipping splits that will enable movement of equipment into interior space of existing facility without structural modifications to the existing facility.

C. Do not install the switchgear equipment specified herein until designated installation spaces are suitable for intended service.

D. Final or temporary HVAC systems shall be in place and operational to maintain the ambient temperatures and humidity conditions at occupancy levels prior to energizing the switchboard and shall be maintained for the remainder of the construction period.

E. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not exceeding 40ºC.
2. Altitude: Not exceeding 6,600 feet (2,010 m).

1.10 Coordination

A. Coordinate layout and installation of switchgear and components with other construction. Maintain required clearances for workspace and equipment access doors and panels.

B. Coordinate size and location of openings through concrete vault slab. Concrete, reinforcement, and formwork requirements are specified in DIVISION 03.

PART 2 - Products

2.01 Manufacturers

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB Inc.
2. Cutler-Hammer, Inc.; Eaton Corporation.
3. General Electric Company.
4. Siemens Energy & Automation, Inc.
5. Square D; Schneider Electric.

2.02 Ratings

A. Nominal System Voltage: 480V, 3 wire, 60 Hz.

B. Main-Bus Continuous: 3,200 A or as indicated.

C. Short-Time and Short-Circuit Current: Match rating of highest-rated circuit breaker in switchgear assembly.

2.03 Fabrication

A. Factory assembled and tested and complying with IEEE C37.20.1.

B. Enclosure Material: Steel.

C. Switchgear shall accommodate bottom entry for all incoming and feeder circuit cables and conduits.

D. Outdoor Enclosure Material: Galvanized steel.

E. Outdoor Enclosure Fabrication Requirements: Weatherproof; integral structural-steel base frame with factory-applied asphaltic undercoating; and each compartment equipped with the following features:

1. Structural design and anchorage adequate to resist loads imposed by 120-mph wind.
2. Space heater operating at one-half or less of rated voltage, sized to prevent condensation.
3. Louvers equipped with insect and rodent screen and filter; arranged to permit air circulation while excluding insects, rodents, and exterior dust.
4. Common internal aisle of sufficient width to permit protective-device withdrawal, disassembly, and servicing in aisle.
5. Aisle access doors with outside padlocking provisions and interior panic latches.
6. Aisle space heaters operating at one-half or less of rated voltage, thermostatically controlled.
7. Vaporproof LED aisle lights, controlled by wall switch at each entrance.
8. GFCI duplex receptacles, a minimum of two, located in aisle.

F. Aisle ventilation louvers equipped with insect and rodent screen and filter and arranged to permit air circulation while excluding insects, rodents, and exterior dust.Finish: IEEE C37.20.1, manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.

G. Section barriers between main and tie circuit-breaker compartments shall be extended to rear of section.

H. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.

I. Circuit-breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors. All breaker compartments, including those indicated as equipped spaces, shall be complete with rails, guides, interlocks, primary and secondary disconnecting devices, and all other features as required for installation of a breaker to serve a circuit by connection of power cables to rear load terminals and connection of control cables to terminal blocks.

J. Fabricate enclosure with removable, hinged rear cover panels to allow access to rear interior of switchgear.

K. Auxiliary Compartments: Match and align with basic switchgear assembly. Include the following:

1. Bus transition sections.
2. Hinged front panels for access to metering, accessory, and blank compartments.

L. Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.

1. Main Phase Bus: Uniform capacity the entire length of assembly.
2. Neutral Pad: 100 % of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for service neutral and bonding conductors.
3. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
4. Phase-bus and Neutral-pad Material: Hard-drawn copper of 98% minimum conductivity, with copper feeder circuit-breaker line connections.
5. Use copper for connecting circuit-breaker line to copper bus.
6. Contact Surfaces of Buses: Tin plated.
7. Feeder Circuit-Breaker Load Terminals: Tin-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
8. Ground Bus: Hard-drawn copper of 98% minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4 by 2 inches.
9. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.
10. Provide for future extensions from either end of main phase and ground bus by means of predrilled bolt-holes and connecting links.
11. Bus-Bar Insulation:
    a. Individual bus bars wrapped with factory-applied, flame-retardant insulation.

b. Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

2.04 Components

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary-voltage rating of 120V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.

2. Current Transformers: Ratios as indicated; burden and accuracy class suitable for connected relays, meters, and instruments.

B. Multifunction Digital-Metering Monitor: UL-listed or -recognized, microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600V.

2. Switch-selectable digital display of the following:

a. Phase Currents, Each Phase: ±1%.

b. Phase-to-Phase Voltages, Three Phase: ±1%.

c. Phase-to-Neutral Voltages, Three Phase: ±1%.

d. Three-Phase Real Power: ±2%.

e. Three-Phase Reactive Power: ±2%.

f. Power Factor: ±2%.

g. Frequency: ±0.5%.

h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: ±2%.

i. Accumulated energy, in megawatt hours (joules), ±2%; stored values unaffected by power outages for up to 72 hours.

3. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

D. Surge Arresters: Distribution class, metal-oxide-varistor type. Comply with IEEE C62.11 and NEMA LA 1.

1. Install in cable termination compartments and connect in each phase of circuit.

2. Coordinate rating with circuit voltage.

E. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

F. Control Power Supply: Control power transformer supplying 120V control circuits through secondary disconnect devices. Include the following features:

1. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.

2. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.

   a. Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.

3. Control Power Fuses: Primary and secondary fuses with current-limiting and overload protection.

G. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.

2. Conductors sized according to NFPA 70 for duty required.

2.05 Circuit Breakers

A. Description: Comply with IEEE C37.13.

B. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.

C. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

1. Normal Closing Speed: Independent of both control and operator.

2. Stored-Energy Mechanism: Electrically charged, with optional manual charging.

3. Operation counter.

D. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features.

1. Functions: Long-time-delay, short-time-delay, instantaneous, and ground fault-trip functions, independent of each other in both action and adjustment.

2. Temperature Compensation: Ensures accuracy and calibration stability from -5 to +40ºC.

3. Field-adjustable, time-current characteristics.

4. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.

5. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."

6. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I^2t operation.

7. Pickup Points: Five minimum, for instantaneous-trip functions.

8. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:

    a. Three-wire circuit or system.

9. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.

E. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two Type "a" and two Type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.

F. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions without opening the door. Include the following features:

1. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.

2. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:

    a. Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.

    b. Disconnected Position: Primary and secondary devices and ground contact disengaged.

G. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.

H. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.

I. Operating Handle: One for each circuit breaker capable of manual operation.

J. Electric Close Button: One for each electrically operated circuit breaker.

K. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.

L. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

M. Provide arc reduction maintenance mode switch on all main breakers and feeders to comply with NEC.

N. Provide remote racking for breakers and 120V remote racking device.

2.06 Automatic Transfer Controls

A. An automatic transfer system shall be provided in the switchgear assembly and serve as the main transfer control system for the incoming utility services and the emergency stand-by generator service.

B. Features:

1. The transfer control system shall consist of a programmable logic controller and a touchscreen operator interface panel mounted on the face of the switchgear. Control power for all transfer operations shall be derived from the line side of the source to which the load is being transferred.

2. The transfer control system shall provide for positive interlocks both mechanically and electrically to prevent simultaneous closing of both sources under either automatic or manual operation. Main contacts shall be mechanically locked in position in both normal and positions.

3. The transfer control system shall be capable of being operated manually under full rated load conditions. Manual operation shall be accomplished by touchscreen operation on an operator interface, and by integrally mounted selector switches and/or pushbuttons. Removable manual operating handles, and handles that may move in the event of an electrical operation during the manual operation, are not acceptable. Manual operators requiring source or load disconnection prior to manual operation are not acceptable.

4. Indicators shall be provided to show the availability of each source as well as breakers in a tripped or disconnected position.

5. Normal operation will be with the primary utility main breaker closed, and the generator and secondary utility main breaker open. The tie breaker will be normally closed and will only be opened manually for maintenance purposes. A status contact off the tie breaker shall be wired to the controller. Whenever the tie breaker is open, the controller shall inhibit the automatic transfer between sources in auto mode. The transfer system must be placed in manual mode before the tie breaker is allowed to be opened.

6. The transfer system shall be controlled by a microprocessor-based controller. The controller shall be hardened against potential problems from transients and surges. Operation of the transfer system, monitoring of all sources, and input and output functions shall be managed by the controller.

C. Microprocessor-based Controller:

1. The microprocessor-based logic controller shall be mounted in the switchgear and the touchscreen interface shall provide the operator with an overview of the transfer system status, system parameters, and diagnostic data. The controller shall have a voltage range of 0-790V (50/60 Hertz) and an accuracy of ±.3 Hertz. Control power input range shall be from 65Vac - 145Vac rms 50/60 Hertz.

2. The microprocessor-based controller shall include a touchscreen LCD display for operator interface, and shall display the follow:

   a. Line-to-line voltages for each source and the load.

   b. Line frequency for each source.

   c. Timer countdown for each time while functioning.

   d. Real-time clock.

   e. Set points.

   f. Transfer system status

3. The microprocessor-based controller shall include individual LEDs or touchscreen indicating the following:

   a. Primary main circuit breaker status.

   b. Secondary main circuit breaker status.

   c. Generator main circuit breaker status.

   d. Tie breaker status.

D. The microprocessor-based controller shall contain the following features:

1. Password programming protection.

2. Set points shall be stored in Non-Volatile memory, and the use of an external battery source to maintain operation during "dead" periods shall not be required.

3. Provision shall be made for manual transfer capabilities in the event of a touchscreen or LCD display failure.

4. The voltage of each phase of the primary source, the secondary source, and the generator source shall be monitored, with undervoltage dropout adjustable from 50% to 97% of nominal and pickup adjustable from dropout setting ±2% to 99% of nominal.

5. The voltage of each phase of the sources shall be monitored, with overvoltage dropout adjustable from 105% to 120% of nominal and pickup adjustable from dropout setting +2% to 103% of nominal.

6. The frequency of the sources shall be monitored, with underfrequency dropout adjustable from 90% to 97% of nominal and pickup adjustable from dropout setting +1 Hertz to 99% of nominal.

7. The frequency of the sources shall be monitored, with overfrequency dropout adjustable from 103% to 110% of nominal and pickup adjustable from dropout setting +1 Hertz to 101% of nominal.

8. A time delay shall be provided to override a momentary power outage or voltage fluctuation, adjustable from 0 to 120 seconds.

9. A time delay shall be provided on transfer from primary utility source to generator source, adjustable from 1 to 1800 seconds.

10. A time delay shall be provided on retransfer from generator source to primary source, adjustable from 0 to 1800 seconds. This time delay shall be bypassed if generator source fails and primary source is available.

11. The secondary utility main breaker shall initially be excluded from automatic or manual transfer control, however, wiring interface shall be provided and programming provisions shall be available to enable future control of the secondary source by the transfer control system.

12. A time delay shall be provided for the neutral position, adjustable from 0 to 120 seconds.

13. All delays shall be field adjustable from the operator touchscreen interface without the use of special software or tools.

14. Pre-transfer signal, range 0-120 seconds.

15. Transfer exerciser, selectable - disabled, daily, or 7, 14, 28 day interval, 0-600 minutes. Shall be operator programmable.

16. Retransfer mode - manual or automatic.

17. Test pushbutton mode - disabled or enabled.

E. The microprocessor-based controller shall be able to communicate on an Ethernet/IP network. The microprocessor controller shall function as indicated on drawings and be able to communicate the following signals to and from a remote PLC through the local area network.

   1. Loss of primary utility source.
   2. Transfer system fail.
   3. Primary main circuit breaker is closed.
   4. Secondary main circuit breaker is open.
   5. Generator main circuit breaker is open.
   6. Tie breaker is closed.

2.07 Accessories

A. Accessory Set: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

   1. Racking handle to manually move circuit breaker between connected and disconnected positions.
   2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
   3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.

B. Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.

C. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

2.08 Identification

A. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.

   1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
   2. Medium: Painted graphics, as selected by Architect.

3. Color: Contrasting with factory-finish background; as selected by Architect from manufacturer's full range.

B. Operational Description: Provide type-written instructions and sequences for transferring from normal to generator and from generator back to normal. Provide laminated hard copy for attachment to the front of the switchgear and electronic version submitted with instruction manuals.

C. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads. Include as-built data for low-voltage power switchgear and connections as follows:

1. Frame size of each circuit breaker.

2. Trip rating for each circuit breaker.

PART 3 - Execution

3.01 Examination

A. Examine elements and surfaces where switchgear will be installed for compliance with installation tolerances, required clearances, and other conditions affecting performance.

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

3.02 Installation

A. Comply with applicable portions of NECA 400 and NEMA PB 2.1.

B. Anchor switchgear assembly to 4-inch, channel-iron floor sill embedded in concrete base and attach by bolting.

1. Sills: Select to suit switchgear; level and grout flush into concrete base.

2. Concrete Bases: Refer to Structural drawings for concrete base detail.

C. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear units and components.

3.03 Identification

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in DIVISION 26, Section "Electrical Identification."

B. Diagram and Instructions:

1. Frame and mount under clear acrylic plastic on the front of switchgear.

   a. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.

   b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.

2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

3.04 Connections

A. Ground equipment according to DIVISION 26, Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to DIVISION 26, Section "Low-Voltage Electrical Conductors and Cables."

3.05 Field quality control

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect switchgear installation, including wiring, components, connections, and equipment. Test and adjust components and equipment.

2. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in DIVISION 26 Sections.

3. Complete installation and startup checks according to manufacturer's written instructions.

4. Assist in field testing of equipment including pretesting and adjusting of equipment and components.

5. Report results in writing.

C. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

D. Perform the following field tests and inspections and prepare test reports:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:

    a. Switchgear.

    b. Circuit breakers.

    c. Protective relays.

    d. Instrument transformers.

    e. Metering and instrumentation.

    f. Ground-fault systems.

    g. Battery systems.

    h. Surge arresters.

    i. Capacitors.

2. Remove and replace malfunctioning units and retest as specified above.

E. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.

2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 Grounding

A. Provide equipment grounding connections for switchgears as indicated. Tighten connections to comply with tightening torques specified in UL 486A to assure permanent and effective grounding.

3.07 Adjusting

A. Set field-adjustable, protective-relay trip characteristics according to results in DIVISION 26, Section "Overcurrent Protective Device Coordination Study."

3.08 Cleaning

A. On completion of installation, inspect interior and exterior of switchgear. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.09 Protection

A. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

3.10 Demonstration

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear. Refer to DIVISION 01, Section "Manufacturer Services."

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section specifies switchboard work that is indicated by drawings and schedules.

B. Types of switchboards specified in this Section include the following:

1. Dead-Front Distribution:
    a. Circuit-breaker switchboards.

1.03 Related Requirements

A. Refer to applicable DIVISION 26 Sections for wires/cables, grounding, identification, electrical raceways, fittings, and other items required in connection with switchboards.

B. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

C. Section 26 05 53 – Identification for Electrical Systems.

D. Section 26 43 13 – Surge Protection Devices for Low-Voltage Electrical Power Equipment.

1.04 Reference Standards

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

B. American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE):

1. C37.13 – Low-Voltage AC Power Circuit Breakers Used in Enclosures.
2. C36.16 – Related Requirements and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Protectors, Preferred Ratings.

C. Institute of Electrical and Electronic Engineers (IEEE):

1. 241 – Recommended Practice for Electric Power Systems in Commercial Buildings, Pertaining to Switchboards.

D. National Electrical Manufacturers' Association (NEMA):

1. PB2 – Dead-Front Distribution Switchboards.
2. PB 2.1 – General Instruction for Proper Handling, Installation, Operation, and Maintenance of Dead-Front Distribution Switchboards Rated 600V or Less.
3. SG 3 – Low-Voltage Power Circuit Breakers.

E. National Fire Protection Association (NFPA): Comply with applicable local code requirements of the authority having jurisdiction and that portion of the NEC which pertains to installation and construction of switchboards.

1. 70 – National Electrical Code (NEC).
2. 70E – Standard for Electrical Safety in the Workplaces.

F. Underwriters Laboratories (UL) Compliance: Provide switchboards and components which are UL-listed and labeled.

1. 98 – Enclosed and Dead Front Switches.
2. 486A – Wire Connections and Soldering Lugs for Use in Copper Conductors.
3. 489 – Molded Case Circuit Breakers and Circuit Breaker Enclosures.
4. 891 – Dead Front Electrical Switchboards.
5. 977 – Fused Power Circuit Devices.
6. 1054 – Ground-Fault Sensing and Relaying Equipment.
7. 1449 – Surge Protective Devices.

1.05 Submittals

A. Refer to Division 01 and Section 26 05 10 - Basic Electrical Requirements for administrative and procedural requirements for submittals.

B. Submittals shall be custom prepared by the switchboard manufacturer for this specific application.

C. Product Data: Submit for each type of product specified and included, with the following as minimum:

1. Data sheets for all components furnished as part of the equipment package. Indicate voltages, number of phases, frequency, short-circuit, and continuous current ratings.
2. Provide application data and time-current trip curves for main and branch circuit-breakers.

3. Instrument transformer performance curves and data.

D. Shop Drawings: Provide the following as minimum:

  1. Submit dimensioned drawings of switchboards showing accurately dimensioned equipment sections, including auxiliary compartments, section components, and combination sections.
  2. Indicate shipping splits and weight of each section. Complete loading diagrams covering static and dynamic loadings for all conditions of operation and structural steel details. Indicate all required access points for all terminations.
  3. Wiring Diagrams: Submit a wiring diagram for the complete switchboard unit showing connections to electrical power feeders, distribution branches, and associated auxiliaries. All external power and control connections shall be clearly identified.
     a. Differentiate between portions of wiring that are manufacturer factory-installed and portions that are field-installed.
  4. Nameplate schedule.
  5. Surge Protective Device data and testing laboratory reports.

E. Special Procedure Submittals:

  1. Start-up and commissioning instructions.
  2. Syllabus for Owner training.

F. Test and Evaluation Reports:

  1. Factory test reports.
  2. Commissioning and Field test reports.

G. Closeout Submittals: Final documentation shall include the following as minimum:

  1. Operation and Maintenance Manuals including the following:
     a. Operation and maintenance manuals for all components furnished.
     b. Certified “As-Built” drawings of all equipment with information listed above.
     c. Copies of all approved Product Data.
     d. Copies of all approved Test Reports.
     e. Spare parts and supply list with supplier names and part numbers.
     f. Warranty Information.

g. Manufacturer’s service and repair support during and after warranty including contact information.

h. Training Materials.

H. Maintenance Material Submittals:

1. Spare Parts:

a. Three spare LED indicating lamps for each type and color used.

b. Three spare indicating light assemblies.

c. Three spare power and control fuses of each voltage and current rating used.

d. One 12oz aerosol cans of manufacturer’s touch-up paint for each color used. Color shall match the original factory applied color.

e. All parts supplied with the equipment shall be properly labeled for ease of identification and to permit the shortest possible time to repair.

1.06 Quality Assurance

A. Materials and Equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall be the manufacturer’s latest standard design that has been in satisfactory use for at least five years prior to Bid opening.

B. Factory Tests:

1. The switchboard assembly shall be completely and functionally tested in the manufacturer's facility prior to shipment. For systems shipped in multiple sections, the switchboard shall be quality tested utilizing the plug-together wiring system which shall be unplugged prior to shipment and plugged together again when the equipment is installed in order to maintain the integrity of the manufacturer's quality assurance testing.

2. Conduct tests on all system components and subassemblies to assure that all devices and systems are in proper working order before delivery to jobsite.

3. Submit test reports as specified in DIVISION 01.

1.07 Delivery, Storage, and Handling

A. Deliver switchboards and components properly packaged and mounted on pallets or skids to facilitate handling of heavy items. Utilize factory-fabricated type containers or wrappings for switchboard and components which protect equipment from damage. Install impact measuring meters in containers which will indicate whether the container has been bumped or dropped. Return impact meters to the manufacturer for reuse upon delivery of switchboards. Inspect equipment to ensure that no damage has occurred during shipment.

B. All necessary hardware for reconnecting shipping splits shall be provided.

C. Store switchboard equipment in original packaging and protect from weather and construction traffic and according to the manufacturer’s instructions. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with a watertight wrapping.

D. Handle switchboard equipment carefully to prevent physical damage to equipment and components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which would damage the electrical equipment contained therein. Do not install damaged equipment; remove damaged equipment from the site and replace with new.

1.08 Sequencing and Scheduling

A. Schedule delivery of switchboard equipment which permits ready building ingress for large equipment components to their designated installation spaces. Coordinate delivery of equipment with the installation of other building components.

B. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into concrete pad. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.09 Project Site Conditions

A. Do not install the switchboard equipment specified herein until designated installation spaces are suitable for intended service.

B. Final or temporary HVAC systems shall be in place and operational to maintain the ambient temperatures and humidity conditions at occupancy levels prior to energizing the switchboard and shall be maintained for the remainder of the construction period.

1.10 Warranty

A. All equipment furnished under this section shall be warranted by the Contractor and the equipment manufacturer(s) for a minimum period of two years after completion of startup or as specified in Section 01 43 33.

B. Warranty shall include all parts, labor, and expenses to perform necessary work.

PART 2 - Products

2.01 Manufacturers

A. Subject to compliance with requirements, provide switchboard from the same manufacturer that furnishes the Low Voltage Switchgear specified in SECTION 26 23 00.

2.02 Equipment Sections and Components

A. General: Except as otherwise indicated, provide switchboards and ancillary components of types, sizes, characteristics, and ratings indicated which comply with manufacturer's standard design, materials, components, and construction, in accordance with published product information, and as required for complete installation. Provide terminals UL rated for 75ºC (minimum) conductors.

B. AC Dead-Front Distribution Switchboards:

1. Factory-assembled, dead-front, metal-enclosed, self-supporting secondary power switchboards, of types, sizes, electrical ratings, and characteristics indicated.

2. Assemblies consisting of vertical panel units and containing circuit-breakers assemblies of quantities, ratings, and types indicated.

3. Provide tin-plated copper main bus with connections to switching devices and circuit-breaker branches of sufficient capacity to limit rated continuous current operating temperature rise to no greater than 65ºC above average ambient temperature of 30ºC.

4. Main bus and tap connections silver-surfaced and bolted tightly according to manufacturer's torqueing requirements for maximum conductivity.

5. Copper bus current density shall not exceed 1,000 amperes per square inch.

6. Brace bus for short-circuit stresses greater than or equal to the minimum interrupting capacity indicated.

7. Provide accessibility of line and load terminations from front of switchboard.

8. Switchboard shall accommodate top entry for all incoming and distribution circuit cables and conduits.

9. Provide equipment with built-in lifting eyes and yokes.

10. Provide vertical individual panel units, suitable for bolting together at project site.

11. Construct switchboard enclosures suitable for the following environment:

    a. Installation: Indoors, NEMA Type 12.

C. Enclosures: Construct dead-front switchboards suitable for floor mounting, with front cabling/wiring accessibility and conduit accessibility as indicated. Provide welded steel channel framework; hinge front wireway covers to permit ready access to branch circuit-breaker load side terminals. Enclosure shall be suitable for being rolled or pushed into final location. Coat enclosures with manufacturer's standard corrosive-resistant finish.

D. Finish:

1. Paint system with manufacturer's standard coating system suitable for intended service.

2. Exterior paint color shall be light gray.

E. Nameplates:

1. Wording and equipment tags as indicated.

2. Engraved phenolic nameplates for each circuit breaker unit and other equipment units included in the assembly.

3. Engraved phenolic "master" nameplate for each switchboard.

F. Circuit Breakers: Except as otherwise indicated, provide circuit breakers and ancillary components, of types, sizes, ratings and electrical characteristics indicated, which comply with manufacturer's standard design, materials, components, and construction in accordance with published product information and as required for a complete installation.

1. Molded-Case Circuit Breakers (Feeders):

    a. Factory-assembled, molded-case, manually-operated.

    b. Frame sizes and ampere rating as indicated, 600V, 60 Hz, 3 poles with RMS symmetrical interrupting ratings indicated.

    c. Provide breakers with permanent thermal and instantaneous magnetic trips in each pole and ampere ratings as indicated.

    d. Construct with overcenter, trip-free, toggle-type operating mechanisms with quick-make, quick-break action and positive handle trip indication.

    e. External handle clearly indicates when breaker is "ON," "OFF," or "TRIPPED," and lockable in the "OFF" position.

    f. Provide push-to-trip button on enclosure cover for mechanical tripping circuit breakers.

    g. Construct breakers for mounting in any physical position and operating in an ambient temperature of 40ºC.

    h. Provide breakers with mechanical screw type removable connector lugs, AL/CU rated.

G. Switchboard Bus: Provide switchboard busing with sufficient cross-sectional area to fulfill UL 891 pertaining to temperature rise. Bus shall be continuous rated 2500A amperes as indicated. Construct through-bus of tin-plated copper with silver-plated connections, with ampacity rating indicated, and with short-circuit current rating of 65kAIC with 30hz bracing to allow turning off instantaneous trip of upstream switchgear breaker. Provide fully rated main bus (tapered bus is not acceptable).

Provide ground bus full length of switchboard, firmly connected to each vertical section of the switchboard.

H. Ground-Fault Protectors: Solid-state, ground-fault protection units for feeder breakers as indicated: equip with static relays, sensors, pilot lights, and push-buttons for fault indication, test, and reset; include fuse blocks, fuses, and control power transformers. Provide system which operates at 120Vac.

2.03 Surge Protective Devices (SPD)

A. Switchboard shall be provided with an integral Surge Protective Device (SPD) as indicated. Refer to Section 26 43 13 – Surge Protection Devices for Low-Voltage Electrical Power Equipment for requirements.

PART 3 - Execution

3.01 Examination

A. Examine areas and conditions under which switchboards and components are to be installed. Do not proceed with the work until unsatisfactory conditions have been corrected.

B. Final or temporary HVAC systems shall be in place and operational to maintain the ambient temperatures and humidity conditions at occupancy levels prior to energizing the switchboard and shall be maintained for the remainder of the construction period.

3.02 Installation of Switchboards

A. Install switchboards as indicated, in accordance with manufacturer's written instructions, and with recognized industry practices.

B. Comply with applicable requirements of NEC, NEMA PB 2.1, and NECA's "Standard of Installation."

C. Install a 4-inch high concrete equipment pad 4 inches wider and 4 inches deeper than the switchboard.

D. Level, shim, and anchor to floor or wall with bolts or concrete anchors.

E. Install all necessary wiring or interconnections as required.

F. Make all internal and external connections as indicated and as required by manufacturer's wiring diagrams.

G. Check all internal and external connections, especially current transformer secondary short circuiting jumpers, and tighten as required.

H. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and the National Electrical Code.

I. Grounding:

1. Provide equipment grounding connections for switchboards as indicated. Tighten connections to comply with tightening torques specified in UL 486A to assure permanent and effective grounds.

2. Test for ground continuity. Test neutral continuity to grounded point of derived system.

J. Identification:

1. Provide switchboard identification as specified in Section 26 05 53 - Electrical Identification.

2. Provide switchboard with nameplate indicating designation, incoming line circuit number, voltage, and number of phases. Provide typed circuit directory indicating circuit number and load served. Provide each overcurrent device with a corresponding adhesive label with associated number and load served as indicated.

3. Place arc flash label on equipment.

3.03 Field Quality Control

A. Manufacturer’s Field Services:

1. Manufacturer's field service shall be provided as specified in this Section and in DIVISION 01.

2. Switchboard manufacturer shall provide the field services of a factory technician for a minimum of 3 days on 1 separate occasion to supervise/inspect installation, test and start-up all equipment provided. All travel and living expenses shall be included. All equipment required for testing, start-up and performance verification shall be provided by the start-up technician.

3. Additional days and trips shall be provided as required to fully complete field testing, startup, and training as specified.

B. Field Testing:

1. Perform “start-up” tests as recommended by manufacturer.

2. Prior to energization of circuitry, check all accessible connections to manufacturer's torque tightening specifications.

3. Prior to energization, check for electrical continuity of circuits and for short-circuits.

4. Prior to energization check with an insulation resistance tester: phase-to-phase and phase-to-ground insulation resistance levels to ensure requirements are fulfilled. Record and submit field test data.

C. Additional Field Testing:

1. Provide additional field testing as required by switchboard manufacturer.

D. Submit field testing and commissioning reports as specified in DIVISION 01.

3.04 Finishes

A. Equipment coatings shall be free from scratches, rust, or other defects.

B. All damaged or defective coatings shall be repaired prior to final acceptance.

C. Field Painting:

1. Touch Up:

a. Contractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.

b. Field painting shall be performed based on manufacturer's recommended procedures.

c. Switchboard manufacturer shall furnish Contractor with an adequate quantity of touch-up paint to match the factory applied finish.

3.05 Adjusting and Cleaning

A. Adjust operating mechanisms for free mechanical movement.

B. After field installation and final wiring terminations are completed the field connected power and control wiring and cables shall be adjusted and neatly secured with tie wraps, hook-and-loop straps, or the like.

C. Prior to final acceptance the switchboard interior and exterior shall be wiped clean and free from dust and debris.

3.06 Demonstrations

A. Subsequent to installation of switchboard and all main, feeder, and branch circuit wire and cable hook-ups, energize switchboards and demonstrate functioning in accordance with requirements.

B. Where necessary, correct malfunctioning units and then retest to demonstrate compliance.

3.07 Training

A. The switchboard manufacturer shall provide a qualified representative for a minimum of one day of training at the customer's facility for operations, maintenance and service personnel.

1. The training session shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment.

2. Topics covered shall include safety, hardware layout and functions, power and control wiring, diagnostic indicators, keypad/display interface, programming, setup, configuration, operational indicators, faults, diagnostic tools, troubleshooting, and preventive maintenance.

3. Hands-on training shall be provided on the equipment.

4. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.

B. The Owner at their option shall be allowed to video record all training sessions for future reference.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section specifies panelboards [and mini-power centers,] including cabinets and boxes, as indicated by Drawings and Schedules, and as specified herein.

B. Types of panelboards and enclosures required for the Project include the following:

1. Lighting and appliance branch-circuit panelboards.

1.03 Related Requirements

A. Other Division 26 Sections for wires/cables, electrical boxes, fittings, and raceways required in conjunction with the installation of panelboards and enclosures.

B. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

C. Section 26 05 53 – Electrical Identification.

D. Section 26 43 13 – Surge Protection Devices for Low-Voltage Electrical Power Equipment.

1.04 Reference Standards

A. Publication Dates: Comply with the latest standards revision in effect as of the date of the Contract Documents unless otherwise indicated.

B. National Electrical Manufacturers Association (NEMA):

1. NEMA 250 – Enclosures for Electrical Equipment (1,000V Maximum).
2. NEMA PB 1 – Panelboards.
3. NEMA PB 1.1 – General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600V or Less.
4. NEMA PB 2.2 – Application Guide for Ground-Fault Protective Devices for Equipment.
5. NEMA ST 20 – Dry Type Transformers for General Applications.

C. National Fire Protection Association (NFPA):

1. NFPA 70 - National Electrical Code (NEC): Comply with applicable local code requirements of the authority having jurisdiction and NEC as applicable to installation and construction of electrical panelboards and enclosures.

D. Underwriters Laboratories (UL): Provide panelboard units which are UL listed and labeled.

1. UL 50 - Electrical Cabinets and Boxes.

2. UL 67 - Electrical Panelboards.

3. UL 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors.

4. UL 489 - Molded-Case Circuit Breakers and Circuit Breaker Enclosures.

5. UL 869A - Electrical Service Equipment.

6. UL 1053 - Ground-Fault Sensing and Relaying Equipment.

1.05 Submittals

A. Submit as specified in Division 01 and Section 26 05 10 – Basic Electrical Requirements for administrative and procedural requirements for submittals.

B. Submittals shall be custom prepared by the panelboard manufacturer for this specific application.

C. Product Data: Submit for each type of product specified and included, with the following as a minimum:

1. Data sheets for all components furnished as part of the system package.

D. Shop Drawings: Provide the following as a minimum:

1. Panelboard dimensions and weight.

2. Complete data on circuit breakers.

3. Panelboard short-circuit interrupting capacity, and information on buses: Phase, neutral, and ground.

4. Information on whether panelboard is fed from top or bottom.

5. Data on maximum and minimum incoming and outgoing feeder and branch circuit wire size.

6. Data on door, locks, and mounting: Surface or flush.

7. Data on total number of poles and number of unused poles that is available for future use.

E. Closeout Submittals: Final documentation shall include the following as minimum:

1. Operation and Maintenance Manuals including the following:

   a. Operation and maintenance manuals for all components furnished.

   b. Certified "As-Built" drawings of all equipment with information listed above.

   c. Copies of all approved Product Data.

   d. Copies of all approved Test Reports.

   e. Warranty Information.

F. Maintenance Material Submittals:

1. Furnish extra materials and spare parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

   a. Keys: Two spares for each type of panelboard cabinet lock.

1.06 Quality Assurance

A. Materials and Equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall be the manufacturer's latest standard design that has been in satisfactory use for at least one year prior to Bid opening.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Panelboards shall comply with NEMA PB 1.

F. Comply with NFPA 70.

1.07 Delivery, Storage, and Handling

A. Panelboards shall be stored according to the manufacturer's instructions and in a conditioned space to avoid condensation, dust, and other environmental contaminants.

B. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating if necessary to prevent condensation.

C. Handle and prepare panelboards for installation according to NEMA PB 1 and manufacturer’s instructions.

1.08 Project Site Conditions

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed, weathertight, dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Service Conditions: Rate equipment for continuous operation under the following conditions unless otherwise indicated.

    a. Ambient Temperature Limits: -5ºC through 40ºC.

    b. Altitude not exceeding 6,600 feet.

1.09 Coordination:

A. Coordinate the layout and installation of panelboards and components with other types of equipment including raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.10 Warranty

A. All equipment furnished under this Section shall be warranted by the Contractor and the equipment manufacturer(s) for a minimum period of one year after Equipment start-up or as specified in Section 01 43 33.

B. Warranty shall include all parts, labor, and expenses to perform necessary work.

PART 2 - Products

2.01 Manufacturers

A. Subject to compliance with requirements, provide panelboard and mini-power center products of one of the following (for each type and rating of panelboard and enclosure):

1. Eaton.

2. General Electric Company.

3. Siemens.

4. Square D, Schneider Electric.

2.02 General Requirements for Panelboards

A. Except as otherwise indicated, provide panelboards, enclosures, and ancillary components of types, size, and ratings indicated, which comply with manufacturer's standard materials and with the design and construction in accordance with published product information.

B. Where types, sizes, or ratings are not indicated, comply with NEC, UL, and established industry standards for those applications indicated.

C. Equip with proper number of panelboard switching and protective devices as required for complete installation.

D. Provide ground fault circuit interrupter type circuit breakers where indicated.

E. Enclosures: Flush- and surface-mounted cabinets as indicated.

   1. Provide enclosures fabricated by same manufacturer as panelboards which mate and match properly with panelboards.

   2. Rated for environmental conditions at installed location. Provide NEMA type as described below and as defined by NEMA 250, unless indicated or specified otherwise.

      a. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA Type 12.

   3. Materials: Galvanized sheet steel cabinet type enclosures, in sizes required. Provide code gage (minimum 16-gage) thickness steel.

   4. Must be UL 50 listed.

   5. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Front doors shall have flush locks with three keys per panelboard, all panelboard enclosures keyed alike.

   6. Finishes:

      a. Color: Baked gray enamel finish over a rust inhibitor coating.

      b. Panels and Trim: Galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.

      c. Back Boxes: Galvanized steel.

   7. Directory Card: Inside panelboard door, equip with interior circuit directory frame and removable card with clear plastic covering.

F. Phase, Neutral, and Ground Buses:

1. Bus shall be braced to withstand available short-circuit currents as indicated.

2. Provide suitable lugs on neutral bus for incoming and outgoing feeders requiring neutral connections.

3. Equipment Ground Bus: Bare, uninsulated, adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

4. Material: Tin-plated copper.

G. Conductor Connectors: Suitable for use with conductor material and sizes indicated and specified.

1. Material: Tin-plated copper.

2. Main and Neutral Lugs: Mechanical type.

3. Ground Lugs and Bus-Configured Terminators.

4. All lugs shall be mechanical type.

5. Provide terminals UL rated for 75ºC (minimum) conductors.

H. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals as indicated.

J. Refer to Section 26 43 13 – Surge Protection Devices for Low-Voltage Electrical Power Equipment for device requirements.

K. Provide panelboard nameplate as indicated.

2.03 Lighting and Appliance Branch-Circuit Panelboards

A. Panelboards: NEMA PB 1, dead front, safety type, 208Y/120V, 3 phase, 4 wire, 60 hertz with full-sized neutral bus.

B. Lighting and appliance branch-circuit type as indicated with switching and protective devices in quantities, ratings, types, and arrangements shown.

C. Incoming Mains Location: Top or bottom as required.

D. Mains: Circuit breaker or lugs only as indicated.

E. Branch Overcurrent Protective Devices:

1. Bolt-on, molded-case circuit breakers.

2. Molded-case circuit breakers shall have toggle handles that indicate when tripped.

3. Where multiple pole breakers are indicated, provide with common trip so overload on one pole will trip all poles simultaneously.

4. Circuit breakers shall be replaceable without disturbing adjacent units.

F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

G. Provide spare 20A single pole breakers for all unused space within the panelboard

2.04 Panelboard Integral Surge Protection Device

A. Provide surge protection device (SPD) designed for installation within the panelboard. The SPD shall connect directly to the bus bar and have an integral disconnect. SPD shall be approved by panelboard manufacturer for installation within the panelboard. Indicating lights shall be mounted in the face of the panelboard. The unit shall provide the following modes of protection: line-to-line (L-L), line-to-ground (L-G), line-to-neutral (L-N), and neutral to ground (N-G).

B. Refer to Section 26 43 13 – Surge Protection Devices for Low-Voltage Electrical Power Equipment for SPD requirements.

PART 3 - Execution

3.01 Examination

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Verify Site conditions are suitable for installation of equipment.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the work.

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

3.02 Installation of Panelboards

A. Install panelboards, mini-power centers, and enclosures as indicated, providing NEC required working space, in accordance with manufacturer's written instructions, applicable requirements of NEC and in compliance with recognized industry practices to ensure that products fulfill requirements.

B. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A.

C. Fasten enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically anchored.

D. Provide properly wired electrical connections for panelboards within enclosures.

E. Install numbers on all circuit breakers and type the panelboard's circuit directory card upon completion of installation work. Clearly identify the load on each circuit and the circuit number according to the Contract Drawings.

F. Provide filler plates in all unused spaces.

3.03 Grounding

A. Provide equipment grounding connections for panelboard enclosures as indicated and as required by NEC. Tighten connections to comply with tightening torques specified in UL 486A to assure permanent and effective grounds. Provide grounding as specified in Section 26 05 26 – Grounding and Bonding for Electrical Systems.

3.04 Identification

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 26 05 53 – Identification for Electrical Systems.

B. Create a directory to indicate installed circuit loads; incorporate equipment served and room designations as indicated on the Drawings. Use a computer or typewriter to create directory; handwritten directories are not acceptable. Panelboard directory shall be subject to approval by the Engineer.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 05 53 – Electrical Identification.

D. Device Nameplates: Label each branch circuit device in power distribution panelboards with a nameplate complying with requirements for identification specified Section 26 05 53 – Identification for Electrical Systems.

3.05 Field Quality Control

A. Perform tests and inspections as specified and as recommended by the equipment manufacturer.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Prior to energization of electrical circuitry, check all accessible connections to manufacturer's tightening torque specifications.

4. Prior to energization, check panelboard circuits for short circuits, electrical continuity of circuits, enclosure grounding and neutral grounding at service entrance and at incoming derived source transformer.

5. Prior to energization of panelboards, check with insulation resistance tester the phase-to-phase and phase-to-ground insulation resistance levels of each phase bus to ensure requirements are fulfilled. Record and submit test results.

6. Panelboards will be considered defective if they do not pass tests and inspections.

7. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 Finishes

A. Equipment coatings shall be free from scratches, rust, or other defects.

B. All damaged or defective coatings shall be repaired prior to final acceptance.

C. Field Painting:

  1. Touch Up:

    a. Contractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.

    b. Field painting shall be performed based on manufacturer’s recommended procedures.

    c. Panelboard manufacturer shall furnish Contractor with an adequate quantity of touch-up paint to match the factory applied finish.

3.07 Adjusting and Cleaning

A. Adjust moving parts and operable components to function smoothly, and as recommended by manufacturer.

B. Upon completion of installation, clean interior and exterior of panelboards. Remove paint splatters, spots, dirt and debris.

C. Touch-up scratched or marred surfaces to match original finishes.

3.08 Protection

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.09 Demonstration

A. Subsequent to final wire and cable hook-ups, energize panelboards and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section covers wiring devices for lighting and utilization equipment including but not limited to the following:

1. Receptacles.
2. Switches.
3. Wall Plates.
4. Plugs.

1.03 Related Requirements

A. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

B. Section 26 05 33 – Raceways, Boxes, Seals and Fittings for Electrical Systems.

C. Section 26 50 00 –Lighting.

1.04 Reference Standards

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

B. National Electrical Manufacturers Association (NEMA):

1. NEMA WD 1 – General Color Requirements for Wiring Devices.
2. NEMA WD 6 – Wiring Devices - Dimensional Specifications.
3. NEMA 410 – Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts.

C. National Fire Protection Association (NFPA):

1. NFPA 70 – National Electrical Code (NEC).

D. Underwriters Laboratories (UL):

1. UL 20 – General-Use Snap Switches.
2. UL 486A-486B – Wire Connectors.
3. UL 498 – Attachment Plugs and Receptacles.
4. UL 514D – Cover Plates for Flush-Mounted Wiring Devices.
5. UL 943 – Ground-Fault Circuit-Interrupters.

1.05 Submittals

A. Refer to Division 01 and Section 26 05 10 – Basic Electrical Requirements for administrative and procedural requirements for submittals.

B. Product Data for each product specified.

1.06 Quality Assurance

A. Conform to the requirements of NFPA 70.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this Section with minimum 3 years documented experience.

1.07 Delivery, Storage, and Handling

A. Wiring devices shall be packaged and shipped to the project site to avoid damage.

B. Store in a clean, dry space in original manufacturer's packing to avoid condensation, dust, and other environmental contaminants until ready for installation.

1.08 Sequence and Scheduling

A. Schedule installation of wiring devices and associated wall plates after the surface upon which they are installed has received the final finish.

PART 2 - Products

2.01 Manufacturers

A. Appleton, Emerson Electric Co.

B. Cooper, Crouse-Hinds, Division of Eaton.

C. Hubbell, Inc.

D. Leviton Manufacturing Co., Inc.

E. Pass & Seymour, Legrand North America, Inc.

F. Russellstoll, Thomas & Betts.

G. Woodhead, Molex.

H. Source Limitation: Wiring device and associated wall plate shall be supplied from a single manufacturer for each type of device for consistency throughout project.

2.02 Receptacles

A. General:

1. All receptacles and associated materials shall bear a UL 498 label and comply with NEMA WD 1 and WD 6 as applicable.
2. Provide all necessary wiring and accessories as required for complete installation.

B. Ground Fault Circuit Interrupter (GFCI) Receptacles:

1. Flush or surface mounted as indicated.
2. Rated 20A at 125Vac, Fed. Spec. W-C-596.
3. Back and side wired terminals with feed-through design.
    a. Terminal installation unless indicated otherwise.
4. UL Standard 943 Class A, Group 1.
5. Leakage current sensitivity: 5 mA ±1 mA.
    a. Opens circuit within 25 milliseconds of reaching 5 mA.
6. Duplex, arc resistant and pre wired.
7. Cover plate materials and colors shall match standard receptacles as specified this Section.
8. FD box.
9. Locations as indicated.

2.03 Switches

A. General:

1. All switches and associated materials shall bear a UL 20 label.
2. Provide all necessary wiring and accessories as required for complete installation.

B. All single-pole, double-pole, three-way, and four-way switches as indicated.

C. Surface-Mounted, Tumbler, Self-Grounding, Heavy-Duty Switches:

1. Rated 20A at 120V or 277Vac.
2. "Specification" grade (Fed. Spec. W-S-896) switch with gray toggle.
3. FS and FD single or multiple gang cast boxes.
4. Cast aluminum cover plates and matching countersunk screws.
5. Locations indicated.

PART 3 - Execution

3.01 Installation

A. General:

1. Install wiring devices and accessories in accordance with manufacturer's written instructions, and in accordance with recognized industry practices.
2. Coordinate with other work, including painting, electrical boxes, and wiring installation.
3. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A-486B.
4. Install wiring devices only in electrical boxes which are clean - free from building materials, dirt, and debris.
5. Wiring devices shall not be installed in boxes until wire pulling is completed.
6. Painting work shall be completed prior to device wall plate installation.

B. Receptacles:

1. Mount receptacles outlets 1'-6" above floor, walkways, or finished grade unless indicated otherwise.

C. Switches:

1. Mount 4 feet above floor, walkways, or finished grade unless indicated otherwise.
2. Install close to trim on lock side when located near doors.

D. Wiring Circuits:

1. Home Run Groupings:
    a. Group in home runs with not more than one conductor of each phase and 100% sized neutral and ground wire in one conduit.
    b. Circuits which are protected by ground fault circuit interrupter (GFCI) devices shall use their own separate and isolated neutral between the GFCI device and load.
2. Use circuit numbers as indicated.
3. Use type SVN3 wire for lighting and receptacle circuits unless indicated otherwise.
4. Do not install wire smaller than No. 12 AWG.
5. Install larger size wire as indicated or required to conform to requirement of NFPA 70 (NEC).
6. Install in concealed and exposed conduit systems as indicated.

3.02 Protection

A. Protect installed devices from damage.

B. Devices and wall plates that are damaged, stained, or painted shall be replaced prior to final acceptance.

3.03 Field Quality Control

A. Testing:

1. Prior to energizing circuits, test wiring for electrical continuity and for short-circuits. Ensure proper polarity of connections is maintained.
2. After circuits are energized, test wiring devices and demonstrate compliance with requirements.
    a. Test each receptacle with a receptacle tester to ensure proper polarity.
    b. Test ground fault circuit interrupters with the local test button and with a receptacle tester to simulate a remote ground fault.
    c. Test ballasts for overcurrent protection in accordance with NEMA 410.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section specifies starters, contactors, push buttons, switches, indicating lights, relays, and motor controller work as indicated and specified.

1.03 Related Requirements

A. Refer to applicable Division 26 Sections for wires/cables, grounding, identification, electrical raceways, and boxes and fittings required in connection with enclosed controllers.

B. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

C. Section 26 05 33 – Raceways, Boxes, Seals, and Fittings for Electrical Systems.

D. Section 26 05 53 – Electrical Identification.

1.04 Reference Standards

A. National Electrical Manufacturers Association (NEMA):

1. NEMA 250 – Enclosures for Electrical Equipment (1,000V Maximum).
2. NEMA AB 1 – Molded-Case Circuit Breakers.
3. NEMA ICS 1 – General Standards for Industrial Control Systems.
4. NEMA ICS 2 – Industrial Control Devices, Controllers, and Assemblies.
5. NEMA ICS 3 – Industrial Systems.
6. NEMA ICS 6 – Enclosures for Industrial Controls and Systems.
7. NEMA KS 1 – Enclosed Switches.
8. NEMA MG1 – Motors and Generators.

B. National Fire Protection Association (NFPA):

1. NFPA 70 – National Electrical Code (NEC): Comply with applicable local electrical code requirements of the authority having jurisdiction and NEC Articles 200, 250, 430 and 702 as applicable to installation and construction of enclosed controllers.

C. Underwriters Laboratories (UL): Provide controllers and components which are UL-listed and labeled.

   1. UL 50 – Enclosures for Electrical Equipment.
   2. UL 98 – Enclosed and Dead-Front Switches.
   3. UL 486A – Wire Connectors and Soldering Lugs for Use with Copper Conductors.
   4. UL 489 – Molded Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.
   5. UL 508 – Electric Industrial Control Equipment.

1.05 Definitions

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. N.C.: Normally closed.

E. N.O.: Normally open.

F. OCPD: Overcurrent protective device.

G. SCR: Silicon-controlled rectifier.

1.06 Submittals

A. Refer to Division 01 and Section 26 05 10 – Basic Electrical Requirements for administrative and procedural requirements for Submittals.

B. Includes, but not limited to, the following:

   1. Product Data: Submit manufacturer's data and installation instructions on motor controllers, contactors, push buttons, selector switches, indicating lights and relays.
   2. Shop Drawings: Submit Shop Drawings of motor controllers showing dimensions and weights. Submit dimensional data on push buttons, selector switches, indicating lights and relays.

a. Show tabulations of the following:

    (1) Each installed unit's type and details.

    (2) Factory-installed devices.

    (3) Nameplate legends.

    (4) Short-circuit current rating of integrated unit.

    (5) Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.

3. Wiring Diagrams: Submit power and control schematic and wiring diagrams for motor controllers and contactors. Differentiate between portions of wiring which are manufacturer factory installed and portions which are field-installed.

4. Field quality-control reports.

5. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

C. Closeout Submittals:

1. Information listed above.

2. Operation and Maintenance Data: Include the following as minimum:

    a. “As-Built” drawings.

    b. Field quality-control reports.

    c. Warranty information.

    d. Routine maintenance requirements for enclosed controllers and installed components.

    e. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.

    f. Manufacturer's written instructions for setting field-adjustable overload relays. Include installed and operating load current with list of settings.

    g. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.

D. Maintenance Material Submittals:

1. Spare Parts:

    a. One spare LED indicating lamps for each type and color used.

    b. One spare indicating light assembly.

    c. Ten spare power and control fuses of each voltage and current rating used.

  2. All parts supplied with the equipment shall be properly labeled for ease of identification and to permit the shortest possible time to repair.

1.07 Product Delivery, Storage, and Handling

A. Deliver Equipment and components properly packaged in factory-fabricated type containers.

B. Store Equipment and components in original packaging and in a clean dry space; protect from weather and construction traffic.

C. Handle Equipment and components carefully to avoid breakage, impact, denting, and scoring of finishes. Do not install damaged Equipment; replace and return damaged units to Equipment manufacturer.

1.08 Coordination, Sequencing and Scheduling

A. Sequence equipment installation work with other work to minimize possibility of damage and soiling during remainder of construction period.

B. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.09 Quality Assurance

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 2 - Products

2.01 Manufacturers

A. Subject to compliance with requirements, provide motor controllers, contactors, push buttons, switches, indicating lights, and relays of one of the following:

  1. Allen-Bradley, Rockwell Automation, Inc.

  2. Eaton.

  3. General Electric.

4. Schneider Electric.

5. Siemens.

2.02 Combination Magnetic Motor Starters

A. Full-voltage, nonreversing, reversing or two speed, NEMA style, with motor circuit protector (MCP) type disconnect.

B. Minimum NEMA Size 1.

C. Motor Circuit Protector:

  1. Shall be provided with an external handle that clearly indicates when the MCP is "ON," "OFF," or "TRIPPED" and be lockable in the "OFF" position.

  2. Molded-case, manually-operated, 3-pole.

  3. Adjustable, instantaneous-trip, magnetic-only-type circuit breaker.

  4. Coordinated unit rating for circuit protector and starter.

D. Interrupting rating of 65,000 A RMS Symmetrical minimum unless indicated otherwise.

E. Provide with solid-state, self-powered overload relay sized for and adjusted to full load current of motor being protected. Overload relay shall be manually reset and provide phase loss protection. Solid-state overload relay shall provide additional functions as indicated.

F. External manual reset of overload relay from outside of the enclosure.

G. Built-in 480/120V control transformer on 480V units of adequate capacity for all control devices as indicated on Contract Drawings.

H. Auxiliary contacts as required by Contract Drawings.

I. Momentary or maintained start-stop push buttons, selector switches, control switches, control relays, and indicating lights to implement control sequence indicated.

  1. Heavy duty, 30 mm units.

  2. Start push buttons shall have a black operator.

  3. Stop push buttons shall have a red operator.

  4. 120Vac cluster LED, push to test type indicating lights.

  5. Green lights shall indicate “Equipment Off”.

  6. Red lights shall indicate “Equipment On”.

7. Amber lights shall indicate “Equipment Failure”.

2.03 Contactors

A. Magnetically held contactor.

B. Rated 600Vac.

C. Number of poles: As indicated or required.

D. 30Amp rated contacts unless indicated otherwise.

E. Auxiliary control devices, push buttons, and indicating lights as indicated.

F. Push Buttons and Selector Switches:

   1. Heavy-duty 30 mm units with contacts rated 10A continuous at 120Vac.

   2. NEMA 4X rated.

   3. Provide the number of contacts and contact development as indicated.

G. Pilot Lights:

   1. Heavy-duty, 30 mm units.

   2. NEMA 4X rated.

   3. 120Vac cluster LED push-to-test type, with color as indicated.

2.04 Circuit Breakers

A. Rated 480V, 3-phase, 60-hertz, with interrupting rating of 50,000A RMS Symmetrical minimum.

B. External handle which clearly indicates when breaker is "ON," "OFF," or "TRIPPED" and is lockable in the "OFF" position.

C. Molded-case, manually-operated, 3-pole.

D. Trip-free from handle.

E. Inverse time thermal element overload protection.

F. Instantaneous magnetic short-circuit protection on all poles.

G. Provide neutral and grounding lug kit.

H. Shall comply with NEMA AB1 and UL 489.

2.05 Safety Switches

A. Provide as required by NEC, specified or indicated.

B. Positive quick-make, quick-break mechanism, visible blades, and line terminal shield.

C. Single throw or double throw type when specified for source or load transfer.

D. Provide number of poles as indicated.

E. Provide auxiliary contacts for interlocking with motor starter or VFD when indicated.

F. Furnish heavy duty type.

G. Shall comply with NEMA KS 1 and UL 98.

2.06 Enclosures

A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.

B. Unless otherwise indicated, provide enclosed controllers with the following NEMA enclosure ratings:

1. NEMA 4X, stainless steel enclosures for outdoor areas.
2. NEMA 12 enclosures for interior finished areas and electrical rooms.

PART 3 - Execution

3.01 Examination

A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.

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

3.02 Installation

A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall.

B. For controllers not at walls, provide freestanding racks complying with Section 26 05 33 – Raceways, Boxes, Seals, and Fittings for Electrical Systems.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Comply with NECA 1.

E. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 468A and the National Electrical Code.

3.03 Identification

A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Section 26 05 53 – Electrical Identification.

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.04 Grounding

A. Provide equipment grounding connections for motor controller and control equipment as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounding.

B. Grounding shall conform to Section 26 05 26 – Grounding and Bonding for Electrical Systems.

3.05 Field Quality Control

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation.
2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.

3. Test continuity of each circuit.
4. Check all equipment grounds for continuity.
5. Remove all blocking used for shipments.
6. Verify that voltages at controller locations are within ±10% of motor nameplate rated voltages. If outside this range for any motor, notify Engineer before starting the motor(s).
7. Test each motor for proper phase rotation.
8. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed controllers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 Adjusting and Cleaning

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

B. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Engineer before increasing settings.

C. Coordinate with Section 26 05 73 – Overcurrent Protective Device Coordination Study.

3.07 Demonstration

A. Upon completion of installation of motor controller and control equipment and electrical circuitry, energize circuitry and demonstrate functioning of equipment in accordance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and retest to demonstrate compliance.

B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section includes variable frequency drives (VFD) and associated equipment.

B. Every variable frequency drive system shall consist of all system components required to meet the performance, protection, safety, testing, and certification criteria of this specification.

C. The VFD system must:

1. Represent a fully integrated package. Any components not manufactured by the VFD manufacturer shall be purchased by the VFD manufacturer and supplied with the VFD.

2. Include all material and labor necessary to interconnect any VFD system elements, even if shipped separately.

D. Any modifications to a standard product provided to meet this specification shall be performed by the VFD manufacturer only.

E. The VFD system shall be completely factory pre-wired, assembled and then tested as a complete package by the VFD manufacturer, to assure a properly coordinated, fully integrated drive system.

F. 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.

1.03 Related Requirements

A. Section 26 05 10 – Basic Electrical Requirements.

B. Section 26 05 19 - Low-Voltage Electrical Conductors and Cable.

C. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

D. Section 26 05 53 – Electrical Identification.

1.04 Reference Standards

A. Provide equipment in full accordance with the latest applicable rules, regulations, and standards of:

1. National Electric Code (NEC).
2. Underwriters' Laboratories (UL).
3. American National Standards Institute (ANSI).
4. National Electrical Manufacturers Association (NEMA).
5. Institute of Electrical and Electronics Engineers (IEEE).
    a. IEEE 519: Recommended Practice and Requirements for Harmonic Control in Electric Power Systems.
6. Federal Communications Commission (FCC).

1.05 Submittals

A. Submit as specified in Division 01.

B. Submittals shall be custom prepared by the VFD system manufacturer for this specific application.

C. Product Data: Submit for each type of product specified and included, with the following as minimum:

1. Data sheets for all components furnished as part of the system package.

D. Shop Drawings: Provide the following as minimum:

1. Equipment dimensions, including stub-up locations, shipping splits and shipping weights.
2. Block diagram showing the basic control and protection systems specifying the protection, control, trip and alarm functions at the different locations, the reference signals and commands and the auxiliary supplies.
3. Electrical one-line diagram showing main and auxiliary circuitry, including main power input, VFD system grounding and auxiliary supplies.
4. Wiring diagrams, including external connection terminals.
5. Certifications.

E. Special Procedure Submittals:

1. Start-up and commissioning instructions.

2. Syllabus for Owner training.

F. Test and Evaluation Reports:

1. Factory test reports.
2. Efficiency and power factor values.
3. Field test reports.

G. Closeout Submittals: Final documentation shall include the following as minimum:

1. Operation and Maintenance Manuals including the following:
    a. Operation and maintenance manuals for all components furnished.
    b. Certified “As-Built” drawings of all equipment with information listed above.
    c. Copies of all approved Product Data.
    d. Copies of all approved Test Reports.
    e. Spare parts and supply list with supplier names and part numbers.
    f. Warranty Information.
    g. Manufacturer’s service and repair support during and after warranty including contact information.
    h. Training Materials.

H. Maintenance Material Submittals:

1. Spare Parts:
    a. Three spare LED indicating lamps for each type and color used.
    b. Three spare indicating light assemblies.
    c. Three spare power and control fuses of each voltage and current rating used.
    d. Two 12oz. aerosol cans of manufacturer’s touch-up paint for each color used. Color shall match the original factory applied color.
    e. All parts supplied with the equipment shall be properly labeled for ease of identification and to permit the shortest possible time to repair.

1.06 Quality Assurance

A. Materials and Equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall be the manufacturer’s latest standard design that has been in satisfactory use for at least one year prior to Bid opening.

B. Qualifications:

1. The VFD manufacturer shall be able to demonstrate at least ten years of experience in manufacturing VFDs to demonstrate their capability to provide parts and service support.

2. It is the intention of this specification to purchase dependable and reliable equipment offering the best performance available from currently proven technology. All equipment furnished under this contract must, therefore, have documentation showing proof of actual operation for a minimum of two years in similar service. New components or design topologies that have less than two years of actual operating experience will not be accepted.

C. Factory Tests:

1. The manufacturer shall conduct tests according to industry standard requirements.

2. Perform factory tests on all VFD assemblies to assure that all devices and systems are in proper working order before delivery to jobsite.

3. Test all power, control and communication systems for proper operation.

4. Simulate actual system operation.

5. System Level Tests:

   a. The system shall be given preliminary checks including verification of electrical connections including ground connections, power and control wiring shall be resistance checked point-to-point.

   b. Firmware shall be checked for correct revision level.

   c. Visual check shall be performed to verify: degree of protection for cabinets, input isolation is lockable in the off-position, marking of terminals and wiring, space availability for cable termination, accessibility of components and ease of maintenance and repair.

   d. The VFD system shall be fully checked against the approved drawings for compliance and correct physical dimensions.

   e. All control voltage levels are to be checked and verified.

   f. A no load test is to be performed on the system.

   g. Drive is to be connected to an unloaded motor and feedback signals shall be verified.

h. Output voltage shall be calibrated.

i. All logic and interlocks including customer logic and instrumentation shall be tested.

6. Submit test reports as specified in Division 01.

D. VFDs shall be manufactured, assembled, tested and provided with a UL label.

1.07 Delivery, Storage, and Handling

A. The VFD system shall be delivered to the site pre-assembled and wired with all specified interconnecting wiring and cable. Cabling for connection across shipping splits shall be neatly coiled and identified. Exposed sections of equipment shall be fully protected from damage during shipment. All necessary hardware for reconnecting shipping splits shall be provided.

B. The VFD system manufacturer shall be responsible for all system interconnections across shipping splits at the site.

C. Complete instructions for handling and storage shall be provided prior to delivery of the equipment. All equipment shall have adequate provisions for handling by overhead crane or fork lift truck.

D. VFDs shall be stored according to the manufacturer’s instructions and in a conditioned space to avoid condensation, dust, and other environmental contaminants.

1.08 Project Site Conditions

A. Do not store or install the VFD equipment specified herein until designated installation spaces are suitable for intended service.

B. Final or temporary HVAC systems shall be in place and operational to maintain the ambient temperatures and humidity conditions at occupancy levels prior to energizing the VFDs and shall be maintained for the remainder of the construction period.

1.09 Warranty

A. All equipment furnished under this section shall be warranted by the contractor and the equipment manufacturer(s) for a minimum period of two years after completion of startup or as specified in Section 01 43 33.

B. Warranty shall include all parts, labor, and expenses to perform necessary work.

1.10 Maintenance

A. All maintenance materials supplied with the equipment shall be properly labeled for ease of identification and to permit the shortest possible time to repair.

B. Any parts that come from a sub-supplier shall be labeled with that manufacturer’s name and part number.

C. Manufacturer shall state closest point where spare parts are stocked and where service can be obtained.

D. Manufacturer shall warrant that all parts shall be available for a minimum of ten years.

E. Maximum response time for trouble calls shall be two hours.

F. A qualified service technician shall be onsite within twenty-four hours of a qualified request.

PART 2 - Products

2.01 Manufacturers

A. Danfoss.

B. Schneider Electric.

C. Fuji Electronic.

D. General Electric.

2.02 Construction

A. General Requirements:

1. VFD shall be microprocessor based and utilize Pulse Width Modulation (PWM) for speed control of an induction motor.
2. The VFD shall utilize Insulated Gate Bipolar Transistors (IGBT’s).
3. The VFD shall be sized to operate the indicated motor. Loads driven by VFD are variable torque.
4. The VFD shall be capable of producing a variable AC voltage/frequency output to provide continuous operation of a standard induction motor over a 5-100% speed range.
5. As a commissioning and troubleshooting feature, the VFD power circuit shall be capable of operating without a motor connected to the VFD output.
6. VFD rated for variable torque loads shall be capable of a momentary overload of 110% for one minute.
7. VFD shall be capable of delivering a minimum rated current of 215A at 40°C.

B. Input Harmonics:

1. The VFD shall be equipped with an integral 3% line reactor.

2. All VFDs greater than 50 horsepower shall be provided with a harmonic mitigation device.

    a. The harmonic mitigation device shall limit the total harmonic voltage distortion at the point of common coupling to 5% and total demand (current) distortion (TDD) to the levels defined by the latest version of IEEE 519 with the following exception:

        (1) The TDD shall not exceed 12% even when higher limits are allowed. The point of common coupling shall be defined as the bus servicing the feeder breaker to the harmonic mitigation device.

    b. The harmonic mitigation shall be by passive inductor/capacitor network.

    c. Power factor shall be 0.98 lagging to 0.95 leading in the operating range of 50-100% load.

    d. The harmonic mitigation device shall not introduce reactive power (kVAR) in excess of 15% of its kVA rating.

    e. The harmonic mitigation device shall not resonate with system impedance or attract harmonic currents from other harmonic sources.

    f. The harmonic mitigation device shall have an efficiency of greater than 99%.

    g. All wiring within the harmonic mitigation device shall be copper.

    h. The harmonic mitigation device shall have a maximum temperature rise of 130°C with a minimum 220°C insulation system.

    i. The harmonic mitigation device shall be approved by Engineer.

C. Input Protection:

1. The VFD shall be provided with an input circuit breaker.

2. The circuit breaker shall have a minimum 65,000 –AIC rms symmetrical minimum rating.

3. The circuit breaker shall be equipped with a door interlocked external operator and have provisions to be locked in the off position.

D. Motor Compatibility:

1. Motor life expectancy shall not be compromised in any way by operation with the VFD system. The VFD shall provide motor overload protection in any operating condition.

2. The VFD output waveform shall be suitable for operating a squirrel cage induction motor without derating or requiring additional service factor.

3. The system design shall not have any inherent output harmonic resonance in the operating speed range.

4. The VFD output shall produce no electrically-induced, pulsating torque to the output shaft of the mechanical system eliminating the possibility of exciting a resonance caused by VFD induced torque pulsations.

5. The VFD shall protect the motor from high-voltage dv/dt stress which would cause insulation breakdown of an "inverter ready" motor. If the VFD requires an output filter to meet this requirement, it shall be an integral part of the VFD system and be included within the VFD enclosure.

E. VFD System Efficiency:

1. Guaranteed minimum total VFD system efficiency (η_{sys}) shall be a minimum 96% at 100% speed. Efficiency evaluation shall include all applicable devices such as the input harmonic filter, isolation transformer, VFD converter, and output filter, as indicated below. Auxiliary controls, such as internal VFD control boards, cooling fans, shall be included in all loss calculations.

2. The VFD system efficiency is as follows: $\eta_{sys} = \eta_{VFD} \text{ x } \eta_{tans} \text{ x } \eta_{harm} \text{ x } \eta_{filter}$

Converter/Inverter (VFD)	η_{VFD}
Isolation Transformer	η_{trans}
Input Harmonic Filter	η_{harm}
Output Filter	η_{filt}

F. System Input Power Factor: VFD system shall maintain a 95% minimum power factor from 30% to 100% of rated speed.

G. Speed Regulation: VFD speed regulation shall be ±0.5% without encoder or tachometer feedback.

H. Sound Level: Maximum allowable audible noise from the VFD system will be 80 dBA at a distance of one meter (3.3 ft) at any speed or load condition. VFD systems with audible noise in excess of this limit shall be provided with sufficient noise abatement treatment to reduce the sound pressure level below 80 dBA.

2.03 Availability and Reliability

A. Firing Signals: All internal firing signals, and other communications (which link operational controls with power components such as status and diagnostic signals) shall meet noise immunity and safety requirements as defined by applicable IEEE Standards.

B. Power Sag Ride-Through: The VFD system shall be capable of continuous operation with a 20% voltage sag on the input power line.

C. "Catch-A-Spinning-Load" Capability: The VFD system shall be able to catch and take control of a spinning load if started while rotating equipment is already spinning. Appropriate safeguards shall be included in this operation to prevent damaging torque(s), voltages or currents from impacting any of the equipment. The user shall have the option of employing this feature or disabling it.

D. Auto-Restart Capability: The VFD system shall be capable of automatically restarting in the event of a power failure or drive trip. The VFD system shall provide the user with the choice of automatically restarting or not. The user shall be able to selectively apply this feature to some, but not necessarily all, conditions as determined by the user to be appropriate for the specific application.

E. Ground Fault Withstand: In the event of a ground fault, the VFD shall annunciate the ground fault condition and trip offline to clear the fault. The cause of the shutdown shall be logged to the fault history and be available at the keypad.

2.04 Serviceability/Maintainability

A. Front Access: The VFD system shall be designed for front access only.

B. Power Component Accessibility: All power components in the converter sections shall be designed for easy removal and accessibility to minimize repair downtime.

C. Marking/Labeling: Sleeve-type wire marker tags or other acceptable means of permanent identification shall be applied to power and control wiring. Individual nameplates shall be provided for all major components of the VFD system.

2.05 Physical Requirements

A. Environmental Requirements: The VFD system shall be capable of continuous operation in an average ambient temperature between 0°C and 40°C at an elevation up to 3300 feet (1000 meters) above MSL without derating. The VFD system shall also be simultaneously suitable for continuous operation in a maximum humidity between 0 and 95% noncondensing.

B. Heat Dissipation/Cooling System:

1. The VFD system shall be air-cooled.

C. Enclosure:

1. All VFD system components including, but not limited to, circuit breaker, line reactor, isolation transformer, and output filters shall be mounted and wired by the VFD system manufacturer in a grounded enclosure meeting the following requirements:

2. VFD and auxiliary components shall be housed in a NEMA 12 enclosure.

a. Cabinets and doors shall be fabricated using heavy gauge steel for sturdy construction and dimensional integrity to assure long-term fit and function. All doors shall be gasketed to provide environmental protection and secure fits.

b. Units shall be provided with air filters covering all air inlets. Inlet air filters shall be 100% washable, with a progressively structured, corrosion-free media. Filters shall be front replaceable (for cleaning) while the VFD is in operation without exposing maintenance personnel to any of the power components.

c. Paint procedures and materials shall be manufacturer’s system designed and proven for resistance to chemical attack in industrial power-house environments.

3. The enclosure shall be sized and designed for proper heat dissipation or equipped with an external corrosion resistant heat sink.

4. Access to the VFD keypad and other control devices shall be available without opening the enclosure.

5. Enclosures shall be designed to avoid harmonic and inductive heating effects. The enclosure shall be designed to shield any outside equipment from interference, enclosing and shielding the complete system to eliminate any radio frequency interference in compliance with FCC Part 18 requirements.

D. Installation/Cabling: All VFD system wiring (power, control and protection) shall be located internally within the VFD system enclosure. If special requirements of the project require that one or more VFD system components must utilize external cabling or connections to complete the VFD system, this cabling and connecting shall be entirely supplied and/or contracted by the VFD system supplier, and approved by the Engineer. All external power conductors (bus or cable) shall be insulated. Power wiring shall be isolated by voltage class. Control and instrument wiring shall be isolated from power wiring.

2.06 Protective Devices/Diagnostics

A. Protective Features and Circuits:

1. The controller shall include the following alarms and protective features:

a. Static instantaneous over-current and over-voltage trip.

b. Under-voltage and power loss protection.

c. Over-temperature protection.

d. Electronic motor inverse time overload protection.

e. When power is restored after a complete power outage, the VFD shall be capable of catching the motor while it is still spinning and restoring it to proper operating speed without the use of an encoder.

2. The VFD system shall be protected from damage due to the following, without requiring an output contactor:

a. Single-phase fault or three-phase short circuit on VFD system output terminals.

b. Loss of input power due to opening of VFD input disconnect device or utility power failure during VFD operation.

c. Loss of one (1) phase of input power.

d. Motor regeneration due to backspin or loss of VFD input power.

3. The VFD shall be able to withstand the following fault conditions without damage to the power circuit components:

a. Failure to connect a motor to the VFD output.

b. VFD output open circuit that may occur during operation.

4. The VFD shall include a customer selectable automatic restart feature. When enabled, the VFD shall automatically attempt to restart after a trip condition resulting from over-current, over-voltage, under-voltage, or over-temperature.

5. The VFD system shall have the user selectable option of programming up to three speed avoidance bands. This gives the user the ability to block out and prevent operation at any undesirable speed, such as one that may be coincident with a mechanical resonance condition.

B. Diagnostics and Fault Recording:

1. The control logic section shall be fully digital and not require analog adjustment pots or fixed selector resistors.

2. Fault log data shall be stored in nonvolatile memory.

3. The VFD shall include a comprehensive microprocessor based digital diagnostic system which monitors its own control functions and displays faults and operating conditions.

4. A "FAULT LOG" shall record, store, and display upon demand, a minimum of the last four fault events.

2.07 Interfaces

A. Switches and Lights:

1. Selector switches, pushbuttons and pilot lights shall be provided on the front panel of the unit as indicated and specified.

2. Selector switches, pushbuttons and pilot lights shall be heavy duty 30 mm units with NEMA rating suitable for the specified enclosure. Pilot lights shall be LED type.

3. As a minimum the following devices shall be provided:

    a. Local/Off/Remote selector switch.

    b. Start pushbutton.

    c. Stop pushbutton.

    d. Emergency Stop pushbutton.

    e. Off indicating light.

    f. Fault indicating light.

B. Keypad and Display:

1. A front panel mounted keypad with integral digital LCD display shall be furnished, capable of controlling the VFD and setting drive parameters. The display shall present all diagnostic message and parameter values in standard engineering units when accessed, without the use of codes. The keypad shall allow the operator to enter exact numerical settings in standard engineering units. A plain English user menu (rather than codes) shall be provided in software as a guide to parameter setting.

2. As a minimum, the following parameters shall be available for display:

    a. Speed demand in percent.

    b. Output current in amperes.

    c. Output Frequency in hertz.

    d. Output voltage.

    e. Total 3-phase kW output.

    f. Kilowatt hour meter.

    g. Elapsed time running meter.

    h. Run status.

    i. Fault status.

3. Drive parameters shall be factory set in non-volatile memory and re-settable in the field through the keypad. Password security shall be available to protect drive parameters from unauthorized personnel.

4. The keypad module shall contain a "self-test" software program that can be activated to verify proper keypad operations.

C. Hard-Wired I/O and Control Devices:

1. The VFD shall include programmable I/O for application specific configuration. The drive shall be configurable to operate in a local and remote mode. The drive shall provide for the following programmable input/output points to be associated with the control functions:

a. Digital Inputs:

(1) Provide a minimum of 6 fully programmable inputs configured, as indicated.

b. Digital Outputs, Form C Relay (Dry Contract rated a minimum of 2 Amps at 120 Vac);

(1) Provide a minimum of 3 fully programmable outputs configured, as indicated.

c. Analog Input:

(1) One 4-20 mA isolated input to control drive output (motor speed) when indicated.

d. Analog Output:

(1) One 4-20 mA isolated output signal representing drive speed and scaled 0-100%.

2. All programming shall be initially be performed at the factory and tested at the factory. Specific requirements for the starting and stopping sequences shall be as indicated.

3. The VFD shall have provisions to power auxiliary devices as indicated.

4. Provide terminal blocks, pushbuttons, indicating lights and control relays as indicated, to provide control, indication and isolation of field-mounted devices.

5. The VFD shall be capable of implementing a speed control PID loop to maintain a level setpoint as indicated.

D. Communication and Protocols:

1. The VFD shall be capable of direct Ethernet communication to a standard personal computer for setup of parameters, fault diagnostics, trending and diagnostic log downloading.

2. Provide a complete list of available control and indication points including required documentation for network configuration.

2.08 Component Requirements

A. Printed Circuit Boards: All printed circuit boards shall be new. They shall be conformably coated for moisture and chemical resistance, in addition to any dielectric coating properties. All boards shall be tested as specified.

B. Wiring:

1. All control wiring shall be physically separated from the power wiring. The VFD system shall be pre-wired within the enclosure. Spade-type connectors are not acceptable. No soldering shall be used in connection with any wiring. Wiring shall be adequately supported to avoid tension on conductors and terminations. All wiring shall be run in surface mounted conduit or wire-ways. Any section of wiring outside of conduit or wire-way shall be securely tied with cable ties or hook-and-loop (Velcro type) straps at intervals not exceeding 6 inches. No cables shall be tied off to or in any way supported from power busses. Wherever wiring passes metal edges or through holes, suitable guards or grommets shall be provided to prevent cutting or chafing of the insulation.

2. All terminal blocks shall have at least 20% spares. No more than two wires shall be terminated on one terminal.

3. All wiring shall be tagged with permanent labels at each termination, junction box, and device. Labels shall correspond to the schematic and wiring diagrams.

C. Ground Connection: Corrosion resistant grounding pads or terminals shall be provided in each power cubicle. A copper ground bus shall be provided for grounding of control circuits.

D. Input Power Terminations: Input and output power connections shall be made to isolated, supported and plated bus strap connections or terminal blocks. Sufficient space shall be provided for termination connections from the top or the bottom of the VFD cubicle.

E. Control Power:

1. A suitable sized 480 volt to 120 volt single phase control power transformer shall be provided to power all cooling fans and auxiliary devices. Additional capacity shall be provided for control devices powered from the VFD as indicated.

2. Control power for 24Vdc digital inputs shall be provided.

PART 3 - Execution

3.01 Examination

A. Verify site conditions are suitable for installation of equipment.

3.02 Installation

A. Install to conform to manufacturer's instruction

B. Completely install as specified, indicated, or required for operation and continuous service at the locations indicated.

C. Provide all openings in floors, walls, roofs, and other structures necessary for complete equipment installation, unless such openings are specifically indicated as being provided by others.

D. Place Dow Corning 3-6548 Silicone RTV or General Electric RTF762 sealant in the following locations:

  1. All holes in concrete walls, floors and roof slabs after installation of conduit.

  2. All unused holes and sleeves as approved by Resident Project Representative.

E. Level, shim, and anchor to floor or wall with bolts or concrete anchors, and grout all floor-mounted equipment.

F. Install all necessary wiring or interconnections as required.

G. Make all internal and external connections as indicated and as required by manufacturer's wiring diagrams.

H. Check all internal and external connections and tighten as required.

I. For freestanding enclosures install a 4-inch high concrete equipment (housekeeping) pad 4-inches wider and 4-inches deeper than the VFD.

3.03 Field Quality Control

A. Manufacturer’s Field Services:

  1. Manufacturer's field service shall be provided as specified in this Section and in Division 01.

  2. VFD system manufacturer shall provide the field services of a factory technician for a minimum of 2 days to supervise/inspect installation, test and start-up all equipment provided. All travel and living expenses shall be included. All equipment required for testing, start-up and performance verification shall be provided by the start-up technician.

B. Field Testing:

  1. Perform “start-up” tests as recommended by manufacturer.

  2. Establish proper direction of rotation for the motor controlled by the VFD.

3. Verify that the VFD operates properly in the “manual” control mode and in the “automatic” or “remote” control mode.

4. Verify that the VFD’s speed adjusts properly with local speed controls and “automatic” or “remote” speed signals.

5. Set the maximum “locked rotor” current draw as recommended by the manufacturer and approved by the Engineer.

6. Set the minimum and maximum speed set points and the acceleration and deceleration ramp times as indicated or recommended by the Engineer.

7. Operate the VFD at 100% speed for at least 10 minutes and monitor output current. The output current should remain below the full load current listed on the motor nameplate. Check for excessive heating of the VFD and motor. Report any discrepancies to Engineer.

8. Verification of VFD input harmonic voltage and current distortion limits specified shall be verified at rated speed and rated power as part of final startup and acceptance of each VFD installation. A recording type Fluke, Multilin PQM, BMI or equivalent harmonic analyzer displaying individual and total harmonic currents and voltages shall be utilized.

9. Compliance with harmonic distortion limits shall be verified with field measurements at the point of common coupling (PCC) for each VFD. Measurements shall be made with all VFDs (or all VFDs that can be operated simultaneously) which are connected to the PCC in operation, and the measurements repeated without the VFDs in operation. Any distortions present when the VFDs are not in operation shall be subtracted from the readings when the VFDs are in operation. Test report shall be submitted as specified in Division 01.

3.04 Finishes

A. Equipment coatings shall be free from scratches, rust, or other defects.

B. All damaged or defective coatings shall be repaired prior to final acceptance.

C. Field Painting:

1. Touch Up:

    a. Contractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.

    b. Field painting shall be performed based on manufacturer’s recommended procedures.

    c. VFD manufacturer shall furnish Contractor with an adequate quantity of touch-up paint to match the factory applied finish.

3.05 Adjusting and Cleaning

A. After field installation and final wiring terminations are completed the field connected power and control wiring and cables shall be adjusted and neatly secured with tie wraps, hook-and-loop straps, or the like.

B. Prior to final acceptance VFD interior and exterior shall be wiped clean and free from dust and debris.

3.06 Training

A. The VFD system supplier shall provide a minimum of one day of training at the customer's facility for operations, maintenance and service personnel.

1. The training session shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment.

2. Topics covered shall include safety, hardware layout and functions, power and control wiring, diagnostic indicators, keypad/display interface, software mapping, programming, setup, configuration, control loop tuning, operational indicators, faults, diagnostic tools, troubleshooting, and preventive maintenance.

3. Hands-on training shall be provided on equipment.

4. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.

B. The Owner at their option shall be allowed to video record all training sessions for future reference.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section shall consist of providing a packaged standby emergency generator set and associated controls with all required accessories as specified and shown on the plans. The equipment supplier must be the authorized distributor for each component of the products specified herein. The Work includes the furnishing of all labor, materials, equipment, test, and training to provide a complete and operational power system as shown on the plans, drawings, and specifications herein.

B. The power system shall be furnished by a single manufacturer who shall be responsible for the design, coordination, and testing of the complete system.

C. The equipment shall be produced by a manufacturer who has produced this type of equipment for a period of at least five years and who maintains a service organization available twenty-four hours a day throughout the year.

D. The complete packaged electrical system shall meet all requirements of the State of Tennessee, city, and local codes, especially pertaining to emissions and fuel storage/delivery/shutoff/monitoring systems.

1.03 Related Requirements

A. Section 26 23 00 – Low-Voltage Switchgear.

1.04 Reference Standards

A. National Fire Protection Association (NFPA):

1. 30 – Flammable and Combustible Liquids.
2. 37 – Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.
3. 70 – National Electrical Code. Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
4. 110 – Emergency and Standby Power Systems. (The generator set shall meet all requirements for Level 2 systems.)

B. Institute of Electrical and Electronic Engineers (IEEE):

1. 446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications (Orange Book).

2. 241 – Recommended Practice for Electric Power Systems in Commercial Buildings (Gray Book).

C. Underwriters' Laboratories, Inc. (UL):

1. 486A – Wire Connectors and Soldering Lugs for Use with Copper Conductors.

2. 2200 – Stationary Engine Generator Assemblies.

D. National Electrical Manufacturers Association (NEMA):

1. MG 1 – Motors and Generators.

2. MG 2 – Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators.

3. 250 – Enclosures for Electrical Equipment (1000V Maximum)

E. International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC):

1. ISO 8528 part 4 – Control Systems for Generator Sets.

1.05 Submittals

A. Submit as specified in DIVISION 01.

B. Product Data: Submit for each type of product specified and included, with the following as minimum:

1. Submit manufacturer’s data on engine-driven generator set and components.

2. Manufacturer’s warranty.

3. Submit application for Service Agreement with annual cost to Owner from Manufacturer for on-site service and maintenance (Owner may accept or decline such Service Agreement).

4. Verification that complete packaged electrical system shall meet all requirements of the state, city, and local codes where the project is located.

C. Shop Drawings: Provide the following as minimum.

1. Submit dimensioned drawings indicating weights, combustion air requirements, cooling air requirements, heat rejection rate, fuel consumption, noise criteria, field connection points, and nameplate data.

2. Provide lifting requirements for setting equipment in place.

3. Submit wiring diagrams for all power and control interconnect wiring. Complete drawing and wiring diagrams including, but not limited to, showing coordination and connections between the following:
    a. Engine generator.
    b. Generator control panel.
    c. Automatic starting controls.
    d. All auxiliaries.
4. Certifications.

D. Special Procedure Submittals:
    1. Start-up and commissioning instructions.
    2. Syllabus for Owner training.

E. Test and Evaluation Reports:
    1. Provide generator test records of the following final production tests:
        a. Single step load pickup.
        b. Transient and steady-state governing.
        c. Safety shutdown device testing.
        d. Voltage regulation.
        e. Rated power.
        f. Maximum power.

F. Closeout Submittals: Final documentation shall include the following as minimum:
    1. Operation and Maintenance Manuals including the following:
        a. Operation and maintenance manuals for the generator, engine, and all auxiliary components furnished.
        b. Certified “As-Built” drawings of all equipment and interconnecting diagrams.
        c. Copies of all approved Product Data.
        d. Copies of all approved Commissioning and Test Reports.
        e. Recommended preventive maintenance (PM) service and schedules.
        f. Spare parts and supply list with supplier names and part numbers.

g. Warranty Information.

h. Manufacturer’s service and repair support during and after warranty including contact information.

G. Maintenance Material Submittals:

1. Spare Parts:

a. Two complete sets of oil, air and fuel filters.

b. Required amount of lube oil for one complete oil change.

c. One quart of touch-up paint.

d. Two spare sets of fuses of each type and rating.

1.06 Quality Assurance

A. Materials and Equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall be the manufacturer’s standard design that has been in satisfactory use for at least one year prior to Bid opening.

B. Factory Tests of the generator shall include, but not limited to, the following:

1. Maximum power (kW).

2. Maximum motor starting (kVA) at 35% instantaneous voltage dip.

3. Alternator temperature rise by embedded thermocouple and/or by resistance method per NEMA MG1-32.40.

4. Governor speed regulation under steady-state and transient conditions.

5. Voltage regulation and generator transient response.

6. Harmonic analysis, voltage waveform deviation, and telephone influence factor.

7. Three-phase short circuit tests.

8. Alternator cooling air flow.

9. Fuel consumption at 100%, 75%, and 50%.

10. Overall engine-generator set efficiency.

11. Torsional analysis to verify that the generator set is free of harmful torsional stresses.

C. The complete packaged electrical system shall be UL 2200 listed and shall be provided with UL listed components.

1.07 Delivery, Storage, and Handling

A. Deliver the engine-driven generator properly packaged and mounted on skids to facilitate handling. Utilize factory-fabricated type containers or wrappings for protection of equipment.

B. Store diesel engine-driven generator equipment in original packaging and protect from weather and construction traffic. Store indoors when possible; where necessary to store outdoors, store above grade and enclose with watertight wrapping.

C. Handle diesel engine-driven generator equipment carefully to prevent physical damage to equipment and components. Do not install damaged equipment; remove from site and replace damaged equipment with new.

D. Provide lifting information for setting gen-set in place to include lifting points, center-of-gravity, etc. Identify lifting items needed including crane capacity, spreader bars needed, special rigging, etc.

1.08 Warranty

A. All equipment furnished under this section shall be warranted by the contractor and the equipment manufacturer(s) for a minimum period of two years after completion of startup or as specified in Section 01 43 33.

B. The manufacturer and its distributor of the packaged standby power system shall maintain a 24-hour parts and service organization. This organization shall be regularly engaged in a maintenance contract program to perform preventive maintenance and service on equipment similar to that specified.

C. Warranty shall include all parts, labor, and expenses to perform necessary work.

D. Other requirements as specified in Division 01.

1.09 Maintenance

A. All maintenance materials supplied with the equipment shall be properly labeled for ease of identification and to permit the shortest possible time to repair.

B. Any parts that come from a sub-supplier shall be labeled with that manufacturer’s name and part number.

C. Manufacturer shall state closest point where spare parts are stocked and where service can be obtained.

D. Manufacturer shall warrant that all parts shall be available for a minimum of ten years.

E. Maximum response time for trouble calls shall be two hours.

F. A qualified service technician shall be onsite within twenty-four hours of a qualified request.

PART 2 - Products

2.01 Manufacturers

A. Caterpillar, Inc.

B. Cummins Power Generation, Inc.

C. Kohler Power, Kohler Co.

D. MTU Onsite Energy, Rolls-Royce Power Systems AG.

2.02 Equipment

A. Generator Set: The generator system shall be completely self-contained and integrally assembled, with the engine, generator, exciter, control panel, muffler, battery, battery charger, water jacket heater, main circuit breaker, service panel, convenience duplex GFCI receptacle, intake air cleaner, radiator and fan and all necessary parts shall be mounted on a steel skid on vibration isolator and shall be housed in a weather protective and sound attenuated enclosure. The complete packaged standby power system shall include the engine-generator set and other necessary parts for a complete functioning system. The generator system shall meet or exceed EPA tier emission levels based on its size and use.

B. The engine generator set shall be provided with anchors, supports and bracing that will meet the local seismic zone rating when installed per the manufacturer's instructions.

2.03 Engine

A. General:

1. Four-stroke cycle, water-cooled diesel engine.
2. Maximum operating speed of 1,800 rpm.
3. Operate on No. 2 diesel fuel.
4. 24Vdc starting.
5. Suitable for standby duty operation at nameplate rating.

B. Fuel System:

1. No. 2 diesel fuel.

2. A UL listed double wall sub base fuel tank with the capacity of 24 hours of operation at 100% of rated load. Provide all required tank openings. An interstitial tank leak alarm system shall be provided to detect fuel tank rupture.

    a. The tank leak alarm shall be provided with a dry contact for remote monitoring. The dry contact shall be rated for a minimum 3A at 120Vac operation and shall be factory wired to the generator control panel.

3. The fuel system shall be provided with primary and secondary fuel filters, water separator, fuel priming pump, fuel pressure gauge, low fuel level alarm, flexible fuel lines, pressure relief vent, and electric and manual shutoff valves.

    a. The low fuel level alarm shall be provided with a dry contact for remote monitoring. The dry contact shall be rated for a minimum of 3A at 120Vac operation and shall be factory wired to the generator control panel.

4. Provide fuel level transmitter for the fuel tank factory wired to the generator control panel.

    a. The fuel level system shall provide a 4-20mA signal proportional to fuel level for remote monitoring.

5. All fuel train components shall be engine mounted and piped.

6. Fuel tank fill nozzle shall be located on the southwest side of unit for easy access for filling. Coordinate with site location to determine fill nozzle location.

7. Fuel tank and system shall meet all requirements of the state, city, and local codes where the project is located.

C. Muffler:

1. The engine exhaust silencer shall be a critical-grade type with a tailpipe and rain cap provided. The silencer shall be coated to be temperature and rust resistance for outdoor application.

2. Gas-proof, seamless, stainless steel, flexible exhaust bellows with threaded NPT or flange connection as necessary.

D. Battery and Battery Charger:

1. 24Vdc lead-acid type storage battery, sized for ten cycles of 15-second cranking with engine at 0° ambient temperature.

2. Filled with proper quantity of electrolyte and fully charged at time of installation.

3. Battery system shall be provided with a disconnect switch.

4. Battery rack and battery cables, capable of holding the manufacturer's recommended batteries, shall be supplied.

5. Provide an automatic float and equalize battery charger with ±1% constant voltage regulation from no load to full load over ±10% AC input line variation, current limited during engine cranking and short circuit conditions, temperature compensated for ambient temperatures from -40°C to +60°C, 5% accurate voltmeter and ammeter, fused, reverse polarity and transient protected.

6. Battery charger shall operate from 120Vac, 60-hertz supply from the generator service panel and shall be capable of fully charging batteries within 24 hours.

7. The battery and battery charger shall be housed in the weather protective generator set enclosure.

8. Battery charger shall be provided with a dry contact for common alarm for remote monitoring. The dry contact shall be rated for 3A at 120Vac operation and shall be wired to the generator control panel.

9. Interlock preventing automatic restart attempts for the following shutdown conditions:

   a. Low lube oil pressure.

   b. High coolant temperature.

   c. Failure to start.

E. Cooling:

   1. Thermostatically controlled water jacket heater for 480Vac operation to maintain 140°F minimum jacket water during idle periods.

   2. Extended life coolant shall be provided to completely fill the radiator tank at the installation site.

   3. Low coolant level alarm.

   4. Unit mounted radiator with guard and duct flange.

   5. Coolant drain line with valve.

   6. Fan and belt guards.

F. Air inlet:

   1. Air cleaner restriction indicator to indicate the need for maintenance.

   2. Heavy-duty single element canister type air cleaner.

   3. Air inlet louvers and baffles shall be designed to reduce rain and snow entry.

G. Lube:

   1. Lubricating oil and filter.

2. Oil drain line with valves.

3. Lube oil pump, if required.

H. Governor:

1. Electronic isochronous type.

2.04 Generator

A. Alternator:

1. Full standby kW rating as indicated at 0.8 power factor.

2. 480/277 Vac wye, 3-phase, 4-wire, 60-hertz, 1,800-rpm operation.

3. Salient-pole, brushless, self-ventilated, drip-proof construction with amortisseur rotor windings and skewed stator for smooth voltage waveform.

4. The insulation shall meet the NEMA standard for Class H.

5. Class F temperature rise of 130°C above 40°C ambient.

6. Winding and bearing temperature detectors to sense high temperature in windings and bearings.

7. Complete with voltage regulation, control panel, and excitation system.

8. Provide segregated low voltage accessory boxes for AC/DC. Separate boxes for generator AC output, low voltage AC auxiliary power and control wiring, and DC wiring. Provide single point access to accessory connections.

9. Condensate strip heater to prevent the accumulation of moisture for dampness in the generator windings.

10. Harmonic distortion of less than 5%.

11. Overspeed capability of not less than 125%.

B. Excitation:

1. Permanent magnet.

C. Voltage Regulation:

1. Digital voltage regulator, 3-phase sensing, selectable voltage range, and volts/hertz.

2. Accuracy of less than 1% no-load to full-load and less than 0.5% at steady-state.

D. Control Panel:

1. Environment:
    a. -40°C to +70°C operating temperature range.
    b. 5-95% humidity, non-condensing.
2. Unit mounted controller mounted on vibration isolators.
3. The controller shall be rated for outdoor installation.
4. Configured for 2-wire start/stop remote control (remote contact operation) from an automatic transfer scheme.
5. Control panel shall include as minimum:
    a. Automatic start/stop operation.
    b. Adjustable cycle cranking.
    c. Digital ac metering with phase selector switch.
    d. Digital engine monitoring.
    e. Shutdown sensors and alarms with horn and reset.
    f. Adjustable cool-down timer.
    g. Local emergency stop push-button.
    h. Lamp test.
    i. Voltage control.
6. Control panel shall include as minimum the following displays:
    a. Engine oil pressure.
    b. Coolant temperature.
    c. Engine rpm.
    d. System dc volts.
    e. Engine running hours.
    f. Generator ac volts.
    g. Generator ac amps.
    h. kW meter.
    i. Percentage of rated power.

   j. kVA meter.
   k. kVAR meter.
   l. Power factor meter.
   m. kWhr meter.
   n. Frequency.
   o. Fuel Level.

7. Control panel shall have programmable protective relay functions to include the following:
   a. High and low battery voltage.
   b. Under- and over-voltage.
   c. Under- and over-frequency.
   d. Overspeed.
   e. Reverse power.
8. Adjustable Time Delay Settings:
   a. Generator set run time (0 to 72 hours) - exercise.
   b. Time delay for engine start. Adjustment range, 0-5 minutes in one second increments.
   c. Time delay engine cool-down. Adjustment range, 0-10 minutes in one second increments.
   d. Cyclic cranking that allows up to six crank cycles and up to 45 seconds of crank time per crank cycle.
   e. Over and under voltage delays.
   f. Crank on and crank pause time.
   g. Idle time.
   h. High and low battery voltage trip point.
9. Shall accommodate remote mounted emergency shutdown push button.
10. Provide generator run relay, common warning, and common failure relays.
    a. The common failure relay shall monitor auxiliary faults, emergency stop, high engine temperature, low oil pressure, overcrank, and overspeed.

b. Dry output contacts from these relays will be used for remote alarm.

c. The following minimum status contacts shall be provided and wired through the main generator control panel for field connection.

(1) Generator Control Panel – In Auto Mode.

(2) Run Status.

(3) Common Warning Alarm.

(4) Common Shutdown/Failure Alarm.

(5) Low Fuel Level Alarm.

(6) Fuel Leak Alarm.

11. Control panel shall be capable of communicating control and monitored parameters digitally with the low voltage switchgear.

2.05 Weatherproof Enclosure

A. The weatherproof walk-in style housing shall be as follows:

1. Sound attenuated with the maximum sound level of 70 dBA at 50 feet when operating at full load.

2. Constructed of heavy-gauge steel, cleaned and powder-baked painted inside and out. Provide with the manufacturer's standard color.

3. The complete exhaust system shall be internal to the enclosure.

4. The radiator shall be ducted to the enclosure air outlet on the top to prevent air recirculation within the enclosure.

5. The roof shall be pitched to prevent the accumulation of water.

6. Enclosure shall be designed for local wind and snow loading requirements.

7. The personnel doors shall be double-wide and located on either side of the enclosure.

8. All hinges, latches, and recessed door handles shall be stainless steel and lockable.

9. A permanent aluminum staircase with landing shall be provided at the main access door for ease of access into the generator enclosure.

10. Provide interior lights and receptacles wired to the service panel. Provide LED strip lighting fixtures for normal operation and emergency driver units installed

within the LED strip fixtures for emergency lighting. Provide light switches at each door.

11. Provide enclosure ventilation with exhaust fan(s) and thermostats sized for ambient conditions to maintain internal temperature below component ratings.

2.06 Service Panel

A. Provide a 208/120Vac, three-phase, 100A, NEMA 3R electrical panel with the engine-generator set. The panel shall be unit mounted on the engine-generator set inside the weather protective enclosure. All auxiliary loads such as fuel immersion heater, water jacket heater, battery charger, generator condensate strip heater, convenience duplex GFCI receptacles, lighting, etc. The service panel shall be the means of single point connection to service all auxiliary loads mounted on the engine-generator set. Shall consist of a 100A main molded-case circuit breaker, required number of branch circuit breakers, and 10% spare.

B. All wiring to the auxiliary loads shall be factory wired with copper wires and shall be sized and installed in accordance with the National Electrical Code.

C. The panel directory shall be provided and each load served shall be clearly marked on the panel directory.

D. Provide a 480-208Y/120V step down transformer to accept the required 480V 3-phase auxiliary supply as indicated. The transformer shall be rated a minimum of 30kVA. The transformer shall be installed within the generator weatherproof enclosure and pre-wired to the supplied service panel. Transformers shall conform to Section 26 22 00 – Low-Voltage Distribution Transformers.

2.07 _Automatic Transfer Controls

A. The automatic transfer control system shall be installed in the low-voltage switchgear. Refer to Section 26 23 00.

2.08 Accessories

A. Provide a NEMA 4X push button station with red mushroom head push button for generator emergency stop. The push button shall be provided with a legend "Genset Emergency Stop". Location as indicated on the Contract Drawings.

B. Required amount of lube oil.

C. Required amount of coolant.

D. Vibration isolators for base skid mounting.

E. One set of special engine tools, if applicable.

PART 3 - Execution

3.01 Examination

A. Verify site conditions are suitable for installation of equipment.

B. Examine areas and conditions under which the engine-generator equipment is to be installed. Direct the vertical airflow of exhaust hot air above level of personnel and away from buildings.

C. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.02 Installation

A. Install diesel engine-driven generator units at location indicated.

B. Install in accordance with the equipment manufacturer's written instructions, and with guidance from recognized industry practices, to ensure that engine-generator units fulfill requirements. Comply with NFPA, NEC, and NEMA standards pertaining to installation of engine-generator sets and accessories.

C. Coordinate with other work, including raceways, electrical boxes, fittings, fuel tanks, piping, and accessories, as necessary to interface installation of engine-generator equipment work with other work.

D. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and the National Electrical Code.

E. Final pad dimensions shall be coordinated with equipment supplied.

F. Anchor skids as recommended by the generator set manufacturer.

G. Connect all electrical and fuel connections as required.

H. Install units on vibration isolators in accordance with the manufacturer's instructions.

I. Fill all tanks (coolant, lubricants, diesel, etc.) to full with approved fluids. Refer to Field Testing, this Section for all required fuel during start up and refilling of the fuel tank after start up.

J. Make all necessary adjustments to ensure manufacturer’s recommended tolerances are met.

K. Ground the skid base as shown on the drawings.

L. Supply field power to the generator service panel as specified and indicated.

3.03 Field Quality Control

A. Manufacturer’s Field Services:

1. Manufacturer's field service shall be provided as specified in this Section and in DIVISION 01.

2. Engage manufacturer’s service technician to perform start-up services upon completion of installation and with Engineer in attendance.

B. Field Testing:

1. Check fuel, lubricating oil, and antifreeze for conformity to manufacturer’s recommendations under site environmental conditions.

2. Verify operational status of engine water jacket heaters, battery charger, and other auxiliaries.

3. Perform “start-up” tests as recommended by manufacturer.

4. Check for exhaust leaks, path of exhaust gases outside the enclosure, cooling air flow, motorized louver operation, movement during starting and stopping and vibration during running.

5. Recorded generator operating parameters shall include:

    a. Line-to-line voltage.

    b. Line-to-neutral voltage.

    c. Power factor.

    d. Amperes.

    e. kW.

    f. kVA.

    g. Frequency.

    h. Phase rotation.

    i. Engine temperature.

    j. Oil pressure.

    k. Battery charge level.

6. Verify generator is operational using the automatic transfer controls. Simulate power outage to verify proper start-up and transfer from normal utility power to generator power and retransfer from generator power to utility power.

7. After installation a 2-hour test shall be performed with load bank provided by the contractor..

8. Perform the engine generator acceptance testing as specified in NFPA 110 (7.13) and submit the final results of the acceptance testing to Engineer for review for compliance.

9. Provide all required fuel (coolant, lubricants, diesel, etc.) for start-up. Refill the fuel tank to full level after the completion of start-up.

3.04 Finishes

A. Equipment coatings shall be free from scratches, rust, or other defects.

B. All damaged or defective coatings shall be repaired prior to final acceptance.

C. Field Painting:

1. Touch Up:

    a. Contractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.

    b. Field painting shall be performed based on manufacturer’s recommended procedures.

    c. Manufacturer shall furnish Contractor with an adequate quantity of touch-up paint to match the factory applied finish.

3.05 Training

A. The system supplier shall provide a minimum of one day of training at the customer's facility for operations, maintenance and service personnel.

B. The training shall be performed after successful completion of a demonstration of operation of the equipment by the manufacturer and acceptance by the customer,

C. The training session shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment. Topics covered shall include safety, hardware layout and functions, power and control wiring, diagnostic indicators, keypad/display interface, faults, diagnostic tools, troubleshooting, and preventive maintenance for engine-generator and battery systems.

D. Hands-on training shall be provided on equipment.

E. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.

F. The Owner at their option shall be allowed to video record all training sessions for future reference.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section includes transfer switches rated 600 V and less, including the following:

1. Automatic transfer switches.

1.03 Related Requirements

A. Section 26 05 10 – Basic Electrical Requirements

1.04 References

A. Applicable Standards (latest edition):

1. National Electrical Manufacturer's Association (NEMA):
   a. NEMA ICS 1 - Industrial Control and Systems General Requirements.
2. National Fire Protection Association (NFPA):
   a. NFPA 70 - National Electrical Code.
   b. NFPA 99 - Health Care Facilities Code.
   c. NFPA 101 - Life Safety Code.
   d. NFPA 110 - Standard for Emergency and Standby Power Systems.
3. Underwriters' Laboratories (UL):
   a. UL 1008 - UL Standard for Safety Transfer Switch Equipment.

1.05 Submittals

A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Provide project-specific information indicating specific upstream-protective devices required to achieve indicated withstand current rating. Do not protect a transfer switch with a circuit breaker applied at its series rating.

2. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

3. Controls wiring: Provide drawings showing locations of external controls and monitoring connections.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. Include the following:

1. Features and operating sequences, both automatic and manual.

2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.06 Quality Assurance

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

B. Source Limitations: Obtain automatic transfer switches through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with NEMA ICS 1.

E. Comply with NFPA 70.

F. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.07 Project Conditions

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:

1. Do not proceed with interruption of electrical service without Owner's written permission.

PART 2 - Products

2.01 Manufacturers

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Contactor Transfer Switches:

    a. Emerson; ASCO Power Technologies, LP. (7000 series)

    b. Russelectric, Inc.

    c. GE Zenith Controls.

2.02 General Transfer-Switch Product Requirements

A. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

B. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2% or better over an operating temperature range of minus 20 to plus 70ºC.

C. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

D. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

E. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.

2. Switch Action: Double throw; mechanically held in both directions.

3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts, with arc chutes.

F. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Section 26 05 53 - Identification for Electrical Systems.

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.

2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.

3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

G. Enclosures: General-purpose NEMA 250, Type 12, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.03 Automatic Transfer Switches

A. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

B. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

C. Automatic Transfer-Switch Features:

1. Undervoltage Sensing for Each Phase of Normal Source and second source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100% of nominal, and dropout voltage is adjustable from 75 to 98% of pickup value. Factory set for pickup at 90% and dropout at 85%.

2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer. Adjustable from zero to six seconds, and factory set for one second.

3. Voltage/Frequency Lockout Relay: Prevent premature transfer to secondary source. Pickup voltage shall be adjustable from 85 to 100% of nominal. Factory set for pickup at 90%. Pickup frequency shall be adjustable from 90 to 100% of nominal. Factory set for pickup at 95%.

4. Test Switch: Simulate normal-source failure.

5. Switch-Position Pilot Lights: Indicate source to which load is connected, green for "normal", red for "emergency".

6. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

   a. Normal Power Supervision: White light with nameplate engraved "Normal Source Available."

   b. Emergency Power Supervision: Yellow light with nameplate engraved "Emergency Source Available."

7. Push-to-Test Lights: All lights shall be push-to-test type.

8. LED Lights: All lights shall be LED-type.

9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

2.04 Source Quality Control

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - Execution

3.01 Installation

A. Identify components according to Section 26 05 53 – Electrical Identification.

B. Set field-adjustable intervals and delays, and relays.

3.02 Connections

A. Ground equipment according to Section 26 05 26 - Grounding and Bonding for Electrical Systems.

B. Connect wiring according to Section 26 05 19 - Low-Voltage Electrical Conductors and Cables.

3.03 Field Quality Control

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.

2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.

3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

a. Check for electrical continuity of circuits and for short circuits.

b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.

c. Verify that manual transfer warnings are properly placed.

d. Perform manual transfer operation.

5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

   a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.

   b. Simulate loss of phase-to-ground voltage for each phase of normal source.

   c. Verify time-delay settings.

   d. Verify pickup and dropout voltages by data readout or inspection of control settings.

   e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.

   f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50% from other poles.

   g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

C. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

D. Remove and replace malfunctioning units and retest as specified above.

3.04 Demonstration

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Section 01 79 00 - Demonstration And Training.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section includes parallel and series-wired, surge protective devices (SPDs) for service entrance and AC distribution equipment not exceeding 1000V, including disconnects, switchboards, panelboards, as well as point-of-service equipment.

1.03 Related Requirements

A. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

B. Section 26 23 00 – Low Voltage Switchgear.

C. Section 26 24 13 – Switchboards.

D. Section 26 24 16 – Panelboards.

E. Section 40 67 00 – Process Control Panels and Hardware – For control panel Type 2 and Type 4 surge protective devices that protect data and signal lines, and other hardwired communication devices within a control panel.

1.04 Reference Standards

A. National Fire Protection Association (NFPA):

1. 70 – National Electrical Code (NEC)
    a. Article 285 – Surge-Protective Devices (SPDs) 1 kV or Less.
2. 780 – Standards for the Installation of Lightning Protection Systems.

B. National Electrical Manufacturers Association (NEMA). Comply with applicable requirements of the following standards:

1. 250 – Enclosures for Electrical Equipment (1,000V maximum).

C. Underwriters Laboratories (UL). Comply with applicable requirements of the following standards:

1. 1283 – Electromagnetic Interference Filters.

2. 1449 4th Edition, 2009 – Surge Protective Devices.

D. Institute of Electrical and Electronic Engineers (IEEE) comply with applicable requirements of the following standard.

1. C62.33-1982 – Test Specifications for Varistor Surge-Protective Devices.

2. C62.41.1-2002 – Surge Environment in Low-Voltage (1000V and less) AC Power Circuits.

3. C62.41.2-2002 – Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits.

4. C62.45-2002 – Surge Testing for Equipment Connected to Low Voltage (1000V and less) AC Power Circuits.

5. C62.62-2000 – Test Specification for Surge Protective Devices for Low Voltage AC Power Circuitry.

6. Std 1100-2005 (Emerald Book) – Recommended Practice for Powering and Grounding Electronic Equipment.

1.05 Definitions and Abbreviations

A. I-n: I-nominal rating.

B. MCOV: Maximum Continuous Operating Voltage rating.

C. MOV: Metal Oxide Varistors.

D. SAD: Silicon Avalanche Diodes.

E. SCCR: Short Circuit Current Rating.

F. SPD: Surge Protection Device.

G. VPR: Voltage Protection Rating.

H. Type 1 SPDs – Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service equipment overcurrent device, as well as the load side, including watt-hour meter socket enclosures and intended to be installed without an external overcurrent protective device.

I. Type 2 SPDs – Permanently connected SPDs intended for installation on the load side of the service equipment overcurrent device; including SPDs located at the branch panel.

1.06 Submittals

A. Submit as specified in DIVISION 01 and SECTION 260510 – Basic Electrical Requirements.

B. Product Data – Submit for each type of product specified, including the following as a minimum:

  1. Data sheets:

    a. Physical details and dimensions.

    b. Power input voltage and frequency.

    c. Type category.

    d. UL 1449 Listing documentation verifying the following:

      (1) Short Circuit Current Rating (SCCR).

      (2) Voltage Protection Ratings (VPRs) for all modes.

      (3) Maximum Continuous Operating Voltage rate (MCOV) for Type 1 and Type 2 SPDs.

      (4) I-nominal rating (I-n) for Type 1 and Type 2 SPDs.

      (5) Device type designation.

    e. Peak surge current rating per phase.

C. Shop Drawings: For externally-mounted units, provide shop drawings including manufacturer's installation requirements, field connections and manufacturer's recommended wire and breaker sizes.

D. Closeout Submittals – Final documentation shall include the following as a minimum:

  1. Operation and Maintenance Manuals including the following:

    a. Operation and maintenance manuals for each type of SPD.

    b. Copies of all approved Product Data.

    c. Copies of all approved Shop Drawings.

    d. Warranty information.

1.07_Source Quality Control

A. Tests, inspections: At the shop, factory, plant, or place of manufacture.

B. Verification of performance: Compliance with specified criteria.

1.08 Delivery, Storage, and Handling

A. Non-integral surge protective devices (SPDs) shall be stored according to the manufacturer’s instructions and in a conditioned space to avoid condensation, dust, and other environmental contaminants.

B. Integral SPDs shall be delivered, pre-installed, and stored according to the requirements of the distribution equipment or control panel in which they are installed.

1.09 Project Site Conditions

A. Do not deliver or install SPDs or equipment in which they are installed until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above installation area is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

B. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Engineer and Owner’s Engineer no fewer than two days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without written permission of Engineer.

1.10 Coordination

A. Coordinate layout and installation of remote surge protective devices with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.10 Warranty

A. SPD manufacturer shall provide free replacement of the entire model with a minimum warranty period of 10 years from date of shipment. This warranty shall be limited only by failure to comply with manufacturer's installation instructions and applicable national or local code and may not exclude lightning or temporary overvoltage.

PART 2 - Products

2.01 Manufacturers

A. A manufacturer's presence on this list does not guarantee that all of its models are acceptable. The Contractor is responsible for insuring that each SPD model meets all requirements of this specification.

B. AC Power Distribution Units:

1. Advanced Protection Technologies, Inc.
2. Eaton – Innovative Technology.
3. Erico International Corporation.
4. General Electric.
5. Mersen.
6. Schneider Electric.
7. Siemens.
8. Engineer-approved equal.

2.02 General Requirements for Surge Protective Devices

A. UL 1449 Fourth Edition, listed and labeled.

B. Shall be UL labeled as a Type 1 or Type 2 device, shall be intended to be installed on the load side of the service entrance equipment and shall not require external or supplemental overcurrent safety controls to meet UL 1449 4th Edition.

C. The surge protective device (SPD) shall be of a modular design using fast-acting transient energy protection that will divert and dissipate the surge energy.

D. Shall provide independent, directly-connected suppression components on each mode in the electrical distribution system, at least seven modes in Wye systems (L-N, L-G, N-G) and six modes (L-L, L-G) in Delta and impedance grounded Wye systems.

E. Shall be an internally-mounted or externally-mounted device as specified or indicated.

F. Shall use metal oxide varistor or MOV-hybrid technology as necessary. (Spark gaps, selenium cells and SCRs shall not be acceptable.)

G. Shall include internal fuses and thermally protection over every suppression component of every mode, including N-G unless protecting the service entrance.

H. Shall have integral, panel front status monitors or remote status panel ability as a minimum to indicate a continuous positive status of all protected modes, including N-G mode where applicable. Diagnostics shall be electrically isolated to prevent damage by surges.

I. Shall be UL labeled with a short circuit current rating of 200kA.

J. The maximum continuous operating voltage at 60 Hz shall be capable of sustaining at least 115% of the peak voltages continuously without degrading.

K. The maximum UL 1449 Fourth Edition Voltage Protection Ratings (VPR) for the device must not exceed the following:

Service	L-N	L-G	N-G	L-L	MCOV
120V 2-wire + Gnd	600V	1000V	600V	NA	150
120/240Vac 3-Wire + Gnd	700V	700V	700V	1200V	150
208/120Vac 3-phase, 3 or 4-wire	700V	700V	700V	1200V	150/276
480 Vac 3-phase, 3 Wire Delta	NA	1800V	NA	1800V	550
480/277 Vac 3-phase, 3-wire or 4-wire	1200V	1200V	1200V	2000V	550/320

L. Type 1 and Type 2 SPDs shall be UL labeled with 20kA I-n for compliance to UL 96A Lightning Protection Master Label and NFPA 780.

2.03 Surge Protective Device for Downstream Switchboards, Panelboards and Point of Service Equipment

A. The SPD shall be suitable for 480V, 208/120V 3-phase, 3-wire and 4-wire as indicated, 60Hz.

B. Downstream SPD units shall be tested and demonstrated suitable for application with ANSI/IEEE C62.41 Category B environments.

C. Shall have a peak surge current of 160 kA per phase.

D. Externally mounted units shall have a NEMA 12, steel or composite fiberglass enclosure.

E. Internally-mounted units shall have a NEMA 1 enclosure designed for back panel or DIN rail mounting within a control panel or motor control center.

F. Shall include EMI/RFI filtering for ring wave suppression.

G. Shall have a minimum EMI/RFI filtering of -30dB at 100 kHz.

H. UL 1283 Listed. (Latest Edition)

2.04 Additional Requirements for Plug-On SPDs

A. Shall be directly connected to the equipment bus bar through an integral circuit breaker sized as recommended by the manufacturer.

B. Shall include a display with a resettable counter for the combined total number of transient voltage surges detected since the counter was reset.

2.05 Additional Requirements for SPDs Integral to The Power Distribution Equipment

A. The SPD shall be mounted to the equipment by a direct bus bar connection.

B. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, or sub-feed breaker options.

C. The power distribution equipment shall be capable of re-energizing upon removal of the SPD.

2.06 Accessories

A. Monitoring Diagnostics/Accessories:

1. Protection Status Indicators - Each unit shall have a green/red solid-state indicator light that reports the status of the protection element on each phase.

    a. Wye configured units, shall have indication in the L-N and L-G and N-G modes.

    b. Delta configured units, shall have status indication in the L-G and L-L modes.

    c. The absence of a green light and the presence of a red light shall indicate that damage has occurred on the respective phase or mode. All protection status indicators must indicate the actual status of the protection on each phase or mode. If power is removed from any one phase, the indicator lights must continue to indicate the status of the protection on all other phases and protection modes. Diagnostics packages that simply indicate whether power is present on a particular phase shall not be accepted.

2. Remote Status Monitor: The SPD must include Form C dry contacts (one NO and one NC) for remote annunciation of its status. Both the NO and NC contacts shall change state under any fault condition.

3. Audible Alarm and Silence Button: The SPD shall contain an audible alarm that will be activated under any fault condition. There shall also be an audible alarm silence button used to silence the audible alarm after it has been activated.

4. Surge Event Counter: The SPD shall be equipped with an LCD display that indicates to the user how many surges have occurred at the location.

    a. The surge counter shall trigger each time a surge event with a peak current magnitude of a minimum of 50 ± 20A occurs. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed. The reset button shall contain a mechanism to prevent accidental resetting of the counter via a single, short-duration button press. In order to prevent accidental resetting, the surge counter reset button shall be depressed for a minimum of 2 seconds in order to clear the surge count total.

    b. The ongoing surge count shall be stored in non-volatile memory. If power to the SPD is completely interrupted, the ongoing count indicated on the surge counter's display prior to the interruption shall be stored in non-volatile memory and displayed after power is restored. The surge counter's memory shall not require a backup battery in order to achieve this functionality.

2.07 Finishes

A. Manufacturer shall prepare surfaces, prime, and finish paint all surfaces with manufacturer's standard coating system. Coating system and color shall be suitable for intended services.

PART 3 - Execution

3.01 Examination

A. Examine area and location of equipment to receive SPDs for compliance with manufacturer's environmental conditions and other conditions affecting performance of the Work.

B. Examine field installed SPDs before installation. Reject SPDs that have been wet, moisture damaged, or physically damaged.

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

3.02 General Installation Requirements

A. The installation of the surge suppression system shall be installed in strict accordance with the manufacturer's recommended practices and in compliance with the NEC.

B. The Contractor shall verify the proper application of the SPD (i.e. voltage, phases, etc.)

C. The Contractor shall verify that all neutral conductors are bonded to the system ground at the service entrance or at the serving transformer prior to installation of the SPD.

D. The phase, neutral and grounding conductors serving the SPD shall be gently twisted to reduce the SPD system inductance and shall be kept at the minimum length. Avoid any sharp bends and coils in the conductors.

E. Do not perform insulation resistance tests on a piece of electrical equipment with an SPD installed. SPDs are not designed to withstand the relatively high voltages applied for the duration of a megger test measured in seconds. Disconnect the SPD during insulation testing and reconnect immediately after testing is over.

3.03 Installation of Externally-Mounted SPDs

A. The SPD shall be located immediately adjacent or nippled up to the equipment being protected to meet the manufacturer recommended installation.

B. Provide a disconnecting means or overcurrent protection and wiring as recommended by the manufacturer. When no recommendation is provided install the SPD through a 30A circuit breaker using a #10 gauge wire.

C. When installed at a service entrance, the SPD shall be installed on the load side of the main service disconnect overcurrent device.

D. When installed at a separately-derived system, the SPD shall be connected on the load side of the first overcurrent device.

E. When protecting a panelboard, switchboard or motor control center, install the SPD through a breaker as a disconnecting source per the manufacturer's installation instructions. Installer may reasonably rearrange breaker locations to ensure short and straightest possible leads to SPD.

F. If the lead length exceeds 18 inches, the Contractor shall notify the Engineer and contact the surge suppression manufacturer for installation assistance.

G. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 468A and the National Electrical Code.

H. The SPD installation shall be certified by a licensed electrician that the installation is in accordance with the manufacturer’s recommendations, applicable electrical code requirements, and the requirements of this specification. Any deficiencies noted shall be corrected by the Contractor. Provide written documentation of this inspection as part of the closeout documentation.

3.04 Installation of Internally-Mounted SPDs

A. When installed within a switchboard, motor control center, or panelboard the SPD shall be installed in a dedicated bucket or space.

B. When installed within a control panel, the SPD shall be provided and installed by the control panel fabricator. Refer to Section 40 95 13 – Process Control Panels and Hardware.

C. Provide a disconnecting means or overcurrent protection and wiring as recommended by the manufacturer. When no recommendation is provided install the SPD through a 30A circuit breaker using a #10 gauge wire.

3.05 Field Quality Control

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect SPDs, modules, connections, and installation. Test and Inspect SPDs for proper function per manufacturers recommendations.

3.06 Finishes

A. Externally Mounted SPDs: SPD enclosure coatings shall be free from scratches, rust, or other defects.

B. All damaged or defective coatings shall be repaired prior to final acceptance.

C. Field Painting:

1. Touch Up:

   a. Contractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.

   b. Field painting shall be performed based on manufacturer’s recommended procedures.

c. Contractor shall provide the necessary quantity of Manufacturer's touch-up paint to match the factory applied finish.

3.07 Adjusting and Cleaning

A. For externally mounted SPDs: After field installation and final wiring terminations are completed the SPD wiring and cables shall be adjusted and neatly secured with tie wraps, hook-and-loop straps, or the like.

B. Prior to final acceptance enclosure interior and exterior shall be wiped clean and free from dust and debris.

3.08 Demonstration

A. Upon completion of installation of SPDs and associated electrical circuitry, energize circuitry and demonstrate functioning of equipment in accordance with manufacturer's requirements. Where possible, correct any malfunctioning units at the project site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and retest to demonstrate compliance.

3.09 Training

A. Provide a minimum of 1 hour of training for each type of SPD provided at the customer's facility for operations, maintenance and service personnel.

1. The training session shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment.

2. Topics covered shall include safety, hardware layout and functions, power and control wiring, diagnostic indicators, keypad/display interface, faults, diagnostic tools, troubleshooting, and preventive maintenance.

3. Hands-on training shall be provided on equipment.

4. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.

B. The Owner at their option shall be allowed to video record all training sessions for future reference.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section includes the following:

1. Interior Luminaires:
    a. Light-emitting Diode (LED).
2. Emergency lighting units.
3. Ballasts and drivers.
4. Emergency ballasts and drivers
5. Lamps.
6. Luminaire accessories.

1.03 Related Requirements

A. Section 26 05 10 – Basic Electrical Requirements.

B. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

C. Section 26 05 33 – Raceways, Boxes, Seals, and Fittings for Electrical Systems.

D. Section 26 05 53 – Electrical Identification.

E. Section 26 27 26 – Wiring Devices.

1.04 Reference Standards

A. American National Standards Institute (ANSI)/Institute of Electrical and Electronic Engineers (IEEE):

1. ANSI/IEEE C62.41.2 – Recommended Practice on Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits; 2002 (Cor 1, 2012).

B. Illuminating Engineering Society of North America (IESNA):

1. IESNA LM-63 – ANSI Approved Standard File Format for Electronic Transfer of Photometric Data and Related Information; 2002 (Reaffirmed 2008).

2. IESNA LM-79 – Electrical and Photometric Measurements of Solid-State Lighting; Latest Edition.

C. National Electrical Contractors Association (NECA):

1. NECA 1 – Standard for Good Workmanship in Electrical Construction; National Electrical Contractors Association; 2010.

2. NECA/IESNA 502 – Standard for Installing Industrial Lighting Systems; National Electrical Contractors Association; 2006.

D. National Electrical Manufacturers Association (NEMA):

1. NEMA 410 – Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts; National Electrical Manufacturers Association; 2011.

E. National Fire Protection Associations (NFPA):

1. NFPA 70 – National Electrical Code; National Fire Protection Association; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

2. NFPA 101 – Life Safety Code; National Fire Protection Association; 2012.

F. Underwriters Laboratories (UL):

1. UL 924 – Emergency Lighting and Power Equipment; Current Edition, Including All Revisions.

2. UL 1598 – Luminaires; Current Edition, Including All Revisions.

3. UL 8750 – Light Emitting Diode (LED) Equipment for Use in Lighting Products; Current Edition, Including All Revisions.

1.05 Administrative Requirements

A. Coordination:

1. Coordinate the installation of luminaires with mounting surfaces installed under other sections or by others. Coordinate the Work with placement of supports, anchors, etc. required for mounting. Coordinate compatibility of luminaires and associated trims with mounting surfaces at installed locations.

2. Coordinate the placement of luminaires with structural members, ductwork, piping, equipment, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.

3. Coordinate the placement of exit signs with furniture, equipment, signage or other potential obstructions to visibility installed under other sections or by others.

4. Coordinate placement of poles and associated foundations with utilities, curbs, sidewalks, trees, walls, fences, striping, etc., installed under other Sections or by others. Coordinate elevation to obtain specified foundation height.

5. Notify Engineer of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.

1.06 Submittals

A. Refer to Section 01 33 00 – Submittals and SECTION 26 05 10 – Basic Electrical Requirements, for administrative and procedural requirements for submittals.

B. Shop Drawings:

  1. Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.

  2. Provide photometric calculations where luminaires are proposed for substitution upon request.

C. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, installed accessories, and ceiling compatibility; include model number nomenclature clearly marked with all proposed features. Arrange in order of luminaire designation.

  1. Provide electronic files of photometric data certified by a National Voluntary Laboratory Accreditation Program (NVLAP) lab or independent testing agency in IESNA LM-63 standard format upon request.

  2. Ballasts: Include ballast factor, wiring diagrams and list of compatible lamp configurations.

  3. Lamps: Include rated life, color temperature, color rendering index (CRI), initial and mean lumen output, and energy efficiency data.

  4. Emergency Ballasts and Drivers: Include list of compatible lamp configurations associated lumen output, and battery and charger data.

  5. Emergency Lighting Units: Battery and charger data.

  6. Exit Signs: Battery and charger data.

  7. Provide means of attaching luminaires to supports, and indication that attachment is suitable for components involved.

D. Wiring diagrams: Include diagrams for power, signal and control wiring. Differentiate between portions of wiring which are manufacturer factory-installed and portions which are field-installed.

E. Field Quality Control Reports.

F. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

G. Operation and Maintenance Data: Instructions for each product including information on replacement parts.

1. Provide a list of all lamp types used on the Project; use ANSI and manufacturers' codes.

H. Maintenance Materials: Furnish the following for Owner's use in maintenance of Project.

1. See Division 01 for additional Equipment and Materials provisions.
2. Extra Lenses and Louvers: 2% of total quantity installed for each type, but not less than one of each type.
3. Extra Lamps: 10% of total quantity installed for each type, but not less than two of each type.
4. Extra Globes and Guards: 2% of total quantity installed for each type, but not less than one of each type.
5. Extra LED drivers: 2% of total quantity installed for each type, but not less than one of each type.

I. Project Record Documents: Record actual connections and locations of luminaires, pole foundations, any associated pull or junction boxes, and any remote components.

1.07 Quality Assurance

A. Conform to requirements of NFPA 70.

B. Maintain at the Project Site a copy of each referenced document that prescribes execution requirements.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.

1.08 Delivery, Storage, and Handling

A. Receive, handle, and store products according to NECA/IESNA 500 (commercial lighting), NECA/IESNA 501 (exterior lighting), NECA/IESNA 502 (industrial lighting), and manufacturer's written instructions.

B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

1.09 Field Conditions

A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.10 Warranty

A. See Section 01 78 00 - Closeout Submittals for additional warranty requirements.

B. Interior Lighting:

1. Provide two year manufacturer warranty for all interior luminaires unless specified otherwise.

2. LED luminaires shall have a minimum 5 year manufacturer warranty.

3. Provide five year pro-rata warranty for batteries for emergency lighting units.

4. Provide ten year pro-rata warranty for batteries for self-powered exit signs.

5. Provide three year full warranty for emergency ballasts and drivers.

C. Repair or replace all luminaires and lighting poles that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

PART 2 - Products

2.01 Manufacturers

A. Luminaires:

1. General Electric Company/GE Lighting.

2. Photometrics Pro

3. Lithonia Lighting

B. Emergency Lighting Units and Exit Signs:

1. Lithonia Lighting.

2. General Electric Company/GE Lighting.
3. Photometrics Pro.

C. Ballasts and Drivers:

1. General Electric Company/GE Lighting.
2. Holophane.
3. Universal Lighting Technologies.
4. Philips Lighting Electronics/Advance.
5. Manufacturer Limitations: Where possible, for each type of luminaire provide ballasts produced by a single manufacturer.

D. Emergency Ballasts and Drivers:

1. General Electric Company/GE Lighting.
2. Holophane.
3. Universal Lighting Technologies.
4. Lithonia Lighting.
5. Philips Emergency Lighting/Advance.
6. Manufacturer Limitations: Where possible, for each type of luminaire provide emergency ballast and drivers produced by a single manufacturer.

E. Lamps:

1. General Electric Company/GE Lighting.
2. Osram Sylvania.
3. Philips Lighting Company.
4. Manufacturer Limitations: Where possible, provide lamps produced by a single manufacturer.

2.02 Luminaire Types

A. Furnish products as indicated in the luminaire schedule included on the Contract Drawings.

2.03 Luminaires

A. Provide products that comply with requirements of NFPA 70.

B. Provide products that are listed and labeled as complying with UL 1598, where applicable.

C. Provide products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

D. Provide products with lamp base complying with ANSI C81.61.

E. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.

F. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, supports, trims, accessories, etc., as necessary for a complete operating system.

G. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.

H. Interior Luminaire Materials:

1. Metal Parts:

a. Free of burrs and sharp corners and edges.

b. Sheet metal components shall be steel unless otherwise indicated.

c. Form and support to prevent warping and sagging.

2. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

3. Diffusers and Globes:

a. Acrylic Diffusers: 100% virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

b. Glass: Annealed crystal glass unless otherwise indicated.

c. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

4. Housings:

a. Extruded-aluminum housing and heat sink.

b. Painted finish after fabrication, finish as indicated in luminaire schedule.

5. Conduit: Minimum 3/4 inch (21 mm) in diameter, type as specified.

6. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

    a. Label shall include the following lamp characteristics:

        (1) "USE ONLY" and include specific lamp type.

        (2) Lamp diameter, shape, size, wattage, and coating.

        (3) ANSI ballast type (M98, M57, etc.) for HID luminaires.

        (4) CCT and CRI for all luminaires.

7. Metal Finishes:

    a. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples, and if they can be and are assembled or installed to minimize contrast.

I. LED Luminaires:

1. General:

    a. LED Luminaire Components: UL 8750 recognized or listed as applicable. Tested according to LM-79.

    b. Luminaires shall be binned with a minimum of a three-step MacAdam Ellipse to ensure color consistency among luminaires.

2. LED Luminaires with Integral LEDs:

    a. Correlated Color Temperature (CCT):

        (1) Indoor: 3,500 (neutral)K unless otherwise indicated.

    b. Color Rendering Index (CRI): Not less than 80.

    c. Average Rated Life: Not less than 50,000 hours for an operating cycle of three hours per start.

    d. LED Assembly shall be mounted to die cast aluminum housing for thermal management.

    e. LED drivers shall have a power factor greater than 0.90 lagging and less than 20 percent total harmonic current distortion (THD).

    f. Operating temperature of LED assembly and fixture shall be rated for -30 to +40°C ambient.

    g. Fixture shall be UL listed for operation in damp locations when indicated.

2.04 Emergency Lighting Units

A. Description: Emergency lighting units complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.

B. Operation: Upon interruption of normal power source or brownout condition exceeding 20% voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.

C. Battery:

1. Size battery to supply all connected lamps, including emergency remote heads where indicated.

2. Remote Mounted: Provide NEMA 250, Type 1 enclosure listed for installation inside, on top of, or remote from luminaire. Remote assembly shall be located no less than half the distance recommended by the manufacturer.

D. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.

E. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.

F. Provide low-voltage disconnect to prevent battery damage from deep discharge.

G. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Less than 0ºF (-18ºC) or exceeding 104ºF (40ºC), with an average value exceeding 95ºF (35ºC) over a 24-hour period.

2. Ambient Storage Temperature: Not less than -4ºF (-20ºC) and not exceeding 140ºF (60ºC).

3. Humidity: More than 95% (condensing).

4. Altitude: Exceeding 3,300 feet (1000 m).

H. Accessories:

1. Provide compatible accessory mounting brackets where indicated or required to complete installation.

2. Provide compatible accessory high impact polycarbonate vandal shields where indicated.

3. Provide compatible accessory wire guards where indicated.

4. Where indicated, provide emergency remote heads that are compatible with the emergency lighting unit they are connected to and suitable for the installed location.

5. Provide compatible accessory remote combination test switch/indicator light where indicated.

2.05 Exit Signs

A. Description: Exit signs and similar signs for special purpose applications such as area of refuge/rescue assistance.

B. All Exit Signs: Internally illuminated with LEDs unless otherwise indicated; complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.

1. Number of Faces: Single or double as indicated or as required for the installed location.

2. Directional Arrows: As indicated or as required for the installed location.

C. Self-Powered Exit Signs:

1. Operation: Upon interruption of normal power source or brownout condition exceeding 20% voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.

2. Battery: Sealed maintenance-free nickel cadmium unless otherwise indicated.

3. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.

4. Provide low-voltage disconnect to prevent battery damage from deep discharge.

D. Accessories:

1. Provide compatible accessory high impact polycarbonate vandal shields where indicated.

2. Provide compatible accessory wire guards where indicated.

2.06 Ballasts and Drivers

A. LED Drivers:

1. Provide LED drivers that are UL recognized complying with UL 8750.

2. Inrush Current: Not exceeding peak currents specified in NEMA 410.

3. Input Voltage: Suitable for operation at voltage of connected source, with variation tolerance of ±10%.

4. Total Harmonic Distortion: Not greater than 20%.

5. Power Factor: Not less than 0.95.

6. Sound Rating: Class A, suitable for average ambient noise level of 20 to 24 decibels.

7. Compatibility: Specifically designed for use with the specified LEDs, with no visible flicker and for full light output unless dimmer or bi-level switching control is indicated.

8. Driver Operating Frequency: Greater than 40 kHz.

9. Current Crest Factor: Not greater than 1.5.

10. Surge Tolerance: Capable of withstanding characteristic surges according to IEEE C62.41.2, location category A.

11. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of CFR, Title 47, Part 18, for Class A, non-consumer applications.

12. Driver Marking: Include wiring diagrams with lamp connections.

2.07 Emergency Ballasts and Drivers

A. LED Emergency Drivers:

1. Description: Self-contained, battery powered, LED emergency driver units suitable for use with indicated luminaires, complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.

2. Compatibility:

    a. Drivers: Compatible with AC drivers and LED loads rated for Class 2 output.

    b. Lamps: Compatible with LED lamp manufacturer supplied.

3. Operation: Upon interruption of normal power source, solid-state control automatically switches connected lamp(s) to the emergency driver for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.

4. Emergency drivers shall include sufficient time delays to prevent overcurrent of the LED’s in the event both emergency and standard drivers supply load simultaneously.

5. Battery:

   a. Sealed maintenance-free high-temperature nickel cadmium unless otherwise indicated. Minimum of 7 year life expectancy.

   b. Recharge time shall be 24 hours or less.

6. Emergency Illumination Output:

   a. Luminaires with LED Strip lamps:

      (1) Operate at a minimum of 1,300 lumens unless otherwise indicated

7. Diagnostics: Provide accessible and visible multi-chromatic combination test switch/indicator light to display charge, test, and diagnostic status and to manually activate emergency operation.

8. Operating Temperature: From 32ºF (0ºC) to 122ºF (50ºC) unless otherwise indicated or required for the installed location.

9. Accessories:

   a. Provide compatible accessory remote combination test switch/indicator light where indicated.

2.08 Lamps

A. All Lamps:

1. Unless explicitly excluded, provide new, compatible, operable lamps in each luminaire.

2. Verify compatibility of specified lamps with luminaires to be installed. Where lamps are not specified, provide lamps per luminaire manufacturer's recommendations.

3. Lamp Bases: Comply with ANSI C81.61.

4. Minimum Efficiency: Provide lamps complying with all current applicable federal and state lamp efficiency standards.

5. Color Temperature Consistency: Unless otherwise indicated, for each type of lamp furnish products which are consistent in perceived color temperature. Replace lamps that are determined by the Engineer to be inconsistent in perceived color temperature.

B. LED Lamps: Wattage and bulb type as indicated, with base type as required for luminaire.

1. Correlated Color Temperature (CCT):

    (1) Indoor: 3,500 (neutral)K unless otherwise indicated.

2. Color Rendering Index (CRI): Not less than 80.

3. Average Rated Life: Not less than 50,000 hours for an operating cycle of three hours per start.

4. Lamps shall be dimmable from 100% to 0% of maximum light output where indicated.

2.09 Accessories

A. Interior Lighting:

1. Stems for Suspended Luminaires: Steel tubing, minimum 1/2 inch size, factory finished to match luminaire or field-painted as directed.

2. Threaded Rods for Suspended Luminaires: Zinc-plated steel, minimum 1/4 inch size, field-painted as directed.

3. Wires for Suspended Luminaires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

4. Wires for Suspended Luminaires in Humid Spaces: ASTM A580/A580M, composition 302 or 304, annealed stainless steel, 12 gage (2.68 mm).

5. Hook Hangers for Suspended Luminaires: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug. Hook hanger shall include safety latch.

6. Provide accessory plaster frames for luminaires recessed in plaster ceilings.

PART 3 - Execution

3.01 Examination

A. Verify that field measurements are as shown on the drawings.

B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.

C. Verify that suitable support frames are installed where required.

D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.

E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 Preparation

A. Provide extension rings to bring outlet boxes flush with finished surface.

B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.03 Installation

A. Coordinate locations of outlet boxes provided under Section 26 05 33 – Raceways, Boxes, Seals, and Fittings for Electrical Systems as required for installation of luminaires provided under this Section.

B. Install products according to manufacturer's instructions.

C. Install luminaires securely, in a neat and workmanlike manner, as specified in NECA 1 (general workmanship), and NECA 502 (industrial lighting).

D. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.

E. Supports:

1. Sized and rated for luminaire weight.

2. Able to maintain luminaire position after cleaning and relamping.

3. Provide support for luminaire without causing deflection of ceiling or wall.

4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100% of luminaire weight and vertical force of 400% of luminaire weight.

F. Suspended Ceiling Mounted Luminaires:

1. Do not use ceiling tiles to bear weight of luminaires.

2. Do not use ceiling support system to bear weight of luminaires unless ceiling support system is certified as suitable to do so.

3. Secure surface-mounted and recessed luminaires to ceiling support channels or framing members or to building structure.

4. Secure pendant-mounted luminaires to building structure.

5. Secure to any required outlet box.

6. Secure lay-in luminaires to ceiling support channels using UL listed safety clips at four corners.

7. In addition to ceiling support wires, provide two galvanized steel safety wire(s), minimum 12 gage, connected from opposing corners of each recessed luminaire to building structure.

8. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.

9. Install at least one independent support rod or wire from structure to a tab on luminaire. Wire or rod shall have breaking strength of the luminaire weight at a safety factor of 3.

10. See appropriate Division 09 Section where suspended grid ceiling is specified for additional requirements.

G. Suspended Luminaires:

1. Unless otherwise indicated, specified mounting heights are to bottom of luminaire.

2. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.

3. Provide minimum of two supports for each luminaire equal to or exceeding 4 feet in length, with no more than 4 feet (1.2 m) between supports.

4. Install canopies tight to mounting surface.

5. Where longer than 48 inches (1200 mm), brace to limit swinging.

6. Unless otherwise indicated, support pendants from swivel hangers.

7. Provide damping of luminaire oscillations where needed.

8. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.

H. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.

1. Attach luminaire per manufacturer's recommendations.

2. Do not attach luminaires directly to gypsum board.

I. Install accessories furnished with each luminaire.

J. Bond products and metal accessories to branch circuit equipment grounding conductor.

K. Emergency Lighting Units:

1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.

2. Install lock-on device on branch circuit breaker serving units.

3. Emergency lighting conductors shall be routed in conduit separate from the normal per circuits.

L. Exit Signs:

1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.

2. Install lock-on device on branch circuit breaker serving units.

M. Emergency Ballasts and Drivers:

1. For field-installed units, install inside luminaire unless otherwise indicated. Where installation inside luminaire is not possible, install on top of luminaire.

2. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal ballast(s) or driver(s) in luminaire. Bypass local switches, contactors, or other lighting controls.

3. Install lock-on device on branch circuit breaker serving units.

N. Identify luminaires connected to emergency power system in accordance with Section 26 05 53.

O. Install lamps in each luminaire.

P. Lamp Burn-In: Operate lamps at full output for prescribed period per manufacturer's recommendations prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.

3.04 Field Quality Control

A. Inspect each product for damage and defects.

B. Operate each luminaire after installation and connection to verify proper operation.

C. Test self-powered exit signs, emergency lighting units, and emergency ballast and drivers to verify proper operation upon loss of normal power supply.

D. Verify operation of photoelectric controls.

E. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Engineer.

F. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.05 Adjusting

A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Engineer. Secure locking fittings in place.

B. Aim and position adjustable emergency lighting unit lamps to achieve optimum illumination of egress path as required or as directed by Engineer or authority having jurisdiction.

C. Exit Signs with Field-Selectable Directional Arrows: Set as indicated or as required to properly designate egress path as directed by Engineer or authority having jurisdiction.

D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this Work may be required during hours of darkness.

3.06 Cleaning

A. Clean surfaces according to NECA 500 (commercial lighting), NECA 501 (exterior lighting), NECA 502 (industrial lighting), and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

3.07 Closeout Activities

A. See Section 01 78 00 - Closeout Submittals for closeout submittals.

B. Demonstration: Demonstrate proper operation of luminaires to Engineer, and correct deficiencies or make adjustments as directed.

C. Just prior to Substantial Completion, replace all lamps that have failed.

3.08 Protection

A. Protect installed luminaires from subsequent construction operations.

END OF SECTION

PART 1 - General

1.01 Related documents:

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

1.02 Summary:

A. This Section includes Site preparation activities and certain items of earthwork common to other related work as necessary to complete the Work including:

1. Demolition.
2. Clearing and Grubbing.
3. Disposal of Waste Materials.
4. Stripping and Undercutting.
5. Proofrolling.
6. Excavation.
7. Stockpiling.
8. Fill.
9. Borrow.
10. Site Grading.
11. Subgrade Preparation.
12. Topsoiling.
13. Weed-Killer.
14. Maintenance and Repair.

1.03 Related requirements:

A. Section 01 57 13 – Erosion and Sedimentation Control

B. Section 02 41 19 – Selective Demolition

C. Section 31 23 19 – Temporary Construction Dewatering

D. Section 31 23 23.33 – Flowable Fill

E. Section 31 41 00 – Temporary Excavation Support Systems

F. Appendix C – Report of Geotechnical Exploration, Citico Pump Reliability Improvements, Chattanooga, Tennessee, S&ME Project No. 1281-17-015.

1.04 Reference standards:

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

B. ASTM International (ASTM): (Approved equivalent AASHTO standards may be substituted.)

1. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soils Using Standard Effort (12,400 ft-lbf/ft3 (600 kN□m/m3)).

2. ASTM D1556/D1556M - Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method.

3. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).

4. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.

5. ASTM D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

6. ASTM D4254 - Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

7. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

8. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

9. ASTM STP479 - Special Procedures for Testing Soil and Rock for Engineering Purposes, 5th Edition, "Burmister Method."

C. U.S. Department of Interior, Bureau of Reclamation (USBR):

1. Earth Manual, 2nd Edition, Designation E-12, Relative Density of Cohesionless Soils, Alternate Method.

D. Tennessee Department of Transportation Standard Specifications for Road and Bridge Construction.

1.05 Definitions:

A. Refer to PART 2 for detailed definitions and included materials.

B. Borrow: Earth materials obtained from sources other than excavations or stockpiles within the area to be graded by Contractor.

C. Clearing: The removal of trees, shrubs, and other vegetation above the existing grade surface.

D. Demolition: The removal of improvements without regard to class and type of construction or material.

E. Dike: A fill that will be required to hold water.

F. Excavation: Material removed below the elevation of the existing ground surface.

G. Fill: Material placed above the elevation of the existing ground surface after stripping or material used in restoring an earlier excavation.

H. Geotechnical Engineer: A Geotechnical Engineer registered in the state of Tennessee with whom Contractor has entered into an Agreement for performance of the work specified for a Geotechnical Engineer in this Section.

I. Grubbing: The removal of roots, shrubs, and other vegetation to a depth below the ground surface.

J. Stripping: Excavation of any overlying layer of material to expose material of a different type, use, or class.

K. Subgrade: The surface layer of earth on which structures, pavements, railroads, or other surfacing materials, except topsoil, are to be placed.

L. Topsoil: The final surface layer of earth material intended to support vegetation.

M. Tree Protection Zone: Area surrounding a tree within the limits of tree protection fencing as indicated in the Drawings.

N. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.06 Submittals:

A. Submit as specified in Division 01.

B. Includes, but not limited to, the following:

  1. Qualification data for qualified testing agency.

  2. Test results from laboratory testing of proposed borrow materials.

  3. Test results from laboratory testing of granular fill and pipe embedment materials.

4. Field Quality Control Test Reports.

5. Erosion Control Plan.

6. Excavation Plan, indicating horizontal location and grade of temporary slopes, horizontal location of temporary excavation supports, separation distances from site structures and existing underground utilities, and excavation phasing.

7. Temporary dewatering plans in accordance with 31 23 19 – Temporary Construction Dewatering.

8. Temporary excavation support system plans in accordance with 31 40 00 – Temporary Excavation Support Systems.

9. Subgrade Preparation Plan.

10. Product Data for detectable warning tapes.

11. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

12. Point of disposal for materials to be disposed.

C. Where selecting an option for excavation, trenching, and shoring in compliance with local, state, or federal safety regulations such as OSHA 29 CFR Part 1926 or successor regulations, which require design by a registered professional engineer, submit for information only and not for Engineer approval the following:

1. Copies of design calculations and notes for sloping, benching, support systems, shield systems, and other protective systems prepared by or under the supervision of a professional engineer legally authorized to practice in the jurisdiction where the Project is located.

2. Documents provided with evidence of registered professional engineer’s seal, signature, and date in accordance with appropriate state licensing requirements.

1.07 Quality assurance:

A. Sampling and Testing:

1. Owner will, through the services of an independent, commercial laboratory, perform all testing of Owner-furnished materials.

2. Tests to determine conformance with all requirements of this specification for quality and properties of all Contractor-secured materials, including borrow materials (both on or off-Site) proposed for use, shall be performed by an independent, commercial laboratory retained and compensated by Contractor, and approved by Engineer.

1.08 Job conditions:

A. Lines and grades shall be as indicated. Engineer will furnish bench marks, base lines, and reference points as necessary to permit Contractor to lay out and construct the Work properly.

B. Carefully maintain all bench marks, monuments, and other reference points and replace as directed by Engineer if disturbed or destroyed, at no additional cost to the owner.

C. Prior to submitting Bid, make arrangements with Owner for entry to Site for the purpose of conducting subsurface investigations, including test borings.

D. Temporary Erosion and Sediment Controls: Contractor shall furnish, install, construct, and maintain temporary measures to control erosion and minimize the siltation of intermittent streams and the pollution of private properties. Temporary erosion and sediment control measures shall be constructed in substantial compliance with local, state, federal, and jurisdictional agencies regulation and shall be maintained until completion of Contract. Do not commence with earth moving and site clearing until temporary erosion and sedimentation control measures are in place.

E. Protection of Trees: Protect tops, trunks, and roots of existing trees indicated to remain, as follows:

   1. Box, fence around, or otherwise protect trees before any construction work is started.

   2. Do not permit heavy equipment or stockpiles within branch spread.

   3. Trim or prune to obtain working space in lieu of complete removal when possible. Conduct operation as follows:

      a. With experienced personnel.

      b. Conform to good horticultural practice.

      c. Preserve natural shape and character.

      d. Protect cuts with approved tree paint.

   4. Grade around trees as follows:

      a. Trenching: Where trenching is required around trees which are to remain, avoid cutting the tree roots by careful hand tunneling under or around the roots. Avoid injury to or prolonged exposure of roots.

      b. Raising Grades: Where existing grade at a tree is below the finished grade and fill not exceeding 16 inches is required, place clean, washed gravel, 1 to 2 inches in size, directly around the tree trunk. Extend gravel out from trunk on all sides at least 18 inches and to a height of 2 inches above finished grade at tree. Install gravel before earth fill is placed. Do not leave new earth fill in contact with any tree trunks.

c. Lowering Grades: Regrade by hand to elevation required around existing trees in areas where new finished grade is to be lowered. As required, cut the roots cleanly 3 inches below finished grade, and cover scars with tree paint.

5. Remove and grub when damage occurs which would make survival doubtful.

6. Replace with similar item when damaged through carelessness.

F. Disposition of Utilities:

1. Existing underground utilities are shown on Contract Drawings using the best information available at the time of drawing preparation. Contractor shall locate, clearly identify, and protect all underground utilities which may be affected by construction under this Contract before starting excavation or other Site construction activities which could damage existing utilities.

2. Relocate all active utilities outside the emergency backup pump station or equipment pad areas.

3. Report inactive and abandoned utilities encountered in excavating and grading operations. Remove abandoned utilities and replace with compacted fill, or grout-fill and plug at locations indicated in the Drawings.

G. Locate and clearly identify limits of disturbance, property boundaries, and other construction site limits, as shown on the Drawings.

H. Contractor shall be responsible for the design of the dewatering system to be in place during excavation and construction.

1. Refer to 31 23 19 – Temporary Construction Dewatering.

PART 2 - Products

2.01 Materials:

A. Definitions and classifications of materials used in this Section are stated in PART 3 - EXECUTION, this Section.

PART 3 - Execution

3.01 Demolition:

A. Remove existing structures and improvements to limits indicated.

B. Carefully dismantle, in a manner to avoid damage, all materials and equipment indicated to be relocated or returned to Owner.

C. Any of the material or equipment, specified or indicated to be relocated or returned to the Owner, that is damaged due to Contractor's negligence shall be repaired or replaced, as determined by Engineer, at Contractor's expense.

D. Materials not indicated or specified to be relocated or returned to Owner shall become the property of Contractor and be disposed of as specified in "Disposal of Debris," this Section.

E. Perform demolition work to protect existing facilities, structures, and property which are to remain, against damage from operations, falling debris, or other cause.

F. Take precautions to guard against movement or settlement, and provide shoring and bracing as necessary.

G. If at any time safety of existing structure to remain is endangered, cease operations, notify Engineer, and do not resume operations prior to approval.

H. Prior to construction, remove active utilities and replace with compacted fill. Relocate active utilities outside the emergency backup pump station or equipment pad areas.

I. Remove concrete by jack hammering, sawing, core drilling, or other approved method.

J. Remove existing asphaltic pavement by jack hammering, sawing, scarifying, or other approved methods except as follows:

   1. Existing asphaltic (or portland cement concrete) pavement shall be sawed at point where pavement indicated to remain ends and pavement indicated to be removed begins.

3.02 Clearing and grubbing:

A. Clear and grub all areas where earthwork is to be performed, including borrow areas, and any other areas beyond the earthwork limits where indicated.

B. Clearing:

   1. Clearing includes felling and disposal of trees, brush, and all other vegetation or combustible material found on or above the existing ground surface inside the clearing limits.

   2. Remove existing fence within the limits of clearing. Waste or store as indicated.

   3. Conduct work in a manner to prevent damage to property and to provide for the safety of employees and others.

   4. Keep operations within construction limits indicated.

C. Grubbing:

1. Grubbing includes the removal and disposal of all tree stumps and roots where fill is to be placed and when the excavated material is to be used as fill. Removal and disposal of tree stumps and roots larger than 3 inches in diameter will be required at all other locations.

2. Remove to a depth of at least 18 inches below existing grade elevation at all water containment areas (dikes, ponds, and similar areas). Remove to a depth of at least 12 inches below existing grade elevation at all other locations.

3. Backfill all excavated depressions with approved material and grade to drain.

D. Disposal of Debris:

1. Dispose of debris from clearing and grubbing and demolition at a location off the Site, as arranged for by Contractor, at no additional cost to Owner.

2. Contractor may claim and salvage any timber or other debris which he may consider of value, but shall not delay in any manner either this Contract or other work with salvaging operations.

3.03 Disposal of waste materials:

A. Waste Materials: Includes excess suitable materials, and materials unsuitable for use in the Work.

1. Unsuitable materials include all material that contains debris, roots, organic matter, frozen matter, rock (with any dimension greater than one-half the loose layer thickness), or other materials that are too wet or otherwise unsuitable for providing an acceptable fill or subgrade for roads and structures.

2. Suitable materials include material that is free of debris, roots, organic matter, refuse, coal, ashes, cinders, frozen matter and, which is free of rock with any dimension greater than one-half the specified loose layer thickness and conform to the cohesive or cohesionless fill material specified herein.

B. Remove unsuitable materials from work area as excavated.

C. Keep excess suitable material segregated from unsuitable waste in the disposal area for possible use by others.

D. Unsuitable materials shall be disposed of at a location arranged for by Contractor and approved by Owner, at no additional cost to Owner.

E. Deposit in indicated waste areas.

1. Spaced in lifts not exceeding 12 inches in thickness.

2. Compact by routing hauling and spreading equipment uniformly over the surface of each lift.

3. Place waste rock in interior of waste areas not less than 12 inches below the final surface grade.

4. Grade waste areas to leave them with an orderly uniformly graded appearance and to be free draining. Final slopes shall not be steeper than 2 horizontal to 1 vertical; nor shall final grades be flatter than 1%.

F. Seed and mulch waste areas after grading. Contractor will be held responsible for any erosion that occurs until a sturdy growth over a minimum of 98% of the area seeded is established.

3.04 Stripping and Undercutting:

A. Stripping shall consist of scraping areas clean of all brush, grass, weeds, roots, and other materials.

B. Undercutting shall consist of digging out below asphalt paving materials and removing in its entirety the total depth of asphalt paving materials, including gravel.

C. Remove topsoil and asphalt paving materials from areas within limits of excavation, trenching, borrow, and areas designated to receive fill.

D. Strip to a minimum depth of 6 inches, but to a sufficient depth to remove excessive roots in heavy vegetation, unsuitable material, all asphalt paving materials, or brush areas and as required to remove all soil containing organic material or segregate topsoil.

E. Stockpile topsoil in areas designated and approved by Owner or adjacent property owners where it will not interfere with construction operations or existing facilities. Stockpiled topsoil shall be reasonably free of subsoil, debris, and stones larger than 2-inch diameter.

F. Dispose of removed asphalt paving materials offsite.

3.05 Proofrolling:

A. Proofrolling shall consist of trafficking the site with parallel passes of a vehicle starting at one side of the building pad and continuing to the other; each pass should overlap the preceding pass to provide complete coverage.

B. As a vehicle, use a fully loaded tandem-axle dump truck or other heavy equipment approved by Geotechnical Engineer.

C. A qualified Geotechnical Engineer shall be on-site during proofrolling.

D. Proofrolling shall reveal pockets of soft or unstable soils; Contractor shall receive direction from Geotechnical Engineer on what action to take in areas of soft or unstable materials.

1. In general, unstable materials shall be undercut until stable materials are exposed and backfilled with suitable materials.

E. After proofrolling and prior to placing fill on the site, scarify and properly compact the upper surface soils.

F. Proofrolling may be required on multiple occasions, for example, if:

1. Grading operations are performed during wet periods of the year.

2. Site is brought back to grade with structural fill after remediating areas in need of remediation.

3.06 Excavation:

A. General:

1. Excavate all materials found within the designated limits for excavation.

2. Perform excavation by any recognized method of good practice to complete the Work in the most expeditious manner and in conformance with specified requirements.

3. Take precautions to ensure no damage to existing facilities or equipment, or other work.

4. All materials encountered, regardless of type, character composition and condition thereof, shall be considered "unclassified" for the purpose of payment. The cost of excavation and disposal of unclassified materials is included in the lump sum amount in the BID FORM. Rock encountered shall be handled at no extra cost to Owner.

B. Dewatering:

1. Refer to 31 23 19 – Temporary Construction Dewatering.

C. Excavation Support:

1. Excavations in which workers will be entering are required to have side slopes in accordance with OSHA 29 CFR Part 1926.

2. Refer to 31 40 00 – Temporary Excavation Support.

D. Blasting:

1. BLASTING will not be permitted.

3.07 Stockpiling:

A. Stockpile in amounts sufficient for and in a manner to segregate materials suitable for the following:

1. Topsoiling.

2. Constructing fills.

3. Waste only.

B. Do not obstruct or prevent access to the following:

   1. Roads and driveways.

   2. Utility control devices.

   3. Ditches or natural drainage channels.

   4. Roll-up Doors.

   5. Dumpsters (Non-Construction Waste).

   6. Indicated material storage (lay-down) areas.

   7. Indicated transmission lines, towers, or power poles.

C. Perform in a manner to avoid endangering the Work, stability of banks or structures, or health of trees and shrubs to be saved.

D. Maintain safe distance between toe of stockpile and edge of excavation or trench.

E. Stockpile in other areas or off Site when adjacent structures, easement limitations, or other restrictions prohibit sufficient storage adjacent to the Work. Off-Site areas shall be arranged for by Contractor at no additional cost to Owner.

3.08 Fill:

A. General:

   1. The construction of "fill" shall consist of obtaining suitable materials and placing these materials in compacted lifts.

   2. Suitable fill materials include material from excavations and borrow areas that is free of debris, roots, organic matter, refuse, ashes, cinders, frozen earth, and which is free of rock with any dimension greater than one-half the specified loose layer thickness.

   3. Unsuitable fill materials include material that does not conform to the above, high plasticity clays, or other materials that are determined by Geotechnical Engineer as too wet or otherwise unsuitable for providing a stable fill.

   4. Construct fill to the contours and elevations indicated, using approved equipment and suitable approved materials specified above. Obtain materials for fill construction in the following order of priority:

      a. From on-Site excavation.

    b. From borrow areas secured by Contractor.

5. If the slope bounding the fill area is steeper than 6 horizontal to 1 vertical, step or serrate prior to placing the material as indicated.

6. Do not place snow, ice, or frozen earth in fill and do not place fill on a frozen surface.

7. Place fill material only on ground surfaces which conforms to the following:

    a. Scarified to 6 inches deep prior to placement of first lift.

    b. Compacted prior to placement of second or succeeding lifts.

    c. Wetted or dried as required to obtain correct moisture content.

    d. Tested and approved by Geotechnical Engineer.

8. Do not place fill for dikes on any fractured rock surface. If fractured rock is encountered, remove to a depth of 2 feet below the impoundment bottom and replace with suitable compacted fill.

9. If unacceptable materials, as defined herein, are encountered, excavate the material to stiff or better soils or remediate as recommended by Geotechnical Engineer.

10. Fill soils shall be evaluated by Geotechnical Engineer at the time of construction.

11. All slopes on fills shall be constructed 1 foot wider than indicated and then dressed to the final grade.

B. Earthen (Cohesive) Fill:

1. Material shall be friable sandy or silty clay containing sufficient fine material to provide a dense mass free of voids when compacted. When impact compacted, these materials will produce a well-defined moisture-density relationship curve.

2. Suitable fill soils shall consist of low to moderately plastic clay or silt with a plasticity index of less than thirty (PI<30) and a standard Proctor maximum dry density greater than 95 pounds per cubic foot when tested in accordance with ASTM D4318 and ASTM D698, respectively.

    a. Fill shall contain no rock fragments larger than 4 inches in any dimension.

    b. Fill shall contain no organic matter.

3. Material shall not contain more than 10% by volume of rock and gravel and not contain particles with maximum dimension greater than 4 inches in any dimension.

4. Material for construction of dikes and impoundment liner shall not contain rock or gravel.

5. Compact with approved equipment to a minimum of 95% of maximum dry density within the moisture content range from 3% below optimum to 3% above optimum. Optimum moisture and maximum density shall be determined by ASTM D698.

6. Place fill material in 8-inch maximum layers (uncompacted depth), and compact according to:

    a. Top 1 foot below grade-supported slabs shall be compacted to 100% standard compaction as determined by ASTM D4253 and ASTM D4254.

    b. The rest shall be compacted to 95% of the standard Proctor maximum dry density as determined by ASTM D4253 and ASTM D4254.

7. Perform any wetting or drying of the material as required to obtain the specified density when compacted and to maintain specified moisture content range at the time of placement.

C. Sand and Gravel (Cohesionless) Fill:

1. Include gravels, gravel-sand mixtures, sands, and gravelly sands exclusive of clayey and silty components. These materials have the following properties:

    a. Free-draining.

    b. Impact compaction will not produce a well-defined moisture-density relationship curve.

    c. The maximum density by impact methods will generally be less than by vibratory methods.

D. Controlled Low Strength Material (CLSM):

1. Refer to 31 23 23.33 – Flowable Fill.

E. Structural Fill:

1. Subgrade walls shall be backfilled with compacted aggregate such as No. 57 or No. 67 stone.

    a. Maximum lift thickness (uncompacted depth) and compaction method necessary to obtain suitable compaction shall be determined by Geotechnical Engineer who shall observe compacted aggregate placement.

F. Compaction Testing:

1. The method of in-place compaction testing including density and moisture content shall be as follows:

    a. Density - Cohesive materials: ASTM D6938.

    b. Density - Cohesionless materials: ASTM D6938.

    c. Moisture Content: ASTM D6938.

  2. The minimum frequency of in-place compaction testing including density and moisture content will be as follows:

    a. At least one test for every 200 cubic yards of fill placed in trenches or surrounding structures.

    b. At least one test for every shift of compaction operations on a mass fill.

    c. At least one test for every 2,500 square feet where subgrade preparation for roadways, drives, and parking areas is being performed.

    d. At least one test for every 100 square feet per lift in structural fill.

    e. At least one test when Geotechnical Engineer suspects the quality of moisture control or effectiveness of compaction.

  3. Fill failing to meet required densities shall be removed or scarified and recompacted as necessary to achieve specified results.

  4. Removal of in-place material and replacement with approved new material will be required if scarifying and recompaction do not product the required densities.

G. Equipment:

  1. Compaction equipment shall conform to the following requirements and be subject to the approval of Engineer.

    a. Tamping Rollers:

      (1) May be towed or self-propelled.

      (2) Have staggered uniformly spaced knobs or feet. When fully loaded, they shall exert at least 250 psi on combined area of tamping feet in contact with ground.

      (3) Be equipped with cleaning fingers maintained at full length to prevent accumulation of material between feet.

      (4) Maintain all equipment in good repair.

    b. Pneumatic Rollers:

      (1) Have two axles, not less than nine wheels with pneumatic tires of equal size, diameter, and ply rating, a rigid steel frame, and a body suitable for ballast loading. Tracking wheels shall overlap by a minimum of 1/4-inch.

      (2) Tires shall be uniformly inflated at all times.

      (3) Self-propelled or towed.

c. Vibratory Rollers:

  (1) Have either one or two smooth-surfaced steel drums with a minimum diameter of 42 inches.

  (2) Have a minimum vibrating force of 300 pounds per cycle per inch of drum width.

  (3) Have a minimum vibrating frequency of 1,200 cycles per minute with a means of adjusting the resonance of the dynamic force.

  (4) May be self-propelled or towed.

d. Power tampers shall be used for compaction of material in areas where it is impractical or unsafe to use heavy equipment, and as recommended by Engineer.

e. Vibratory plate compactor may be used for compaction of sand and/or gravel material in areas where it is impractical or unsafe to use heavy equipment, and as recommended by Geotechnical Engineer.

3.09 Borrow:

A. Borrow materials refers to all fill materials and topsoil obtained from approved locations either on or off the jobsite.

B. Borrow shall include all clearing, grubbing, excavating, handling, and final disposal of materials as specified. Borrow, if required, to bring fill areas to the lines and grades indicated, shall be furnished by Contractor, as specified, at no additional cost to Owner.

C. Borrow areas shall be:

1. Arranged for by Contractor at no additional cost to Owner.
2. Subject to approval by Geotechnical Engineer.

D. Prior to incorporating borrow materials into the Project, borrow material from each source shall be tested by an independent laboratory compensated by Contractor. Tests on borrow materials shall include: unified soil classification, grain size analysis, liquid limit, plasticity index, moisture density relations of soils, and permeability. Contractor shall submit copies of test results to Engineer, Owner, and Resident Project Representative. Excavate borrow material in uniform layers not greater than 2 feet in thickness except as indicated.

E. Leave borrow areas graded to drain and to present a neat appearance.

F. Seed and mulch surface of borrow area after grading. Contractor will be held responsible for any erosion that occurs until a sturdy growth over a minimum of 98% of the area seeded is established.

3.10 Site grading:

A. Excavate, fill, and rough grade to bring Project area to subgrades as follows:

1. To underside of respective surfacing or base course for surfaced areas.
2. As indicated on grading sections for seeded areas, ditches, and slopes.
3. As indicated for unsurfaced and unseeded areas.

B. Finish Grading:

1. Grade and compact all areas within the Project, including excavated and filled sections, and adjacent transition areas reasonably smooth and free from irregular surface changes.
2. Degree of finish shall be that ordinarily obtained from blade grader or scraper operations, except as otherwise specified.
3. Finished rough grades shall generally be not more than 0.25-foot above or below established grade or approved cross-sections with due allowance for topsoil.
4. Tolerance for areas within 10 feet of building shall not exceed 0.10-foot above or below established subgrade.
5. Finished subgrades for roads, drives, and surfaced areas shall not be lower than indicated, nor higher than 0.1-foot above that indicated.
6. Finish all ditches and swales to drain readily.
7. Unless otherwise indicated, slope the subgrade evenly to provide drainage away from indicated future building walls in all directions at a grade not less than 1/4-inch per foot.
8. Provide roundings at top and bottom of banks and at other breaks in grade.

C. Construction Runoff Control:

1. If, during construction, Contractor alters the flow characteristics of construction runoff such that untreated runoff is being released or the runoff exceeds the capacity of any of the control facilities designed by Engineer, Contractor shall upgrade existing facilities and/or provide new facilities designed to control construction runoff.
2. All upgraded or new facilities shall be approved by Engineer before implementation.
3. Construct silt fences at locations indicated.

3.11 Subgrade preparation:

A. General:

1. On-site Geotechnical Engineer shall confirm the following subgrade preparation steps after testing the foundation subgrade. If the Geotechnical Engineer’s recommendations differ from the actions described herein, the Geotechnical Engineer’s recommended approach shall be approved by Engineer.

    a. Excavate or fill as specified and as required to construct subgrades to the elevations and grades indicated.

    b. Subgrades shall be sufficiently sloped to provide rapid drainage.

    c. Remove all unsuitable material and replace with approved fill material, and perform all wetting, drying, shaping, and compacting required to prepare a suitable subgrade. Unsuitable material is defined under the Article "FILL," this Section.

B. Subgrade for Pump Station:

1. Undercut loose alluvial sands to stabilize and construct a suitable working platform for foundation construction.

    a. Undercut bearing soils to a depth of approximately 2 feet below the mat bearing elevation.

    b. Stabilize the undercut area with a layer of 9 to 12 inches of riprap type stone compacted into the subsurface soils.

2. Extend subgrade the full width of surfaced areas plus, where possible, 1 foot outside the edges of the overlying course to be placed.

3. Prevent water from collecting behind the forms before backfilling.

    a. If soils exposed in the foundation excavations experience moisture variations prior to concrete placement, undercut the affected bearing materials as recommended by Geotechnical Engineer.

    b. A 2- to 3-inch thick mud mat of lean concrete may be used to protect the exposed support materials if opened excavations cannot be backfilled with concrete the same day.

    c. Isolate foundation soils from heat sources to prevent drying of the foundation soils.

4. Compaction:

    a. Fill:

        (1) Compact material, except for the top 12 inches, to a minimum of 95% of maximum dry density and within the moisture content range from 3% below optimum to 3% above optimum. Optimal moisture and maximum dry density shall be determined by ASTM D698.

        (2) Compact the top 12 inches of the material to a 100% of maximum dry density within the moisture content range from 3% below optimum to 3% above optimum. Optimal moisture and maximum density shall be determined by ASTM D698.

        (3) Perform any wetting or drying of the material as required to obtain the specified density.

C. Subgrade for Mat Foundations for Mechanical and Electrical Equipment:

1. Provide measures to counteract shrink/swell conditions of the soil. Implement the following:

    a. Undercut the perimeter of the mat foundation to a depth of 30 inches below subgrade and backfill with a dense graded aggregate.

        (1) Undercut should be about 2 feet wide at the bottom outside the perimeter and slope up at a 1:1 slope to the bottom of the mat foundation.

        (2) Backfill should be placed in level lifts with a maximum loose thickness of 8 and compacted to 95% of the standard Proctor maximum dry density, with a moisture content range from 3% below optimum to 3% above optimum.

2. Extend subgrade the full width of surfaced areas plus, where possible, 1 foot outside the edges of the overlying course to be placed.

3. Prevent water from collecting behind the forms before backfilling.

    a. If soils exposed in the foundation excavations experience moisture variations prior to concrete placement, undercut the affected bearing materials as recommended by Geotechnical Engineer.

    b. A 2- to 3-inch thick mud mat of lean concrete may be used to protect the exposed support materials if opened excavations cannot be backfilled with concrete the same day.

    c. Isolate foundation soils from heat sources to prevent drying of the foundation soils.

4. Compaction

    a. Fill:

(1) Compact material, except for the top 12 inches, to a minimum of 95% of maximum dry density and within the moisture content range from three 3% below optimum to three 3% above optimum. Optimum moisture and maximum dry density shall be determined by ASTM D698.

(2) Compact the top 12 inches of the material to a 100% of maximum dry density within the moisture content range from three 3% below optimum to three 3% above optimum. Optimum moisture and maximum density shall be determined by ASTM D698.

D. Subgrade for Pavement

1. Extend subgrade the full width of surfaced areas plus, where possible, 1 foot outside the edges of the overlying course to be placed.

    a. Compact material, except for the top 12 inches, to a minimum of 95% of maximum dry density and within the moisture content range from three 3% below optimum to three 3% above optimum. Optimum moisture and maximum dry density shall be determined by ASTM D698.

3.12 Topsoiling:

A. Topsoil Materials:

1. Shall be material excavated from within the upper one-half foot, of on-Site excavations; and be obtained from Site areas having healthy plant growth prior to stripping.

2. Contractor may furnish topsoil from off-Site borrow areas at his option and without additional charge to Owner provided these materials are:

    a. From that portion of the soil profile defined as the "A" horizon by the Soil Science Society of America.

    b. Fertile, friable, and loamy soil of uniform quality without admixture of subsoil materials, gravel, hardpan, debris, or other similar impurities.

    c. Demonstrate healthy plant growth prior to stripping.

    d. From areas from which topsoil has not been previously removed by erosion or mechanical methods.

B. Place topsoil on all areas indicated and on waste areas.

C. Treatment of Subgrade Prior to Topsoil Placement:

1. Clear Site of vegetation heavy enough to interfere with proper grading and tillage operations.

2. Clear surfaces of all stones or other objects larger than 3 inches in thickness or diameter, all roots, brush, wire, grade stakes, or other objectionable material.

3. Loosen subgrade by discing or scarifying to a depth of 2 inches wherever compacted by traffic or other causes to permit bonding of the topsoil to the subgrade.

D. Placement:

  1. Distribute over required areas without compaction other than that obtained with spreading equipment.

  2. Place to extent material is available within following limits:

     a. Not less than 4 inches in depth.

     b. Do not exceed 6 inches in depth.

  3. Shape cuts and fills to drain as indicated, with ground surfaces adjacent to slabs and foundations sloping away from the pad area.

  4. Grade to match contours of adjacent areas and permit good natural drainage.

  5. Provide gentle mound over trenches.

E. After topsoil has been spread, clear surface of stones or other objects larger than 2 inches in thickness or diameter and all other objects that might interfere with planting and maintenance operations.

F. Protect topsoiled areas from the elements until grass is established. Repair eroded areas as required.

G. Keep paved areas clean. Promptly remove topsoil or other dirt dropped on surfacing.

3.13 Weed killer:

A. Weed killer shall be "Krovar I" as manufactured by E.I. duPont or equal product approved by Engineer and meeting federal, state, and local regulations controlling the use of this material.

B. Use in the following areas:

  1. Under fencing in crushed-rock areas.

  2. Under crushed rock service roads.

C. Use in accordance with manufacturer's recommendations.

3.14 Maintenance and repair:

A. Maintenance:

1. Protect newly graded and topsoiled areas from actions of the elements.

2. Settling or erosion occurring prior to landscaping shall be filled and repaired and grades reestablished to the required elevations and slopes.

B. Correction of Settlement:

1. Under provisions of the guarantee, Contractor is responsible for correcting any settlement in excess of the amount of the specified grading tolerance for the specific areas of fill and damages created thereby within one year after acceptance of the Work.

2. Make repairs within 10 days from the date of notification by Owner of fill settlement and resulting damage.

3. Make own arrangements for access to the Site for purposes of repair.

END OF SECTION

PART 1 - General

1.01 Summary

A. Description of System:

1. Work under this Section includes the design, installation, operation, and removal of a temporary dewatering system for the required excavations.

2. Performance Requirements:

   a. Design and place into service a dewatering system to allow for excavation and construction of all facilities in the dry.

   b. Dewatering system shall be adequate to maintain the elevation of groundwater at not less than two feet below the floor of the excavation at all locations and at all times. Groundwater at the site is influenced by the water level of the adjacent Tennessee River. The normal water surface elevation of the Tennessee River at this location is approximately 635 feet (NAVD 88).

   c. In preparing the dewatering plan, consider subsurface information, temporary excavation support requirements, and construction schedule.

   d. Commence dewatering with means to provide positive dewatering of all water sources prior to any appearance of water and continue until Work is complete to the extent that no damage will result from hydrostatic pressure, flotation, quick condition, boils or other causes.

3. The design of the dewatering system shall be Contractor's full responsibility using accepted and professional methods of design and engineering consistent with the best modern practice.

   a. Visit the Site to determine the conditions thereof and be responsible for the accuracy of the drawings and design data required in these Specifications.

   b. Take into account Site topography, access, terrain, existing structures, vegetation, and other factors affecting the dewatering system.

B. Responsibility:

1. Review of drawings and data submitted by Contractor shall not relieve Contractor from full responsibility for errors therein or from the entire responsibility for complete and adequate design and performance of the system in controlling the water level in the excavated areas and for control of the hydrostatic pressures to the depths specified.

2. Contractor shall be solely responsible for proper design, installation, operation, maintenance, removal, and any failure of any component of the system, as well as the discharge point.

3. Obtain and pay for all necessary local, state and federal permits, applications or other notices necessary for dewatering and discharge and shall comply with all such permits. Control grading around excavations to prevent the introduction of surface water to excavations.

1.02 Related Requirements

A. Section 02 32 23 – Piezometers.

B. Section 31 14 00 – Temporary Excavation Support Systems.

C. Section 31 20 00 – Site Preparation and Earthwork.

1.03 Reference Standards

A. General:

1. Standards listed by reference, including revisions by the issuing authority, form a part of this Section to extent indicated. Standards listed are identified by the issuing authority, authority abbreviation, designation number, title or other designation established by issuing authority. Standards subsequently referenced herein are referred to by issuing authority abbreviation and standard designation.

2. Where specifications and reference documents conflict, this Section will be the applicable document.

3. Unless otherwise noted, the latest revision of the following reference standards shall apply to this Section.

B. Applicable Standards:

1. American Water Works Association (AWWA):

   a. A100 - Standards for Water Wells.

1.04 Submittals

A. Submit as specified in DIVISION 01.

B. Submit qualifications at time of bid. A minimum of 10 years' experience in the design of equivalent dewatering systems is required.

C. Submit design and pre-construction information for review two weeks prior to commencing excavation at the Site. Information to be provided includes the scope of work activities, design information and data, and drawings showing methods, materials, and equipment proposed for use in dewatering, including relief of hydrostatic head, and in maintaining the excavation in a dewatered and hydrostatically relieved condition. Specific information includes, but is not limited to the following:

1. Drawings indicating the location and size of berms, dikes, ditches, deep wells, piezometers, well points, sumps, and discharge lines, including their relation to water disposal ditches.

2. Details regarding construction of piezometers, deep wells and well point systems.

3. Capacities of pumps, prime movers, and standby equipment.

4. Design calculations and/or computer modeling proving adequacy of system and selected equipment and estimated flow rate of water to be discharged.

5. Detailed description of dewatering procedures.

6. Maintenance program.

7. Description of supervision, emergency procedures, and standby equipment to be provided to assure that excavations will be maintained in a dewatered condition 24 hours per day and under all conditions which may affect the Site.

8. Emergency Backfill Plan, if required by TVA guidelines.

D. Submit construction and closeout information within one week of completing construction of that portion of work, except as noted:

1. Driller's logs of geologic materials encountered during piezometer and well construction.

2. Well and piezometer "as-constructed" diagrams.

3. Furnish piezometer readings daily.

4. Provide record of pumped flow rates daily.

1.05 Damages

A. Be responsible for, and repair without cost to Owner, any damage to existing structures, Work in place, other contractors' equipment, and the excavation, including damage to the bottom due to heave and including but not limited to, removal of material and pumping out of the excavated area that may result from Contractor's negligence, inadequate or improper design and operation of the dewatering system, and any mechanical or electrical failure of the dewatering system.

B. The dewatering system shall be designed and operated in a manner that precludes settlement of adjacent structures due to piping or subsidence.

1.06 Operations On-site

A. Method of Operation:

1. Notify Owner at least 72 hours in advance of commencing work and indicate the number and type of drilling rigs for well or well point construction to be used on the Site.

2. Furnish all equipment, supplies, labor and services necessary to perform the drilling, sampling, sample storage, pumping, drill site preparation, and related work detailed elsewhere in these Contract Documents during all weather conditions to be expected in this area.

3. Move all necessary equipment to each well location.

B. Surveys:

1. Establish the location and surface elevation of each piezometer.

2. Carefully preserve all survey monuments, bench marks, reference points, and stakes in the drilling areas.

C. Obtain all permits required for the proposed dewatering system.

D. Discharge Line(s):

1. Discharge line(s) may be above ground and shall be routed and installed so as to not interfere with other contractors' operations on the Site.

2. Obtain and submit per jurisdictional requirements all necessary permits, applications, or other notices necessary for discharge.

3. Install temporary earthen ramps as necessary over the discharge pipe at any road or levee road crossings.

4. Install riprap or other erosion control measures at the outlet point or other affected areas to prevent erosion from discharge operations.

5. Do not discharge water from wells in on-site runoff ponds, ditches, sanitary sewers or storm sewers without prior written approval.

1.07 Quality Assurance

A. During normal pumping, levels of fine sand or silt in the discharge water shall not exceed 10 mg/L. A sand tester shall be installed on the discharge of each pump during initial testing to verify that levels of fine sand or silt do not exceed the maximum levels allowed. If required, take appropriate measures to reduce the level of fine sands and silts to less than the maximum specified.

B. Visit the site and inspect the access, site topography, terrain, existing structures, vegetation, and any other factors which may affect Contractor's bid prices.

PART 2 - Products

2.01 Dewatering Equipment

A. Provide a pumping unit (or units) for each dewatering system component capable of producing not less than the discharge indicated on Contractor's dewatering plan and under sufficient discharge pressure, prime mover of ample power, controls, and appurtenances capable of operating uninterrupted for the duration of the dewatering effort.

B. Furnish discharge piping of sufficient length, diameter, and wall thickness for the pumping unit to discharge to the location indicated.

1. Include an orifice or flowmeter in each discharge line for measuring flow.

2. Provide a written record of flow rates concurrent with the daily groundwater measurements in the piezometers.

2.02 Standby Equipment

A. In addition to equipment necessary for operation of the dewatering system, maintain the following standby equipment in good operating condition at the Site for the duration of the dewatering:

1. Not less than one pump of each size and type installed for every 5 pumping units or fraction thereof.

2. Provide no less than one standby pumping unit.

3. Standby generator (or prime mover) having a capacity equal to the generator (prime mover) employed.

4. Connect standby generator (prime mover) to electrical system and test daily.

5. Trip switch to automatically activate standby system and remote telephone dialer or pager system for prompt action should operating and standby systems both fail.

B. All damaged or malfunctioning wells, well points, pumps or other discharge equipment shall be repaired or replaced expeditiously while maintaining all dewatering operations.

PART 3 - Execution

3.01 Maintaining Excavation in Dewatered Condition

A. Coordinate design, installation and operation of the dewatering system with design and installation of any excavation and/or temporary excavation support system as outlined in Section 31 14 00.

B. Subsequent to completion and acceptance of all Work including pipe laying and concrete work in the excavated area, maintain the excavation in a dewatered condition and the water level in the observation wells at the specified elevations until such time as a written directive to cease dewatering operations has been issued by Owner.

C. System maintenance shall include, but not be limited to the following:

1. 24-hour supervision by personnel skilled in the operation, maintenance, and replacement of system components.

2. Standby and spare equipment of the same capacity and quantity as specified above.

D. Dewatering shall be a continuous operation 24 hours per day, 7 days per week and 365 days per year and interruptions due to outages or other reasons shall not be permitted.

E. Installation, maintenance and development of wells or well points shall be in accordance with AWWA A100 unless specified otherwise.

F. If drawdowns are not initially adequate, as monitored by piezometers, modify the system until adequate drawdowns are achieved and maintained.

3.02 Groundwater Monitoring

A. Install not less than two piezometers for the purpose of monitoring groundwater elevations in the vicinity of the excavation. The total number of piezometers shall be such that the Contractor has sufficient information to monitor the groundwater in the vicinity of the proposed excavations.

B. Install piezometers seven days prior to commencing dewatering and begin daily readings immediately after installation.

C. Observe and record the elevation of the groundwater at each of the piezometers on a daily basis throughout the duration of dewatering on a form similar to that included at the end of this Section. Record groundwater level elevations to the nearest 0.1 foot.

D. Furnish a daily written summary of observations.

3.03 Contractor's Equipment, Supplies and Services

A. Owner may, at his option, inspect Contractor's equipment or supplies. If such equipment or supplies or any part thereof is not, in Owner's opinion, sufficient or satisfactory for the purpose of meeting requirements of these Specifications, Contractor will be notified in writing, and will be given a specific period of time within which to meet Owner's requirements. If Contractor fails to comply within the time limit specified, construction operations may be suspended until the requirements are satisfied.

3.04 Schedule

A. Work will be required during all weather conditions which are to be expected in Project area.

B. The dewatering system shall be installed and operable on a schedule that will not cause a delay in the excavation. The system shall be initiated to allow adequate time for drawdown to occur prior to the start of excavation.

C. If Work is substantially delayed, submit a report that shall include:

   1. Description of current and anticipated delaying factors.

   2. Proposed corrective actions.

D. Should operations fall behind the accepted schedule, Contractor shall, at no change in the Contract Price:

   1. Add to his plan, equipment, and construction forces, or

   2. Increase the working hours per week, or

   3. Both of the above.

3.05 System Removal

A. Upon completion of the Work and according to the schedule specified, remove all dewatering equipment and related components from the Site, including related temporary electrical service.

   1. Cut off all wells a minimum of three feet below the final ground surface or completely pull the well casing.

   2. Plug and/or fill the well casing or borehole in accordance with state regulations.

   3. Plug all piezometers installed by Contractor as part of this Contract, in accordance with state regulations.

   4. Backfill sumps with compacted fill or flowable fill.

   5. Removal work required under this paragraph does not address site cleanup work elsewhere in these Specifications.

B. Restore roadways and the ground surface along the dewatering piping corridor to original condition. Seed those areas damaged by installation and removal of the discharge piping.

3.06 Emergency Backfill Plan:

A. If required by TVA guidelines, provide a site-specific emergency backfill plan.

END OF SECTION

Part 1 General

1.01 Related Documents:

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

1.02 Summary:

A. Furnish labor, materials, equipment, and incidentals necessary to place and mix a flowable fill, consisting of Portland Cement, fine aggregate, fly ash, and water in the proper proportions as specified hereinafter. Class A Flowable Fill (Controlled Low-Strength Material) shall be used to bed and backfill around piping and utilities where indicated.

1.03 Related Requirements:

A. Section 31 20 00 – Site Preparation and Earthwork

1.04 Reference Standards:

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

B. Materials shall meet recommendation for mix and design and placement, as published by the National Ready Mix Concrete Association.

C. ASTM International (ASTM): (Approved equivalent AASHTO standards may be substituted.)

1. ASTM C33 Specifications for Concrete Aggregates
2. ASTM C40 Standard Test Method for Organic Impurities in Fine Aggregates for Concrete
3. ASTM C150 Standard Specification for Portland Cement
4. ASTM C260 Standard Specification for Air-Entraining Admixtures for Concrete
5. ASTM C494 Standard Specification for Chemical Admixtures for Concrete
6. ASTM C618 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

D. U.S. Army Corps of Engineers:

1. COE CRD-C611-80

1.05 Definitions:

A. Refer to PART 2 for detailed definitions and included materials.

1.06 Submittals:

A. Submit as specified in Division 01.

B. Includes, but not limited to, the following:

1. Trial mix design on material.

1.07 Quality Assurance:

A. Design Criteria; Concrete Proportions and Consistency: Flowable fill shall be proportioned to give the necessary workability and strength and shall conform to the following governing requirements.

i. 28-Day Compressive Strength: 70 – 150 psi

ii. Cement: 50 lb/CY Minimum

iii. Fine Aggregate: 2,720 lb/CY

iv. Water: 290 lb/CY Maximum

v. Fly Ash: 150 lb/CY Maximum

vi. Fluidity: Shall be measured by the Corps of Engineers flow cone method, according to their specification CRD-C611-80. Prior to filling the flow cone with flowable fill, the mixture shall be passed through a 1/4 inch screen. Time of efflux shall be approximately 12 seconds.

B. Factory Testing: The Contractor shall be responsible for the design of the material. A trial mix shall be designed by an independent testing laboratory, retained by the Contractor. The testing laboratory shall submit verification that the materials and proportions of the trial mix design meets the requirement of the Specifications. Concrete mix additive such as "Darafill" manufactured by Grace Construction Products or equal products may be required to achieve the low strength and the flowability requirements. In lieu of trial mix design, Contractor may submit a mix design used successfully in previous similar work, for similar materials for approval by Engineer. The Contractor shall not make changes in materials, either gradation, source, or brand, or proportions of the mixture after having been approved, except by specific approval of the Engineer.

C. Pre-Job Testing: Pre-job testing for excavatability with actual equipment and intended configuration of concrete sample is required. The testing equipment and configuration of concrete sample shall be determined by the Owner.

D. Owner Testing It is the responsibility of the Contractor to achieve and maintain the quality of material required by this Section of the Specifications. However, the Owner may secure the services of an independent testing laboratory to verify the quality of the concrete. The Owner shall have the right to require additional testing, strengthening, or replacement of concrete which has failed to meet the minimum requirements of this Section.

Part 2 Products

2.01 Materials

A. CEMENT: Portland Cement conforming to the specifications and test for Type I Portland Cement of the American Society for Testing and Materials, Designation C-150.

B. FINE AGGREGATE: Fine aggregate consisting of natural, washed and screened sand having clean, hard, strong, durable, uncoated grains complying with the requirements for ASTM C-33. The sand shall generally be of such size that all will pass a 3/8” sieve, at least 95% pass a 1/4” screen and at least 80% pass a No. 8 sieve. Aggregate shall not contain strong alkali, or organic material which gives a color darker than the standard color when tested in accordance with ASTM C40.

C. FLY ASH/POZZOLANS: Fly ash shall be an ASTM C618, Class "C" or Class “F” fly ash. The fly ash may be used in controlled low-strength material.

D. WATER: Water for concrete shall be clean and free from oil, acid, alkali, organic matter or other harmful impurities. Water which is suitable for drinking or for ordinary household use will be acceptable for concrete. Where available, water shall be obtained from mains of a waterworks system.

E. ADDITIVE:

1. "Darafill" may be required to meet these specifications.

2. Mineral admixtures will be pozzolanic

3. Chemical admixtures shall be in liquid or powder form used in standard ready-mix concrete products unless specifically designed for flowable fill. Permissible types of admixtures are:

    a. High air generators, as manufactured by the Euclid Chemical Company or approved equal, which are specifically designed for flowable fill to lower unit weights, reduce shrinkage and subsidence, and control compressive strength

    b. Air entraining admixtures conforming to ASTM C260.

    c. High range water reducers conforming to ASTM C494 Type F or G

    d. Only non-corrosive accelerating admixtures conforming to ASTM C494, Type C may be used.

2.02 Mixes

A. A. In the determination of the amount of water required for mix, consideration shall be given to the moisture content of the aggregate. The net amount of water in the mix will be the amount added at the mixer; plus the free water in the aggregate; and minus the absorption of the aggregate, based on a thirty (30) minute absorption period. No water allowance shall be made for evaporation after batching.

B. The methods of measurement of materials shall be such that the proportions of water to cement can be closely controlled during the progress of the work and easily checked at any time by the Owner's representative. To avoid unnecessary or haphazard changes in consistency, the aggregate shall be obtained from sources which will insure a uniform quality and grading during any single day's operation and they shall be delivered to the work and handled in such a manner that the variation in moisture content will not interfere with the steady production of concrete of reasonable degree of uniformity. Sources of supply shall be approved by the Owner's representative.

C. All material shall be separately and accurately measured. Measurement may be made by weight or by volume, as determined by the Contractor; however; all equipment for measurement of materials shall be subject to approval by the Owner's representative.

D. The proportions of the mix shall be such as to produce material that can be placed readily into the void area without spading or vibrating, and without segregation or undue accumulation of water or laitance of the surface.

E. When additive is contained in the flowable fill mix, the additive ingredients, proportions and placement of the additive shall be per Supplier's recommendations.

Part 3 Execution

3.01 INSTALLATION

A. Contractor shall give the Owner's representative sufficient advance notice before starting to place material in any area, to permit inspection of the area, and preparation for pouring.

B. Conduct the operation of depositing and compacting the material so as to form a compact, dense, impervious mass.

C. Flowable fill shall be uniformly placed to the depth shown on the Drawings. The fill shall be brought up uniformly to the top of excavation elevation. Placement of flowable fill shall then cease.

D. For Class A flowable fill, the fill shall be protected from traffic for a period of 72 hours.

E. The material shall be placed against undisturbed trench walls, and shall not be placed on or against frozen ground.

F. Material shall be placed in lifts or other measures shall be taken to prevent pipe flotation. Material shall be allowed to harden before placing next lift.

END OF SECTION

PART 1 - General

1.01 Summary

A. Work under this Section consists of furnishing, placing, maintaining and subsequently removing, to the extent required, a positive system of temporary supports for open cut excavations, including bracing and associated items to support the sides and ends of the excavations. The excavation support system shall prevent lateral and vertical ground movements which will cause damage or adversely impact the use or operation of existing buildings, structures, pavements, utilities, and any other adjacent improvements.

B. Where indicated, the excavations for the Emergency Backup Pump Station shall be made vertical and supported according to this Section. The minimum extent of required temporary excavation support systems specified herein are shown on Drawings for the Emergency Backup Pump Station. Additional temporary excavation support systems other than those shown on the Drawings may be needed to complete the Work in the manner proposed. Such additional temporary excavation support systems are not shown on the Drawings.

C. Contractor shall make his own assessment of existing conditions including subsurface conditions, adjacent property, the possible effects of his proposed temporary works and construction methods, and shall select and design such support systems, methods, and details as will assure safety to the public, adjacent property, and the completed Work.

D. The positive system of support may consist of soldier piles and lagging, sheet piling, or other methods as may be approved; which may be secured in place by means of bracing members which may include wales, struts, tieback anchors, or similar members.

E. A trench box is not considered a positive means of support and will not be permitted.

F. Utility modification or relocation shall be performed by Contractor at no additional cost to Owner, if existing utilities interfere with Contractor's proposed method of support.

1.02 Related Requirements

A. Section 03 30 00 – Concrete.

B. Section 31 20 00 – Site Preparation and Earthwork.

C. Section 31 23 19 – Temporary Construction Dewatering.

1.03 Reference Standards

A. General:

1. Standards listed by reference, including revisions by the issuing authority, form a part of this Section to the extent indicated. Standards listed are identified by the issuing authority, authority abbreviation, designation number, title or other

designation established by the issuing authority. Standards subsequently referenced herein are referred to by issuing authority abbreviation and standard designation.

2. Where specifications and reference documents conflict, the Engineer shall make the final determination of applicable document.

3. Unless otherwise noted, the latest revision of the following reference standards shall apply to this Section.

B. Applicable Standards:

1. American Society for Testing and Materials (ASTM):

    a. A36/A36M – Standard Specification for Carbon Structural Steel.

    b. A328/A328M – Standard Specification for Steel Sheet Piling.

    c. A416/A416M – Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.

    d. A572/A572M – Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.

    e. A615/A615M – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

    f. A722/A722M – Standard Specification for Uncoated High-Strength Steel Bars for Prestressing Concrete.

2. American Welding Society (AWS):

    a. D1.1/D1.1M - Structural Welding Code -Steel.

3. American Institute of Steel Construction (AISC):

    a. Manual of Steel Construction

4. Post-Tensioning Institute

    a. Recommendations for Prestressed Rock and Soil Anchors.

1.04 Submittals and Construction Records

A. Submit as specified in DIVISION 01.

B. Submit qualification statements at the time of bid:

1. Contractor and his subcontracted excavation support system engineer shall furnish evidence of having successfully completed one project that meets the following criteria:

        a. Equal or larger total linear footage of an excavation support system for one project of similar scope and conditions.

        b. Complete within the specified contract time.

    2. Qualifications of vibration monitoring firm.

C. Submit design and pre-construction information consisting of the following:

    1. Provide an Excavation Support System Report prepared by or under the supervision of Contractor's excavation support system engineer, for Owner information and review at least 15 days prior to the commencement of any excavation support system work. The Excavation Support System Report shall include working drawings and design calculations with the following information included and considered:

        a. Provide an outline of the entire scope of the excavation support systems.

        b. Details, arrangement, and method of assembly of the proposed system.

        c. The method of bracing and preloading.

        d. The full excavation depth.

        e. Loads for various stages of bracing removal during concrete placement and backfilling.

        f. The anticipated lateral earth pressures, hydrostatic pressure, utility, rail, traffic, and equipment loads.

        g. Assumed groundwater conditions.

        h. The maximum design load to be carried by the various members of the excavation support system and a tabulation of the required preloads.

        i. The depth to which the excavation support system will be installed.

        j. The proposed sequence of strut and excavation support system removal as applicable and as related to concrete placement and backfilling operations.

        k. Proposed monitoring plan, including location of monitoring points, inclinometers, and seismographs.

        l. Construction details of subsurface and surface monitoring points.

        m. Maximum theoretical deflections of the excavation support system members.

        n. Locations of existing utility facilities. After checking their locations by field investigations, the working drawings shall be revised to show the actual locations of facilities, location of excavation supports, interference with the proposed Work, and how Contractor proposes to overcome interferences, if any.

2. Welder certificates signed by Contractor certifying that welders comply with requirements under "Quality Assurance" Article.

3. Pre-excavation survey.

D. Submit construction and closeout information consisting of the following:

   1. Site visit status reports.

   2. Corrective action status reports.

   3. A summary of monitoring data, prepared by Contractor's excavation support system engineer, consisting of both survey and vibration monitoring information.

   4. As-built excavation support system drawings for those components of the system that are left in place.

1.05 Dewatering

A. Design and installation of the excavation support system shall be coordinated with the dewatering plan and criteria specified in Section 31 23 19.

1.06 Protection

A. Provide an excavation support system consisting of shoring, sheeting, and bracing as indicated or required. Meet the following requirements:

   1. Prevent undermining of pavements and slabs. Remove and replace all undermined pavements, either concrete or asphalt, at Contractor's expense.

   2. Excavations shall be accomplished with vertical sides where indicated (at a minimum) and also within the limits of excavation as noted on the Drawings.

   3. A sufficient quantity of material shall be on hand at all times (for sheeting, shoring, bracing and other purposes) for the safe execution of the work and for use in case of accident or other emergency.

1.07 Quality Assurance

A. Design Criteria:

   1. The design and construction of the excavation support system, and the adequacy thereof, shall be the sole responsibility of Contractor. Contractor's excavation support system engineer shall be a professional engineer, legally authorized to practice in the jurisdiction where the Project is located, experienced in the design of earth support systems, and required to visit the Site prior to development of system designs in order to become familiar with existing Site conditions.

2. Use good engineering practice, knowledge of the local or regional subsurface conditions, available geotechnical or subsurface information, and studies performed by the Contractor to investigate the subsurface conditions at the Site, in the analysis and design of the excavation support system.

3. Design the excavation support system in accordance with the design criteria specified herein and in the Contract Documents. The criteria are intended for guidance and are the minimum acceptable.

4. Where applicable, the design and construction of the excavation support system shall conform to the requirements of the AISC Manual of Steel Construction, unless otherwise stated.

5. Design the excavation support system and components to support lateral earth pressures, unrelieved hydrostatic pressures, utility loads, rail loads, traffic and construction loads, and building and other surcharge loads to allow the safe and expeditious construction of the permanent structures without movement or settlement of the ground, and to prevent damage to or movement of adjacent buildings, structures, utilities, and other improvements. All of the above loadings, as applicable to the Work, shall be determined by Contractor's excavation support systems engineer to establish the minimum design criteria. In all cases, the minimum design lateral earth pressure shall be as determined by Contractor’s excavation support system engineer. A minimum uniform surcharge load of 250 psf or greater, as determined by Contractor’s excavation support system engineer, shall be applied to the ground surface above/behind the support system to consider potential live and construction loads.

6. Design members to support the maximum loads that can occur during construction. For the purpose of this Section, the design load is the maximum load the support member will have to carry in actual practice, and the proof load is a specified test load greater than the design load.

7. Employ wales, struts, rakers, and tieback anchors for horizontal support for excavation faces retained by soldier piles and lagging, sheet piling, or other methods as may be approved. Provide struts with intermediate vertical and horizontal supports if necessary to prevent buckling. Bracing members shall be structural steel.

8. Take into account stresses due to temperature variations in the design of the struts. Make provisions to protect struts against deformations and stress variations induced by temperature fluctuations.

9. The splicing of an element of the support system will not be permitted.

10. Analyze elements supporting vertical loads and lateral pressures for combined axial load and bending.

11. As appropriate, the design shall account for staged removal of bracing to suit the sequence of concrete placement for permanent structures and of backfill.

12. Lateral loads due to soil and surcharges shall not be transmitted to the permanent structures, or portions thereof, until the concrete has reached sufficient strength to resist said loads, and then, not until the section to be loaded has been checked for strength and deflection and the method of load transmittal reviewed and approved. The removal of struts shall not increase the design loading on the permanent structures.

13. The calculated maximum deflection of any element of the support system shall not exceed 1-inch during excavation or brace removal.

14. In a bracing system where wales are not used and a direct strut to soldier pile connection is used, consider an additional provision for bending stress due to the eccentricity of lateral loading.

15. Design compression member connections for their compressive loads and for a minimum tensile and shearing load.

16. Consider buckling in the plane perpendicular and parallel to the lagging in the design of soldier piles.

17. Backfill soldier piles installed in predrilled holes with lean concrete and allow for set up prior to the start of excavation.

18. In order to satisfy a hinge condition at the bottom of excavation in soil, the vertical wall members shall have at least the minimum penetration necessary to develop the passive resistance of ground material in which piles are embedded, or cantilever action shall be assumed about the lowest installed brace.

19. Apply earth pressure above the pile subgrade elevation to the full panel width between soldier pile centers and to the width of the soldier pile or encasement below pile subgrade.

20. Account for the concentration of soil pressures at struts and tieback locations.

21. Where the loading conditions on opposite sides of an excavation are not equal, analyze the stability of the temporary retaining structure and design structural members so as to take this condition into account.

22. Design bracing members and connections using basic allowable unit stresses.

23. Where wales are a part of the support system, they shall be designed according to the principles of statics.

24. During installation and removal of the excavation support system for each structure, Contractor's excavation support system engineer shall visit the Site to observe the Work and to verify the compatibility of the Work with design assumptions. Contractor's excavation support system engineer shall prepare a status report with each visit to the Site. This report shall be submitted to Owner one days after each Site visit. This status report shall contain certification that the Work is in concurrence with design assumptions. If deficiencies are observed, these must be noted and the corrective action outlined in the report. In the event

that deficiencies are noted in the excavation support system engineer's report, the excavation support system engineer shall return to the Site within three days after the corrective action has begun to verify that the deficiencies are adequately being corrected. A corrective action status report shall then be prepared by the excavation support system engineer. The above outlined procedures shall be repeated until the corrective action status report confirms that all deficiencies have adequately been corrected.

B. Tieback Analysis and Design:

1. Investigate loading and use the most critical case for design.

2. Make a check of the overall stability (sliding, rotational, etc.) of the zone forming the anchoring mass of earth. For a rotational analysis using the slip circle method, the design shall yield a factor of safety of at least 1.5, based on loading and the physical properties tabulated.

3. Anchors shall be considered as receiving resistance from only the soil mass acting beyond the estimated soil failure plane. Consideration shall be given to increased extent of the failure zone due to high surcharge loads.

4. Determine the allowable value of adhesion and friction between the soil and the anchor for design of effective embedded length of each individual anchor in various strata. The effective length thus found shall be increased by at least 10% to make allowance for unforeseen field variables.

5. The angle between the direction of the anchor and the horizontal line perpendicular to the support of excavation wall shall be chosen by the Contractor within a range of 0 degrees to 30 degrees. Account shall be taken of the effects of resulting vertical components and associated structural implications arising therefrom, particularly regarding toe penetration requirements.

6. Install anchors in predrilled holes and pressure grout to ensure firm contact with the surrounding soil.

7. For drilled-in anchors, the total anchor load shall be developed in bond between steel and grout acting within effective length of the anchorage.

8. The final design stress shall not exceed 70% of the yield strength.

9. For proof and/or performance testing of tieback anchors, the maximum stress in the steel shall not exceed 80% of the ultimate strength nor the manufacturer's recommendations as shown in manufacturer’s catalog or otherwise stated by manufacturer in writing.

10. Spacing of the tiebacks shall ensure no overlap of resisting soil stress bulbs in assuming full value of anchorage for each tieback. In the event of overlap, then a reduction factor shall be used for affected tiebacks. In any one plane the anchors shall have a minimum clear distance between them of five feet. Tiebacks having overlapping soil stress bulbs shall be pretested simultaneously.

11. The value of overburden pressure, if used for friction calculations, shall not include surcharge loads.

12. Tiebacks shall not be placed closer than 10 feet to foundation structures of existing buildings.

C. Monitoring:

1. Monitor installation, performance and removal of the excavation support system by considering pre-excavation conditions, ground movement, and vibrations.

2. Complete a pre-excavation survey by documenting all existing damage to adjacent facilities. Submit the information to the Owner prior to performing any excavation. Documentation shall include a written description, diagrams, measurements, video and photographs as appropriate.

3. Submit monitoring plan including construction details of subsurface and surface monitoring points prior to performing any excavation.

4. Perform ground movement monitoring by completing the following tasks:

    a. Install surface and subsurface monitoring points at locations adjacent to the excavation support system for the Emergency Backup Pump Station, and any other excavations of more than 20 feet in depth. The location of all monitoring point and inclinometer installations shall be selected by Contractor's excavation support system engineer for approval by Owner. All optical readings shall be taken and recorded by a registered surveyor licensed to practice in the jurisdiction where the Project is located. Optical readings shall be made to the nearest 0.001-foot. All readings shall be referenced to an established benchmark or benchmarks located at least 100 feet from the face of the excavation.

    b. Establish lines of monitoring points, perpendicular to the excavation face, for at least two sides of each excavation where monitoring is required. Space the lines of monitoring points no more than 20 feet apart, and a minimum of two lines shall be established for each excavation side to be monitored. Each monitoring line shall consist of a minimum of four monitoring points spaced no more than 10 feet apart. Locate the first monitoring point in each line at the top of the excavation. The monitoring lines shall extend horizontally from the excavation face to a distance equivalent to twice the total excavation depth. The base of each monitoring point shall extend to a depth of at least five feet below the ground surface.

    c. Each survey reading shall consist of measuring the vertical and horizontal location of each monitoring point. Make the initial set of readings prior to the start of the excavation. Make each additional set of readings at each 5-foot increment of vertical excavation depth, and immediately before and immediately after internal bracing or tiebacks are installed. After the excavation has been completed, take readings at one and three day intervals, with repeating 3-day intervals thereafter until movements have been determined by Contractor's excavation support system engineer to have ceased. If portions of the bracing system are removed at any time, make readings immediately prior to removal and immediately after removal.

d. Install inclinometers prior to the excavation at the Emergency Backup Pump Station if determined to be necessary by the Contractor’s excavation support system engineer for appropriate monitoring. If required, install a minimum of two inclinometers at each excavation within three feet of the excavation face. Locate inclinometer and monitoring points on the same sides of the excavations. Install each inclinometer to a depth of at least 1.5 times the total excavation depth. Make inclinometer readings at the same intervals as the survey readings for the monitoring points. Inclinometers are recommended for significant excavations or excavations to be open longer periods of time.

e. Contractor's excavation support system engineer shall reduce and review the monitoring data and submit a summary of the data on a weekly basis. As a minimum, this summary shall include raw monitoring data, along with graphical plots of the monitoring data and the excavation support system engineer's interpretation thereof.

5. If the excavation support system requires installation of components with impact hammers, perform vibration monitoring. Retain a separate, certified firm to perform the following tasks associated with vibration monitoring:

a. Determine locations to set up seismographs, or where to position during various stages of pile driving activities.

b. Measure background vibration response and air response noise along the alignment prior to commencing driving.

c. Perform background monitoring during construction at times corresponding to those times of proposed driving operations.

d. Monitor driving operations at necessary locations along the excavation support system operation throughout all driving operations.

e. Provide a permanent record from each seismograph, referencing location of seismographs and distance away from driving operation.

f. Use a minimum of two seismographs capable of detecting peak particle velocities in three mutually perpendicular components, otherwise known as the x, y, and z axes.

g. Use a minimum of two seismographs capable of recording amplitude (peak particle velocity), and frequency (hertz). Displacement shall be developed, if needed for frequencies as required, from empirical computer relationships.

h. Peak particle velocities and/or displacements at adjacent structures, equipment, exposed or buried, pipelines and conduits shall not exceed the level of criteria as determined by United States Department of Interior, Bureau of Mines in Appendix Figure B-1 from Report of Investigations 8507 by D.E. Siskind, et. al.

D. Work Site Conditions:

1. Provision for Contingencies:

    a. Monitor the performance of the components of the support system for both vertical and horizontal movement at regular intervals as noted above (not to exceed three days).

    b. Provide a contingency plan or alternative procedure for implementation if unfavorable performance is evident.

    c. Keep the materials and equipment necessary to implement the contingency plan on hand.

2. Employ caution in the areas of utility facilities, which shall be exposed by hand or other excavation methods acceptable to Owner.

E. Welding Standards:

1. Comply with applicable provisions of AWS D1.1/D1.1M.

2. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved, and if pertinent, has undergone recertification.

PART 2 - Products

2.01 All Materials

A. All materials shall be of a strength, size, grade and shape, as determined by Contractor’s excavation support system engineer, and as shown in the Excavation Support System Report, best fitted for their intended use and able to resist the loads anticipated with acceptable deflection.

B. Whether new or used, all materials shall be sound and free of defects that might impair strength or function.

2.02 Structural Steel

A. Steel H-piles, WF shapes, bracing members, fabricated connections, and all other accessories shall conform to the requirements of ASTM A572/A572M or A36/A36M.

2.03 Structural Steel Sheet Piles

A. Steel sheet piling shall conform to the requirements of ASTM A328/A328M.

B. Steel sheet piling and interlocks shall not have excessive kinks, camber, or twists that would prevent the pile from free sliding.

2.04 Field Welding

A. Shall be performed by certified welders and be in accordance with AWS D1.1/D1.1M.

2.05 Tiebacks

A. Steel tendons shall be high strength material in accordance with ASTM A416 including supplementary requirement S1 and shall be weldless and low relaxation grade.

B. Steel rods shall be high strength material in accordance with ASTM A615 or A722.

2.06 Concrete

A. Lean concrete shall be a mixture of cement, sand, fly ash, aggregate and water in the proportions determined by Contractor’s support system engineer and shall be placed in such a manner as to present a firm, stable mass capable of retaining shape and position during excavation operations, yet allow relative ease in chipping out for placement of lagging.

B. All other concrete shall conform to the requirements of SECTION 03 30 00.

2.07 Timber Lagging

A. Shall be of a structural grade providing a minimum allowable design stress of 1,100 psi where a system of timber lagging is to be used to support earth excavation.

PART 3 - Execution

3.01 Soldier Pile Installation

A. In the initial positioning of soldier piles at the ground surface, make allowances for installation deviations, and the probable inward movements of the support wall during excavation. Intrusion of wall members into the neat lines of the structures will not be permitted. Where excavation support systems are located contiguous to the neat lines of the structure, provide a reasonable percentage of the depth of excavation to subgrade for initial installation offset.

B. Install soldier piles by pre-boring or other pre-excavating methods to tip elevation shown on the approved working drawings.

C. Case or fill pre-bored holes with bentonite slurry, as required, to prevent caving of the sides of the hole prior to placement of the soldier pile and encasement.

D. Carry the bottom of the excavation support system to a tip depth sufficiently below the main excavation to provide lateral support to limit the maximum pile deflection to 1-inch.

E. After seating the soldier piles in pre-bored holes, completely encase the piles with lean concrete.

3.02 Lagging and Sheeting Installation

A. Use timber lagging or contact sheeting, steel sheeting, or precast reinforced concrete members secured in place for sheeting of excavations.

B. Install sheeting and lagging with no gap between the members. Carefully perform excavation for the installation of sheeting and lagging to minimize or eliminate the formation of voids behind the lagging. As installation progresses, backfill voids between the excavation face and the lagging or sheeting with sand or soil compacted in place. Pack gaps in lagging with materials such as hay or burlap to allow drainage of groundwater without substantial loss of soil.

C. If unstable material is encountered, take measures to retain the material in place or to otherwise prevent soil displacement.

D. Sheeting and lagging placement shall follow the excavation. The maximum height of the unsheeted or unlagged face of excavation shall be determined by the job conditions, but in no case, or at any time, shall it exceed four feet in predominately clayey soils or three feet in sandy soils. If water flows from the face of the excavation, or soil in the face moves toward the excavated area, the maximum height of the unlagged face shall be reduced as directed by the excavation support system engineer.

E. In running sand or silt, provide a positive means of securing the lagging to the soldier piles to avoid shifting or falling off of the lagging. Provide a positive means of securing the material behind the lagging or sheeting.

F. Place wales, when used, on the inside face of the support wall. Make provisions to wedge, pack, shim, or otherwise assure tight bearing between wales and soldier piles, with ample bearing area to assure transfer of the load.

G. Remove lean concrete only to the extent that is required for installation of the lagging.

3.03 Sheet Pile System Installation

A. Use structural steel sheet piles intended for use in excavation support systems.

B. Drive sheet piling by recognized methods of good practice in soil conditions present using a hammer with sufficient energy to penetrate overburden material without damaging the sheet piling or adjacent existing facilities.

C. Avoid splicing of sheet piling when possible.

D. Z-pile sections shall be driven with ball edge "ahead."

E. Sheet piling not cut to length shall be cut off after driving at elevations as indicated, if applicable.

F. Provide protection to sheet pile ends, as required, to ease driving, assure penetration, and prevent tearing or splitting in hard driving conditions.

3.04 Internal Bracing Support System Installation

A. The internal bracing support system includes wales, struts, and shores.

B. Brace as soon as possible after reaching prescribed excavation levels.

C. Provide struts with intermediate bracing if necessary, to enable them to carry the maximum design load without distortion or buckling.

D. Provide diagonal bracing where needed to maintain the stability of the system.

E. Include web stiffeners, plates, or angles to prevent rotation, crippling, or buckling of connections and points of bearing between structural steel members. Allow for eccentricities due to field fabrication and assembly.

F. Install bracing support members and maintain in tight contact with each other and with the surface being supported.

G. Coordinate excavation work with installation of bracing and preloading.

H. Preloading:

1. Primary bracing members including struts, shores, and similar members shall be preloaded at installation. The amount of the preload shall be determined by Contractor's excavation support system engineer. Tiebacks shall be preloaded as specified for those installations.

2. Use procedures that produce uniform loading of the bracing member without appreciable eccentricities, or overstressing and distortion of the members of the wall system.

3. Make provisions for permanently fixing the required load in the member using steel shims or wedges welded into place.

4. Wooden wedges shall not be used to preload a bracing member.

5. The preloading system shall include a means to determine within 5% the amount of preload induced into the bracing members.

I. Excavation shall not go deeper than three feet below the point of support about to be placed. Install the support and preload immediately after installation of bracing and prior to continuing excavation.

3.05 Tieback Support System Installation

A. Install piles or other vertical support system members incorporated in a system using tieback anchors so that vertical support members are capable of resisting vertical components of tieback loads without significant settlement during excavation and construction. In general, install the members to be end bearing in a stratum below the maximum depth of excavation and capable of carrying the total vertical loads without assistance of skin friction in the depth of the excavation.

B. Install the anchorage portion of the tiebacks in soil beyond the estimated failure plane extending upward from the limit of the lowest depth of excavation.

C. Grease and wrap drilled-in anchors or otherwise treat to ensure the absence of bond on the portion of the tieback between the face of wall and the anchorage.

D. Proof Tests on Tiebacks:

   1. All tieback anchors shall be proof loaded.

   2. Stress all the tiebacks to proof loads equal to 120% of the maximum design load. Maintain the proof load for 30 minutes prior to reducing it to the design load. Anchors which lose more than 5% of the proof load during the 30-minute period will not be acceptable.

   3. During proof testing, load in increments of 5 tons at one-minute intervals providing means to measure the load application within an accuracy of plus or minus 5%. Record axial movement corresponding to incremental applications of load to an accuracy of 0.01-inch.

   4. After reducing the tieback load to the design load, encase tiebacks in grout. Maintain the design load until the tiebacks are fixed in place.

   5. Use a method of fixation which will limit the load loss to no more than 5% of the design load in the transfer of the loads from the jacks to the support system.

   6. Provide and maintain convenient access and appropriate means so that these observations may be made.

E. Performance Tests on Tiebacks:

   1. Conduct performance tests on at least one selected tieback prior to installing any of the remaining tiebacks, which will all be proof loaded. Test tiebacks at each level of support in the excavation. A minimum of five percent of the tiebacks installed shall be performance tested. All performance tests shall be measured with a load cell accurate to within 1% of the design load.

   2. Performance tests for tiebacks in cohesionless soils shall follow the guidelines and load increment recommendations of the PTI “Recommendations for Prestressed Rock and Soil Anchors” document to a maximum test load of 1.33 times the design load.

      a. For cohesionless soils, the load shall then be reduced to 100% of the design load and locked off. Record axial movement corresponding to incremental applications of 25% of the design load for each individual cycle of loading to an accuracy of 0.001-inch.

      b. For cohesive soils, the load shall be reduced to 100% of the design load and maintained continuously for a minimum of 10 hours. Then measure axial movements to an accuracy of 0.001 inch and record on 5-minute intervals for the first 100 minutes and 10-minute intervals thereafter.

3. The data from all performance tests shall be interpreted by Contractor's excavation support system engineer. This interpretation will constitute an evaluation of anchor allowable load-carrying capacities and shall be used by Contractor's excavation support system engineer to set a criterion for allowable movement of the proof tests.

4. Provide and maintain convenient access and appropriate means so that these observations may be made.

3.06 Removal

A. Except as otherwise specified herein, excavation support system materials may be extracted and reused at Contractor's option; however, remove and replace any existing structure or utility damaged during excavation support system installation and removal. Where excavation support system materials must be left in place in the completed Work to prevent settlements or damage to adjacent structures or as directed, backfill the excavation to within three feet below the finished grade and remove the remaining exposed portion of the excavation support system before completing the backfill. If H-piles and wood lagging are utilized, remove wood lagging to within three feet of finished grade in incremental steps of approximately six inches as the backfill is constructed. The location of all excavation support system components left in place shall be documented on as-built drawings and given to Owner.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section includes hot-mix, asphaltic-concrete pavement materials, equipment, placement, and testing.

1.03 Related Requirements

A. Site Preparation and Earthwork: Section 31 20 00.

1.04 References

A. Applicable Standards:

1. ASTM International (ASTM):

    a. ASTM C29/C29M - Test Method for Unit Weight and Voids in Aggregate.

    b. ASTM C117 - Test Method for Material Finer than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing.

    c. ASTM C127 - Test Method for Specific Gravity and Absorption of Coarse Aggregate.

    d. ASTM C128 - Test Method for Specific Gravity and Absorption of Fine Aggregate.

    e. ASTM C131 - Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

    f. ASTM C136 - Method for Sieve Analysis of Fine and Coarse Aggregates.

    g. ASTM C183 - Practice for Sampling and the Amount of Testing of Hydraulic Cement.

    h. ASTM D75 - Practices for Sampling Aggregates.

    i. ASTM D140 - Practice for Sampling Bituminous Materials.

    j. ASTM D242 - Mineral Filler for Bituminous Paving Mixtures.

k. ASTM D946 - Penetration-Graded Asphalt Cement for Use in Pavement Construction.

l. ASTM D979 - Practice for Sampling Bituminous Paving Mixtures.

m. ASTM D1559 - Test Method of Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus.

n. ASTM D3381 - Viscosity-Graded Asphalt Cement for Use in Pavement Construction.

2. American Association of State Highway and Transportation Officials (AASHTO):

   a. AASHTO M29 - Fine Aggregate for Bituminous Paving Mixtures.

   b. AASHTO T102 - Spot Test of Asphaltic Materials.

3. Tennessee Department of Transportation (TDOT) Standard Specifications for Road and Bridge Construction (latest edition).

1.05 Submittals

A. Samples: Furnish Samples as specified. Samples shall be delivered to the laboratory designated by Engineer. Sampling shall be under the observation of Engineer when required:

1. Furnish Samples of aggregates and asphalt cement to be used in the Work at least 30 days prior to beginning production of asphalt paving mixture. Sampling methods shall conform to the following:

   a. Asphalt Cement: ASTM D140.

   b. Coarse and Fine Aggregates: ASTM D75.

   c. Mineral Filler: ASTM C183, paragraphs 3, 4, and 6.

2. Furnish at least one Sample from each 272 metric tons (300 tons) of the mix being produced. Sampling method shall conform to ASTM D979.

3. Completed Pavement: Core or saw undamaged Samples of the size and number required by Engineer:

   a. Take Samples in sets of three at locations designated by Engineer.

   b. Replace pavement at Sample locations with fresh bituminous mixture and thoroughly compact repaired area.

4. Furnish additional Samples prior to and during construction of the number and size requested by Engineer.

B. Job-Mix Formula:

1. Formula shall indicate the definite percentage of each sieve fraction, percentage of asphalt, and the temperature of the completed mixture as it is to be discharged from the mixer.

2. Formula shall be furnished by Contractor 30 days prior to beginning production of paving mixtures, and approved by Engineer following testing of the aggregates and bitumen before any bituminous mixtures are manufactured.

3. Formula shall permit adjustments of the bitumen content and aggregate gradation within the limits of the gradation table specified to improve the paving mixtures as required by Engineer.

4. Restrict formula to values so that application of the following tolerances will not cause the limits in the gradation table to be exceeded:

Material	Base Course	Surface Course
Aggregate passing 4.75mm (No. 4) sieve or larger ………………………	±5%	±4%
Aggregate passing 2.0 mm, 425 µm, And 180 µm (No. 10, 40, and 80) sieves ………………………………..	±4%	±3%
Aggregate passing 75 µm (No. 200) sieve ………………………………..	±2.0%	±1.0%
Asphalt …………………………….	±0.5%	±0.3%

1.06 Testing

A. Engineer will test all materials and mixes to determine conformance with these Specifications. Tests will be performed without cost to Contractor.

1.07 Job Conditions

A. Weather Limitations: Do not mix or place hot-mix asphaltic concrete when the ambient temperature is below 5ºC (40ºF).

PART 2 - Products

2.01 Equipment

A. General:

1. Includes all equipment to be used in the performance of the Work covered by this Section.

2. Maintain all equipment, tools, and machines in a satisfactory working condition at all times.

    a. Equipment that drips fuel, oil, or grease shall be removed from the Project until such leakage is corrected.

3. All equipment shall be subject to the approval of Engineer.

B. Haul Trucks:

1. Includes all vehicles used for the transportation of asphaltic concrete from the plant to the paving Site.

2. Trucks shall have tight metal bottoms, and shall be free from materials which may affect the mix being hauled.

3. Provide trucks with covers to protect the load and to prevent cooling of the upper surface of the mix.

C. Blowers and brooms shall be of the power type suitable for cleaning the surface to be paved.

D. Pavers:

1. Pavers shall be of the self-propelled type, equipped with hoppers, distributing screws, adjustable screeds, and equalizing devices capable of spreading hot bituminous mixtures without tearing, shoving, or gouging.

2. Pavers shall be capable of producing a finished surface of specified evenness.

3. Pavers shall be designed to operate forward at variable speeds and in reverse at traveling speeds of not less than 100 feet per minute. Equip paver with an approved control system capable of automatically controlling the elevation and transverse slope of the paver screed from all of the following references:

    a. An erected or traveling stringline on both sides of the paver actuating the control system on each side of the paver independently.

    b. An erected or traveling stringline operating on one side of the paver only.

E. Rollers:

1. Rollers shall be:

    a. Self-propelled, steel-wheel, vibratory, and pneumatic types with reversing mechanism.

   b. Friction clutch and brakes of ample capacity to permit smooth starting, stopping, and reversing.

   c. Adjustable scrapers, water tanks, and sprinkling apparatus to keep the wheels wet.

2. Pneumatic Rollers:

   a. Rollers shall consist of two axles on which are mounted not less than nine smooth wheels of equal size, diameter, and ply rating. Tracking wheels shall overlap by a minimum of 6 mm (1/4 inch).

   b. Rollers shall be capable of exerting average contact pressures varying from 276 to 758 kPa (40 to 110 lbs. per inch^2) by adjusting ballast and tire inflation pressures.

   c. Contact pressure shall be uniform for all wheels.

   d. Wheels shall oscillate in a vertical plane but not wobble.

   e. Rollers shall be provided with a loading platform or body suitable for ballast loading of not less than 4.1 metric tons (4.5 tons).

3. Steel-wheel rollers may be either 3-wheel rollers, 2-axle tandem rollers, or 3-axle tandem rollers:

   a. Rollers shall weigh not less than 9 metric tons (10 tons), and develop contact pressures under the compression rolls of not less than 2.1 MPa (300 psi).

   b. Three-axle tandem rollers shall be so constructed, that when locked in position for all treads to be in one plane, the roller wheels are held with such rigidity that if either front or center wheel is unsupported, the other two wheels will not vary from the plane more than 6 mm (1/4 inch).

   c. Roller wheels shall have no flat areas, openings, or projections which will mar the surface of the pavement.

4. Vibratory rollers may have either one or two smooth-surfaced steel wheels.

   a. Rollers shall be provided with a means of adjusting the resonance of the dynamic force.

5. Trench rollers shall have an auxiliary wheel (or roll) that operates outside the area to be compacted at such a distance from the pavement edge as to not cause any damage to the pavement edge:

   a. Auxiliary wheel shall be mounted upon an axle that is adjustable in height.

   b. Contact pressure per 25 mm (1 inch) of width of compression roll shall be not less than 136 kg (300 lbs.) nor more than 165 kg (364 lbs.).

c. Minimum allowable width of compaction roll shall be 375 mm (15 inches).

F. Hand Tampers: Weight of tamper shall be not less than 11.5 kg (25 lbs.), with a tamping face of not more than 320 cm^2 (50 $inches^2$).

G. Small Tools:

1. Furnish rakes, lutes, shovels, smoothing irons, pavement cutters, wheel-mounted wagons for heating small tools, wood sandals and stilt sandals of standard type, and other small tools as may be required.

2. Tools shall be available at all times in sufficient number to efficiently construct the bituminous pavements.

2.02 Materials

A. Aggregates:

1. General Requirements: Aggregate shall be crushed stone, crushed gravel, screenings, sand, and mineral filler as approved by Engineer prior to use in the Work, and defined as according to Section 411 and other related Sections of the TDOT Standard Specifications for Road and Bridge Construction.

2.03 Mixes

Composition of the Mix: refer to Section 411 and related Sections of the TDOT Standard Specifications for Road and Bridge Construction.

A. Aggregate Gradations: Gradation of aggregate shall be determined conforming to ASTM C117 and C136.

B. Mixture Test Properties:

1. Laboratory test specimens of the paving mix, combined in proportions of the job-mix formula, will be tested by Engineer in accordance with ASTM D1559 and ASTM C29. Test properties shall be as follows for all paving mixtures:

Marshall stability ………………….	1,200 minimum
Number of compaction blows …….	50
Marshall flow ……………………...	8-16
Percent air voids - laboratory specimen	
Base course ………………………..	3-8
Surface …………………………….	3-5

Percent voids filled with asphalt

Base course ……………………….. 65-72

Surface ……………………………. 75-82

PART 3 - Execution

3.01 Preparation of Mixture

A. Hot-mix asphaltic concrete shall be produced in a mixing plant conforming to Section 407 of the TDOT Standard Specifications for Road and Bridge Construction.

1. Preparation of mixture shall be as specified in the same Section.

2. Temperature of the mix as it is discharged from the mixer, and tolerances thereof, shall be as specified in Section 407.11 of the TDOT Standard Specifications for Road and Bridge Construction.

3.02 Transportation of Mixture

A. Haul trucks shall be as specified in Part 2, this Section. Provide trucks of such size, operating speed, and condition to ensure orderly and continuous operation.

B. When necessary to prevent adhesion of mixture to truck beds, coat truck beds with a minimum quantity of paraffin oil, lime solution, or other approved material.

C. Haul trucks shall make no direct frame contact with the paver, and shall not bear down on the paver during dumping operations.

D. Deliveries shall be made so that spreading and rolling of all the mixture prepared for a day's run can be completed during daylight.

E. Deliver to the area to be paved in such a manner that the temperature at the time of dumping into the spreader will not be less than hereinafter specified.

F. Hauling over freshly laid material will not be permitted.

G. Loads wet excessively by rain will be rejected.

3.03 Placing Mixture

A. Underlying Course:

1. Clean of all foreign or objectionable matter with power blowers, power brooms, or hand brooms as approved by Engineer.

2. Prepare as specified in Section 31 20 00.

B. Temperature of mixture shall be within the range determined by Engineer and not be less than 113ºC (235ºF) when dumped into the mechanical spreader or it will be rejected.

C. Automatic screed controls shall be actuated by the following grade references installed by Contractor:

1. An erected stringline on each side of the first lane placed in each course, independently actuating screed control mechanisms on each side of the paver.

2. A traveling stringline operated on the adjacent completed lane, and an erected stringline on the subgrade or previously completed pavement course, independently actuating screed control mechanism on each side of the paver for the second and all successive lanes of each course.

3. Erected stringlines will be required on only one side of the first paving lane of each course for all pavements having a width of 7.3 m (24 ft.) or less providing automatic slope controls produce finish transverse slopes within the specified tolerances for smoothness and grade.

4. Joint matching shoes operating on previously completed gutter sections shall be used for control reference on all paving lanes adjacent to curb-and-gutter sections.

D. Adjust spreader and regulate speed so the surface of the course is smooth and of such depth that when compacted it will conform to the cross section, grade, and contour as indicated.

E. Paving Strips:

1. Begin along centerline of areas to be paved on a crowned section and on high side of a section of an area with a one-way slope.

2. Place in strips with a minimum width of 3 m (10 ft.).

3. Roll, leaving a 150-mm (6-inch) unrolled strip adjacent to the area on which additional material is to be laid, except when the Work is to be discontinued.

4. Place strips in succeeding order while the unrolled 150-mm (6-inch) section of the adjoining strip is hot and in a readily compactable condition, and roll.

5. Paving strips shall be of such length as determined by Engineer, before placing the succeeding strips.

6. Place material as nearly continuous as possible.

7. Paving strips shall be as approved by Engineer where necessary to maintain traffic flow.

F. Handwork:

1. Use a sufficient number of experienced shovelers and rakers following the spreading machine to produce a course that will conform to all requirements specified.

2. In areas where use of machine spreading is impractical, place mixture on dumpboards outside the area to be paved, distribute by hot shovels, and spread with hot rakes in a uniformly loose layer of such thickness that when compacted it will conform to the required grade and thickness.

3. Rakers shall not be permitted to stand in hot mix without stilt sandals.

G. Contact Surfaces:

1. Defined as previously constructed pavement curbs, manholes, and similar structures.

2. Coat with a thin coat of hot bituminous material prior to placing the bituminous mixture.

3.04 Compaction of Mixtures

A. Rollers:

1. Use three-wheel, pneumatic, and steel-wheel rollers specified. Vibratory rollers may be used where approved by Engineer.

2. Begin as soon after placing as mixture will bear the roller without undue displacement. Delays in rolling freshly spread mixture will not be permitted.

B. Operation of Rollers:

1. Only competent and experienced persons shall operate rollers.

2. Do not exceed speeds of 5 km (3 miles) per hour for steel-wheeled rollers and 8 km (5 miles) per hour for pneumatic rollers, and at all times speed shall be slow enough to avoid displacement of the hot mixture.

3. Moisten wheels to prevent adhesion of the mixture to the wheels, but an excess of water will not be permitted.

4. Provide a minimum of one steel-wheeled roller and one pneumatic roller for each spreading machine in operation, with additional 9 metric ton (10 ton) rollers added if it is found that the pavement density specified is not obtained by the minimum number of rollers.

5. Pass over the unprotected edge of the course only when the laying of the course is to be discontinued for such length of time as to permit the mixture to become cold.

C. Roll pavement in the following order:

1. Transverse joints.
2. Longitudinal joints at adjacent completed paving lane or curb and gutter section.
3. Outside edge of first and last paving lanes not adjacent to completed pavement or curb and gutter sections.
4. Breakdown rolling beginning on the low side and progressing toward the high side.
5. Second rolling beginning at the low side and progressing toward the high side.
6. Finish rolling.

D. Joint Rolling:

1. Roll joints directly behind the paving operation.
2. Make first pass with approximately a 150-mm (6-inch) width of roll on the joint and the remainder supported by the previously completed mat.
3. Shift position of roll on joint in 150- to 200-mm (6- to 8-inch) increments on successive passes and continue rolling until a thoroughly compacted neat joint is obtained.

E. Breakdown Rolling:

1. Use either steel-wheeled or pneumatic rollers.
2. Operate with drive wheels or rolls nearest the paver.
3. Roll as close to the paver as possible without causing undue displacement of the mat.

F. Second Rolling:

1. Use pneumatic or vibratory rollers specified.
2. Accomplish while paving mix is still at a temperature that will result in maximum density and following breakdown rolling as closely as possible.
3. Continue rolling until the mix is thoroughly and uniformly compacted to the specified density but make not less than three complete coverages of the mat.

G. Finish Rolling:

1. Use two-axle or three-axle tandem rollers specified.
2. Roll while mat is of sufficient temperature to permit removal of roller marks.

3. Continue rolling until all roller marks have been removed and a uniform surface texture is obtained.

H. Hand Tampers:

1. Use in all places not accessible to the rollers.

2. Use while mixture is hot.

I. Repair:

1. Repair any mixture that becomes mixed with foreign material or is in any way defective.

2. Remove and replace with fresh mixture and compact to the density of the surrounding area.

3. Do not skin-patch an area that has been rolled.

3.05 Joints

A. General Requirements:

1. Joints shall present the same texture, density, and smoothness as other sections of the course.

2. Carefully make joints in a manner that will ensure a continuous bond between the contact surface of the course.

3. Paint with a thin, uniform coat of hot bituminous material just before the fresh mixture is placed on all contact surfaces of previously constructed pavements.

4. Place so that the joint will not coincide with that of the lower course or courses, but will be offset at least 300 mm (1 ft.).

B. Transverse Joints:

1. Pass roller over the unprotected end of freshly laid mixture only when the laying of the course is to be discontinued or when delivery of mixture is interrupted to the extent that the unrolled material may become cold.

2. Cut back previously laid course to expose an even, vertical surface for the full thickness of the course.

3. Rake fresh material against the joint, thoroughly tamping with hot tampers and smoothing with hot smoothers, followed by rolling.

C. Longitudinal Joints:

1. Prior to constructing the adjacent pavement, cut back edge to expose an even vertical surface for the full thickness of the previously laid course.

2. Rake fresh mixture against the joint, thoroughly tamping with hot tampers and smoothing with hot smoothers, followed by rolling.

3. Joints shall not be irregular, honeycombed, or poorly compacted.

3.06 Protection of Pavement

A. Protect pavement from all vehicular traffic of any kind until it has cooled and hardened, and in no case less than 6 hours.

3.07 Surface Smoothness

A. Tests:

   1. Make tests after completion of the final rolling.

   2. Correct the irregularities that exceed the specified tolerances or that retain water on the surface, as requested by Engineer.

B. Tolerances:

   1. Measure with a 3-m (10-ft.) straightedge, applied both parallel and at right angles to the centerline of the paved area.

   2. Smoothness tolerances shall be:

      a. Surface Course: ∀3 mm (∀1/8-inch).

      b. Base Course: ∀6 mm (∀1/4-inch).

3.08 Density

A. Density of completed base-course pavement shall be equal to or greater than the following percentage of the density of a laboratory specimen made from the same day's mixture and compacted in accordance with ASTM D1559:

   1. Base Course: 95%.

   2. Surface and Binder Courses: 97%.

3.09 Waybills and Delivery Tickets

A. Submit waybills and delivery tickets to Engineer for each load of paving mixture placed in completed portions of this Contract:

   1. Submit at the end of each day pavement is placed.

   2. Submit as each load is dumped in the hopper of the paver when requested by Engineer.

B. Submit waybills and refinery analysis for each load of bituminous material on the day received:

1. Certificates shall indicate:

    a. Penetration.

    b. Specific gravity.

    c. Temperature.

    d. Net weight or volume of shipment.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section covers Portland cement concrete pavement.

1.03 Reference Standards

A. Applicable Standards:

1. American Concrete Institute (ACI):
    a. ACI 301 (301M) – Structural Concrete
    b. ACI 305 - Hot-Weather Concreting.
2. American Society for Testing and Materials (ASTM):
    a. ASTM A185 - Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
    b. ASTM A499 - Steel Bars and Shapes, Carbon Rolled from "T" Rails.
    c. ASTM A615/A615M - Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
    d. ASTM A675/A675M - Steel Bars, Carbon, Hot Wrought, Special Quality, Mechanical Properties.
    e. ASTM C31 - Practice for Making and Curing Concrete Test Specimens in the Field.
    f. ASTM C33 - Concrete Aggregates.
    g. ASTM C39 - Test Method Compressive Strength of Cylindrical Concrete Specimens.
    h. ASTM C70 - Test Method for Surface Moisture in Fine Aggregate.
    i. ASTM C78 - Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
    j. ASTM C94 - Ready-Mixed Concrete.

k. ASTM C127 - Test Method for Specific Gravity and Absorption of Coarse Aggregate.

l. ASTM C128 - Test Method for Specific Gravity and Absorption of Fine Aggregate.

m. ASTM C131 - Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

n. ASTM C138 - Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete.

o. ASTM C143 - Test Method for Slump of Hydraulic Cement Concrete.

p. ASTM C150 - Portland Cement.

q. ASTM C156 - Test Method for Water Retention by Concrete Curing Materials.

r. ASTM C171 - Sheet Materials for Curing Concrete.

s. ASTM C192 - Practice for Making and Curing Concrete Test Specimens in the Laboratory.

t. ASTM C231 - Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

u. ASTM C260 - Air-Entraining Admixture for Concrete.

v. ASTM C309 - Liquid Membrane-Forming Compound for Curing Concrete.

w. ASTM D75 - Sampling Aggregates.

x. ASTM D1751 - Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).

y. ASTM D1752 - Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.

z. ASTM D6690 - Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements.

3. American Association of State Highway and Transportation Officials (AASHTO):

a. AASHTO M6 - Fine Aggregate for Portland Cement Concrete.

b. AASHTO M80 - Coarse Aggregate for Portland Cement Concrete.

c. AASHTO M171 - Sheet Materials for Curing Concrete.

d. AASHTO T24 - Standard Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

e. AASHTO T26 - Standard Method of Test for Quality of Water to be Used in Concrete.

4. Federal Specifications (FS):

a. FS CCC-C-467 - Cloth, Burlap, Jute, (or Kenaf).

1.04 Submittals

A. Submit as specified in Division 01.

B. Includes, but not limited to, the following:

1. Acceptance Tests:

a. Furnish one electronic copy of product data to Engineer for the following items:

Aggregate.

Portland Cement.

b. For information only, submit producer's specifications for concrete pavement materials including laboratory test reports or notarized certificates and other data as may be required to show compliance with these Specifications.

c. Field test reports.

1.05 Quality Assurance

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

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual – Section 3, "Plant Certification Checklist").

B. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

C. Concrete Testing Service: Engage a qualified agency to perform material evaluation tests and to design concrete mixtures.

PART 2 - Products

2.01 Materials

A. General: Concrete and components shall comply with Division 03 requirements.

B. Reinforcing Steel:

1. Mesh or bar mats shall conform to ASTM A185.
    a. Gage and spacing of individual bars or wires shall be as indicated.
2. Dowels shall be smooth round steel bars or pipes of sizes indicated and conforming to ASTM A499 or A675/A675M Grade 80.
    a. Grind as required to remove shearing burrs.
3. Bars shall be deformed and of the sizes indicated and conforming to ASTM A615/A615M, Grade 60 for all bars No. 4 or larger.
    a. Tiebars and all No. 3 bars shall conform to A615/A615M, Grade 40.
4. Metal accessories used to support dowels and tiebars shall be designed to hold these items rigidly in place in the center of the slab parallel to the pavement surface without displacement.
5. Metal dowel caps or tubes shall be 32-gage sheet metal of proper size to fit dowels shown on the Drawings.
    a. Indent to provide a limiting stop.
    b. Provide unobstructed expansion space of not less than 1 inch (25 mm).

C. Portland Cement:

1. Furnish cement conforming to ASTM C150, Type I or II.
2. Use standard brand only.
3. Use only one brand.

D. Coarse Aggregate:

1. Coarse aggregate shall conform to AASHTO M80, except as follows:

Deleterious Substances	Maximum Percent by Weight
Clay lumps………………………………….………..	0.25
Shale…………………………………..………..	0.50
Soft particles…………………………………..…...	5.00
Material finer than No. 200 (75 µm) Sieve….….	1.00

Deleterious Substances	Maximum Percent by Weight
Total combined deleterious substances………..	5.00

2. Percentage of wear shall not exceed 40 after 500 revolutions as determined by ASTM C131.

3. Gradation shall conform to the following limits as determined by ASTM C136:

Standard Square Mesh Sieve		Percentage by Weight
U.S. Size or No.	Metric Opening	Passing Square-Mesh Sieve
1 inch	25.0 mm	100
3/4 inch	19.0 mm	90-100
3/8 inch	9.5 mm	20-55
No. 4	4.75 mm	0-5

E. Fine Aggregate:

1. Fine aggregate shall conform to AASHTO M6, except as follows:

Deleterious Substances	Maximum Percent by Weight
Clay lumps…………………………………...	0.25
Shale…………………………………….……	0.50
Coal and lignite……………………………...	0.25
Material finer than No. 200 (75 µm) Sieve…….	2.00
Total combined deleterious substances………...	4.00

2. Gradation shall conform to the following limits as determined by ASTM C136 and be well-graded from coarse to fine.

Standard Square Mesh Sieve		Percentage by Weight
U.S. Size or No.	Metric Opening	Passing Square-Mesh Sieve
3/8 inch	3/8 inch	100
No. 4	No. 4	95-100
No. 20	840 µm	40-75
No. 50	300 µm	5-30
No. 100	150 µm	0.10

3.

F. Water:

1. Mixing and curing water shall be clean, clear, and free from injurious amounts of sewage, oil, acid, alkali, salt, or organic matter.

2. Potable water will be accepted without testing.

3. Provide water per ASTM C 94/C 94M.

G. Admixtures:

1. Air-entraining agents shall be neutralized Vinsel Resin conforming to ASTM C260, of one of the following brands or approved equal:

a. Darex AEA.

b. Protex AEA.

H. Preformed Joint Fillers: Material shall be of the thickness as indicated and accurately punched to the exact diameter and at the locations of any dowels required.

1. Premolded material shall conform to ASTM D1751.

I. Joint Sealant: Sealer for all joints in concrete pavements shall be hot-pour elastic type conforming to one of the following:

1. ASTM D6690 for all joints in pavement, except as modified as follows:

a. Sealer shall be free of all foreign material. When melted it shall be free of lumps.

b. Penetration at 77ºF (25ºC), 150 g, 5 sec: 0.50-0.90.

2. Furnish five certified copies of manufacturer's test reports certifying compliance with the specified requirements for all batches of sealants proposed for use in the Work.

3. Deliver sealant to the Site in containers clearly marked with the name of manufacturer, brand name, weight, batch number, and recommended pouring temperature.

J. Curing Materials:

1. Burlap mats shall conform to Federal Specification CCC-C-467.

2. Waterproof paper shall conform to ASTM C171.

3. White polyethylene sheeting shall conform to AASHTO M171.

2.02 Handling and Storage of Materials

A. General: Adhere to requirements of Division 01 Specifications.

B. Aggregate Stockpiles:

1. Build stockpiles in layers of not more than 3 ft. (1 m) in thickness.

2. Stockpile all fine and coarse aggregates separately.

3. Prepare and maintain stockpile foundation to prevent contamination of aggregates.

4. Completely place each layer before beginning the next layer.

5. Coning of aggregates will not be permitted.

C. Handling Aggregates:

1. Handle aggregates in a manner to secure a uniform grading of the material.
2. Waste segregated aggregates or aggregates contaminated with earth or other foreign material.

D. Cement:

1. Store in dry weathertight and properly ventilated enclosure with adequate provisions for preventing absorption of moisture.
2. Arrange facilities to prevent dead storage and permit easy access for inspection.
3. Store different brands and types of cement separately.
4. Waste lumpy, caked, partially set, or otherwise contaminated cement.
5. Transport cement from storage to proportioning plant or mixer by methods required to ensure:
    a. Cement does not acquire moisture from aggregates or rain.
    b. None is lost during transport.
    c. Cement is not in contact with aggregate more than 45 min. before depositing in the mixer.
    d. All cement is removed from batch truck compartments when depositing in the mixer.

E. Reinforcing Steel: Store all reinforcing steel and accessories above ground.

2.03 Equipment

A. Paving Mixers:

1. All Mixers:
    a. Equip with a device for automatically counting the total batches mixed.
    b. Size to assure volume of concrete mixed per batch is not in excess of the manufacturer's guaranteed capacity as specified in the Concrete Mixer Standards adopted by the Mixer Manufacturer's Bureau and approved by the Associated General Contractors of America.
    c. Maintain in first-class mechanical condition.
    d. Replace blades when worn down more than 10% of their original depth.

2. Ready Mix: Ready-mix equipment and operation shall conform to ASTM C94.

B. Transporting Equipment:

1. Batch Trucks:

   a. Provide separate compartments of the required capacity for each material.

   b. Design to charge mixer, batch by batch, with proper amounts of each material without spillage, wastage, or mixing batches.

   c. Provide covers adequate to prevent loss of any material during haul from plant to mixer.

   d. Gross weight transmitted to subgrade shall not exceed 550 lbs. per inch (250 kg per 25 mm) width of tire.

2. Agitator Trucks:

   a. Equip with closed, watertight revolving drum suitably mounted, capable of discharging concrete without segregation.

   b. Agitating speed of drum shall be within a range of two to six revolutions per min.

   c. Drum volume shall be 20% in excess of volume of concrete in each load.

      Gross volume in cubic feet (cubic meters) shall be supplied by manufacturer.

C. Spreading Equipment:

1. Equipment shall be capable of spreading concrete in a uniform layer without segregation.

2. When nonagitator trucks are used for transporting concrete, a complete spreader designed specifically for use with such trucks shall be used for spreading concrete between paving forms.

D. Compacting and Transverse Finishing Equipment:

1. General: Use self-propelled spreading and finishing machine of an approved vibratory type having two independently operated screeds.

   a. Maintain in first-class condition.

   b. Machine shall be capable of compacting and finishing the concrete specified without displacing the side forms from line and grade.

2. Vibratory Screed Type:

        a. Equip front screed with vibratory units having a frequency of not less than 3,500 pulsations per min.

        b. Provide one vibratory unit for each 8 ft. (2.5 m) length of screed surface or portion thereof.

        c. Front screed shall be at least 12 inches (300 mm) wide and have a "bull-nose" front edge built on a radius of at least 2 inches (50 mm).

    3. Vibratory Pan Type:

        a. Equip with an independent vibratory pan in addition to the two screeds specified.

        b. Mount pan to prevent contact with forms, and permit simultaneous vibration of the full paving lane width.

        c. Provide one vibratory unit for each 6 ft. (2 m) length of pan surface or portion thereof.

        d. Synchronize vibratory units on individual pans at a frequency of at least 3,500 pulsations per min.

        e. Set front screed in a position to strike off concrete at sufficient height above forms to allow for proper compaction.

    4. Internal Vibratory Unit Type:

        a. Provide number and size of units required to properly consolidate concrete without excessive vibration.

        b. Mount units on a frame capable of perpendicular and, when necessary, radial movement sufficient to provide vibrator operation at any depth in the slab or complete withdrawal from the slab.

        c. Operate vibrators at a frequency of at least 5,000 impulses per min.

            Amplitude of vibration shall produce noticeable vibrations at 1-1/2 ft. (450 mm) radii when operated at the proper depth.

        d. Provide sufficient parts or spare vibrators at the Site to permit immediate replacement of any vibrating units that may become defective during placing operations.

        e. Vibrating tubes may be mounted in either of the following configurations:

            Spaced at not more than 30 inches (760 mm) on centers on frame transverse to the paving lane, and in a vertical position.

            Spaced at not more than 4 inches (100 mm) on centers nor more than 2 inches (50 mm) from forms, transverse to the paving lane, and in a horizontal position.

5. Other Equipment:
    a. Other external or internal vibratory equipment may be used on a trial basis providing evidence satisfactory to Engineer of its satisfactory performance in placing and finishing concrete of the same quality and consistency as specified on other jobs is furnished.
    b. Failure to perform satisfactorily, in Engineer's judgment, shall be cause for removal from the Job and replacement with approved equipment.
6. Hand Vibrators: Provide hand vibrators of the size and number necessary to provide supplemental vibration at forms, joints, and around all embedded items.
7. Longitudinal Float:
    a. Provide longitudinal finishing machine having float operated by mechanical means.
    b. Float may be wood or metal of required weight to prevent sinking into the concrete surface.

        Not less than 12 inches (300 mm) wide.

        Not less than 10 ft. (3 m) long.
    c. Float shall be straight, smooth, and readily adjustable to a true plane.
8. Straightedge: Provide straightedge 10 ft. (3 m) in length equipped with a handle 3 ft. (1 m) longer than one-half the pavement width.

E. Concrete Saws:
    1. Use adequately powered circular cutting blades mounted on a sturdy frame supported on wheels designed to protect the green concrete from damage from machine operations.
    2. Equip with positive control device to regulate depth of cut.
    3. Provide alignment and guide devices required to cut joints to specified tolerances.
    4. Blade(s) shall be properly sized to make cut of required dimension.
    5. Maintain equipment in first-class condition and provide standby equipment and blade stocks on the Site as required to ensure against any delays in sawing due to mechanical difficulties.

F. Sealant Applicator: Joint sealing applicator shall be of the pressure type capable of filling the joint from bottom to top without voids.

G. Forms:

1. Side forms shall be steel of an approved section, straight, and equal in depth to the thickness of pavement at the edge.

2. Base width shall be adequate to assure stability, but not less than 8 inches (200 mm) wide.

3. Forms shall be free of warps, bends, or kinks. Face shall not vary from true line in excess of 1/4 inch in 10 ft. (6 mm in 3 m).

4. Provide curved forms of an approved design for all curves having a radius of 150 ft. (45 m) and less.

   a. Wood forms may be used subject to Engineer's approval.

   b. Length of individual form section shall be as required to ensure alignment during paving operations.

5. Use forms with adequate braces and pin sockets to permit anchoring forms securely in place.

H. Subgrade Planers:

1. Subgrade planers shall be designed to operate on the forms or on rubber tires riding on adjacent completed pavement.

2. Planes shall have a continuous cutting edge capable of trimming subgrade or granular subbase to the cross section and slope required across the full width of the paving lanes.

3. Planers shall be equipped with automatic control devices capable of using erected stringlines for horizontal and vertical alignment and grade references when slipform pavers are used.

I. Scratch Template: Scratch template designed to operate on the forms shall be provided for checking grade following completion of planing.

2.04 Concrete Mixture

A. General: Paving concrete shall be composed of coarse aggregate, fine aggregate, Portland cement, an air-entraining admixture, and water.

B. Mix Design:

1. Proportion materials on the basis of trial mixes.

2. Prepare six cylinders and six test beams for each trial mix.

3. Test three cylinders and three beams at seven days, and the remaining three of each at 28 days.

    4. Design mix to produce concrete with an average strength, based on test beams and cylinders, approximately 15% in excess of the design strength specified in "Mix Properties," this Article.

    5. Make specimens and test conforming to ASTM C192, ASTM C39, and ASTM C78.

    6. Submit recommended mix proportions with certified test reports to Engineer for review of the mix design.

C. Mix Properties: Concrete mix shall be designed to produce maximum density, minimum shrinkage during setting, and be uniformly plastic, cohesive, and workable.

    1. Ultimate compressive strength at 28 days shall be not less than 5,000 psi .

    2. Minimum modulus of rupture at 28 days shall be not less than 650 psi.

    3. Minimum cement content shall be not less than 6 sacks per yard^3.

    4. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45.

    5. Slump shall not exceed 4 inches plus or minus 1 inch.

    6. Entrained-air content shall be 4.5% plus or minus 1.5% by volume for 1-inch nominal maximum aggregate size.

D. Field Control of Mix:

    1. Tests to determine conformance with specified design mix proportions and properties will be conducted during the time concrete mixtures are being produced.

    2. Testing will be performed by Contractor-engaged independent Testing Agency through contract cash allowances for concrete testing.

    3. Furnish all Samples of materials and mixtures as required by Engineer.

    4. Determine water required for the batch with allowances for free moisture contained in the aggregates and for the moisture they will absorb by the following tests:

        a. ASTM C127.

        b. ASTM C128.

    5. Consistency: Control of consistency and workability will be maintained by measuring slump conforming to ASTM C143.

    6. Strength: Will be determined on the basis of sets of four compression test cylinders for each 1,000 yds.^{3} (765 m^3) or part thereof and four test beams for each 2,000 yds.^{3} (1530 m^3) or part thereof; but not less than one set each of beams and cylinders for each day's production:

a. Specimens will be prepared conforming to ASTM C31.

b. One cylinder will be tested at seven days and two at 28 days conforming to ASTM C78.

c. One beam will be tested at seven days and two at 28 days conforming to ASTM C78.

7. Cement Content: Will be determined conforming to ASTM C138.

8. Entrained-Air Content: Will be determined conforming to ASTM C231.

9. Mix Adjustments:

a. Make minor adjustments of relative weights of fine and coarse aggregate when required by Engineer; the sum of the weights of aggregates shall remain unchanged.

b. Correct low cement content when determined by yield tests by reducing fine and coarse aggregate batch weights by equal percentages.

PART 3 - Execution

3.01 Preparation of Underlying Course

A. Subgrade or Granular Subbase:

1. Trim previously completed subgrade or granular subbase to exact cross section required using planer specified.

2. Waste excess material outside the forms.

3. Repair low spots by loosening, adding material, recompacting, and planning.

4. Check subgrade with scratch template specified and correct any deviation.

3.02 Setting Forms

A. Clean and oil forms each time they are used.

B. Setting: Set and maintain to grade and alignment during entire operation of placing and finishing concrete.

1. Support on thoroughly compacted material for entire length of forms.

2. Set and secure with adequate devices to main rigidity of the forms without springing, weaving, or settling.

3. Set in a manner to preclude interference with final shaping, compacting, checking of subgrade, and concreting operations.

4. Provide and set sufficient forms to maintain 15 ft. of completed forms on each side in advance of the paving operation.

5. Compact supporting material under forms for full length of the forms with equipment specifically designed for this purpose.

C. Checking:

1. Test forms for grade and smoothness with a 10 ft. (3 m) straightedge.

2. Variations from a true plane at top of forms shall not exceed 1/8 inch (3 mm).

D. Stripping:

1. Forms shall remain in place for at least 12 hours after concrete is finished, except when the temperature is below 50ºF (10ºC); forms shall not be removed in less than 30 hours.

2. Remove forms without damaging concrete.

    a. Do not use crowbars or heavy tools against green concrete.

E. Other Support: Adjacent completed paving lanes may be used for supporting finishing equipment.

1. Concrete must be at least seven days old.

2. Mount equipment on rubber tires.

3. Inside edge of wheels shall not operate within 4 inches (100 mm) of the edge of concrete.

4. Surface of concrete-carrying finishing equipment may not vary in excess of 1/8 inch in 10 ft. (3 mm in 3 m).

3.03 Batching And Mixing

A. All measurements of aggregates and cement shall be by weight.

B. Weigh each aggregate on the specified scales. Maintain accuracy of weighing within ±1% of design mix requirements.

C. Weigh cement in a separate hopper. Maintain accuracy of weighing within ±0.5% of design mix requirements.

D. Measure water by weight or volume. Adjust net mixing water to compensate for water added with admixtures and free and absorbed moisture in the aggregates.

1. One gal. (1 L) of water shall be considered equal to 8.33 lbs. (1 kg).

E. Add admixture in solution form at the mixer. Maintain accuracy within ±3% of design mix requirements.

F. Place materials for a batch of concrete in mixer drum only after the previous batch has been completely discharged.

1. Discharge mixing water for batch within ten seconds after all aggregates are in drum.

2. Part of aggregates shall have entered drum before beginning discharge of mixing water.

G. Mixing time shall be at least the minimum specified, and shall be increased if required to produce a mixture of uniform composition and consistency, or when samples from the front, center, and back of mixer vary more than 10% in sand-cement or water-cement ratio.

1. Mixer shall revolve within a range of 14 to 20 revolutions per min. throughout the specified mixing time.

2. Mixing time for mixers at the Site shall be at least 1-1/4 min. per batch beginning after all materials are in the drum.

    a. Transfer time for dual-drum mixers shall not be included in mixing time required.

3. Central plant mixers 1 yd.^{3} (1 m^3) and less in capacity shall have a mixing time of at least one min. per batch. Increase minimum by 15 seconds for each additional cubic yard (cubic meter) or fraction thereof unless otherwise approved by Engineer.

3.04 Transporting Concrete

A. Transport materials from batching plant or central mix plant in the hauling equipment specified.

B. Agitating speed of drum on agitator trucks shall be within a range of two to six revolutions per min.

C. Discharge concrete delivered in truck mixers or truck agitators within 60 min. after water is added to the mix.

D. Discharge concrete delivered in nonagitating trucks within 30 min. after water is added to the mix.

E. Waste all concrete that is not placed within the time specified.

F. Route haul units to eliminate all traffic from prepared subgrade or subbase.

G. Haul on completed pavements only after at least seven days have elapsed since placing, or after a longer period when required by Engineer.

1. Route haul units on new pavement to prevent channelizing of traffic.

3.05 Placing Reinforcement

A. Clean reinforcement as required to remove dirt, scale, or other foreign matter and rust of such degree that bond would be impaired.

B. Sequence:

   1. Place concrete in two layers.

   2. Strike first layer off uniformly at the depth of reinforcement.

   3. Place reinforcement on first layer of concrete.

   4. Place balance of concrete in second layer within 20 min. after the first layer is struck and finish as specified.

C. Placement:

   1. Strike concrete off to the entire width of the pour, and a sufficient length to permit the reinforcing sheet or mat to be laid full length without further manipulation of the reinforcement.

   2. Lap steel fabric sheet at least one wire spacing.

   3. Position reinforcing to provide 2 to 4 inches (50 to 100 mm) clearance from the slab edges to the extreme longitudinal members, and 2 to 4 inches (50 to 100 mm) clearance from all transverse expansion and construction joints.

3.06 Embedded Items

A. Construct recesses and blockouts conforming to dimensions and details indicated.

B. Finish concrete in these areas to provide a smooth true surface of the same texture as surrounding area.

3.07 Placing And Finishing

A. Sequence of placing and finishing shall be as follows:

   1. Machine spreading.

   2. Strikeoff and machine compacting.

   3. Transverse machine finishing.

   4. Longitudinal floating.

   5. Smoothing and surface testing.

6. Texturing.

7. Joint edging.

B. Preparation: Anchor all embedments including dowels, tiebars, joint assemblies, conduit, boxes, anchor bolts, sleeves, and castings securely in place before placing concrete.

C. Machine Spreading: Spread concrete in a uniform, unsegregated layer of the loose thickness required to produce a finished pavement of the required thickness.

D. Compacting and Transverse Finishing: Compact and finish using the equipment specified.

1. Operate machine over each section of pavement two or more times at intervals as required to produce finished pavement of the required quality.

2. Each section of pavement shall receive at least one, but not more than two, vibratory passes.

   a. Limit vibration to the amount necessary to achieve satisfactory consolidation of the concrete.

   b. Use hand-manipulated internal vibrator to consolidate concrete along forms, joints, and other embedded items when external vibratory equipment is used.

   c. Insert internal vibrators in the concrete to the depth that provides the best compaction, but not closer than 2 inches (50 mm) to the underlying course.

3. Maintain a uniform ridge of concrete at least 3 inches (75 mm) in depth ahead of the full length of strike off screed.

4. Add concrete to all low areas and honeycombed spots after the first finishing machine pass and rescreed.

5. Maintain a uniform head of concrete ahead of rescreeding strike off for its full length.

E. Longitudinal Floating:

1. Operate float parallel to centerline of paving lane.

2. Maintain contact with surface at all times.

3. Advance float lapping previous position by at least one-fourth the float length.

F. Smoothing and Surface Testing:

1. Remove minor surface irregularities with long-handled wood floats and straightedges.

2. Remove excess water and laitance with finishing straightedge.

3. Use long-handled floats only to correct local irregularities. Do not float entire pavement surface.

4. Test surface for smoothness with 10 ft. (3 m) straightedge.

5. Hold straightedge in successive position parallel and at right angles to centerline of paving lane.

6. Advance straightedge in successive stages of not more than one-half its length.

7. Fill depressions with fresh concrete, strike off, compact, and refinish.

8. Continue straightedge testing and finishing until a true surface conforming to specified smoothness and elevation is obtained.

G. Edging:

1. Edging shall be done at slab edges along forms and at joints and only on areas with sufficient mortar to obtain good solid edges.

2. Remove and replace soupy mortar with mortar of correct proportions and consistency.

3. Use edging tool to form smooth rounded surface edges.

4. Protect during removal of forms and patch any damaged or honeycombed areas as required.

3.08 Hand Finishing

A. Hand-finish only those areas where use of finishing machines would be impractical.

B. Obtain prior approval of Engineer.

C. Spread, compact, float, and finish handwork areas using equipment and methods required to produce finished pavement conforming to Specifications.

3.09 Cold Weather Construction

A. Temperature of concrete when placed shall not be less than 65ºF nor more than 85ºF (30ºC). Subgrade shall be entirely free from frost.

B. The temperature of forms, reinforcement, embedments, or other surfaces to be in contact with the concrete shall not be less than 10ºF (5ºC) of the temperature of the concrete at placement.

C. Heat mixing water and aggregates to maintain minimum temperature of 65ºF. Aggregates shall be free from ice and snow. Methods and equipment for heating are subject to prior approval of Engineer.

D. Provide covering and other means to maintain concrete at a minimum of 65ºF ([_____]ºC) for not less than 72 hours, and above freezing for the remainder of curing period. Do not use salt, chemicals, or other additives.

E. Remove concrete damaged by freezing to the nearest contraction or construction joint and replace at Contractor's expense.

3.10 Hot Weather Construction

A. Hot weather is defined as when the rate of evaporation approaches 0.2 lb. per ft.^{2} per hour (kg per m^2 per hour) as outlined in Fig. 2.1.4 of ACI 305.

B. Concrete shall have a maximum temperature of 80ºF (27ºC) when placed in form.

C. Temperature of mix shall be controlled by cooling the mixing water, sprinkling aggregates, or other acceptable methods.

D. Cease operations during intense hot weather if concrete shows excessive hairline cracking or poor finish due to hot weather or if requested in writing by Engineer.

3.11 Joints

A. General:

1. Construct joints as indicated and perpendicular to the pavement surface.
2. Surfaces of adjacent slabs shall not vary in excess of 1/8 inch (3 mm) when tested with a 10 ft. (3 m) straightedge placed at right angles to the joint.
3. Construct joints true to line. Horizontal deviation shall not exceed 1/4 inch (6 mm) from true line or from designated position.
4. Form keyways with metal templates sufficiently anchored, and of proper gage to ensure full keyways of the required dimension at the correct location.
5. Set offset hubs for each transverse joint in curved paving lanes, and as required at tangent sections of paving lanes to assure accurate joint location.

B. Longitudinal Construction Joints:

1. Install tiebars and dowels where required.
2. Finish edges of joints adjacent to other paving lanes flush with forms.
3. Saw sealant groove to the dimensions indicated.

C. Longitudinal Center Joints:

1. Form by sawing grooves of dimensions indicated.

2. Install tiebars by supporting rigidly in place with approved devices or placing with equipment mounted on the transverse finishing machine, capable of accurately positioning tiebars in the center of the slab and at the spacing indicated.

3. Keyed longitudinal construction joints may be used in lieu of sawed center joints at Contractor's option.

D. Longitudinal Expansion Joints:

1. Install at locations and conforming to details indicated.

2. Install premolded filler conforming to ASTM 1751. Filler shall extend for the full width and required depth of joint.

3. Fasten filler securely in position perpendicular to the finished surface with top of filler 1 inch (25 mm) below the proposed surface.

4. Protect top of filler with metal or wooden cap. Withdraw cap after finishing operations and edge joint with a 1/4 inch (6 mm) radius edging tool.

E. Transverse Construction Joints:

1. Locate joints at plan location of transverse contraction joints.

2. Install joints at any time placing is suspended for 30 min. or more.

3. Construct joint as detailed and specified for longitudinal construction joints, including keyway.

F. Transverse Expansion Joints:

1. Install premolded filler conforming to ASTM 1751. Secure in position and protect as specified for "Longitudinal Expansion Joints," this Article.

2. Use oiled steel plate cut to the cross section of the pavement and slotted for dowels where required to maintain position of premolded material during placing and finishing.

3. Devices used for installation of joints shall be easily removable without disturbing concrete.

4. Remove joint caps and any concrete bridging joint following finishing operations and edge joint with 1/4 inch (6 mm) radius edging tool.

G. Transverse Contraction Joints:

1. Construct by sawing a groove of the dimensions indicated.

2. Saw after concrete has hardened and before random cracking occurs.

3. Begin sawing as soon as concrete has hardened enough to prevent excessive chipping, spalling, or tearing; saw approximately four to eight hours after placement.

4. Continue sawing without interruption for any reason. Saw joints at the required spacing consecutively in the order of placement.

5. Locate and install all marks and guides required to ensure accurate location of sawed grooves.

6. Wet surface of pavement cured with membrane compounds prior to sawing.

7. Limit personnel working on slab to only those essential for construction of joints. Equip all personnel with rubber-soled footwear.

8. Flush each joint and adjacent concrete surface to remove all debris from sawing operations immediately after sawing.

9. Respray joint and any damaged membrane with curing compound as specified as soon as free water disappears from the surface.

10. Install dowels where required prior to placing and finishing concrete.

H. Joint Accessories:

1. General: Install tiebars, dowels, and preformed filler conforming to details indicated after final testing of underlying course.

2. Supports: Use adequate baskets or supports to rigidly fix all joint accessories in position in proper location, and in planes parallel or perpendicular to the pavement surface.

3. Tiebars:

   a. Install at right angles to centerline of paving lane.

   b. Place parallel to the surface and at mid-depth of slab.

   c. Tiebars extending into unpaved lanes may be bent at right angles against the side forms at keyed longitudinal construction joints.

4. Dowels:

   a. Secure dowels rigidly in place in the middle of the slab by an approved assembly device to be left permanently in place.

   b. Assembly and support shall be rigid enough to permit lifting and placing as a unit.

   c. Alignment tolerance for any dowel or assembly shall not exceed 1/8 inch per ft. (3 mm in 300 mm).

d. Furnish an approved template for checking position of dowels.

e. Install expansion caps on dowels used in expansion joints.

f. Paint one entire half of all dowels with one coat of red rust-inhibitive paint at the Site of the Work.

g. Thoroughly coat the painted half of the dowel with a heavy oil after the paint has dried, and immediately before dowel is placed in position in the slab.

3.12 Curing

A. General: Cure concrete by protecting against loss of moisture and action of the elements and mechanical injury.

1. Curing period shall be seven days after completion of pavement.
2. Curing method used shall retain at least 90% of the original water present in the mix at the end of the curing period.

B. Moist Curing:

1. Cover concrete with two or more layers of burlap conforming to FS CCC-C-467 or Engineer-approved equal.
2. Saturate covering immediately before placing and keep saturated throughout the curing period.
3. Place covering to completely cover the surfaces and edges of the slab.

C. Paper or Polyethylene-Sheet Curing:

1. Place blankets or impermeable paper conforming to ASTM C171 or white polyethylene sheeting conforming to AASHTO M171 on the pavement surface and along the slab edges as soon as possible without marring the surface, but early enough to prevent loss of moisture.
2. Wet surface with water applied in the form of a fine spray before covering with paper or sheeting when required by Engineer.
3. Extend blankets at least 12 inches (300 mm) beyond pavement edges and weight in place.
4. Pleat blankets as required to allow for shrinkage.
5. Overlap adjoining blankets at least 4 inches (100 mm) and cement joint with an asphalt cement suitable for use with the blanket material used as required to produce a waterproof joint.

6. Reuse only those blankets that have been satisfactorily repaired to provide an airtight cover.

3.13 Sealing Joints

A. General: Seal all joints with specified material before permitting any traffic on the pavement.

B. Time of Application:

1. Seal immediately after the curing period or as soon thereafter as weather permits.

2. Seal only when weather conditions will not reduce adhesion of sealant. Do not apply sealant during rainy or foggy weather.

C. Preparation:

1. Clean joints immediately before filling. Remove all laitance, curing compound, protrusions of hardened concrete, and foreign material.

2. Wire-brush or resaw all joints as required to remove all traces of curing compound on inside joint faces.

3. Clean joints with compressed air immediately prior to application of sealant.

D. Heating:

1. Heat sealant in the specified equipment to the temperature recommended by the sealant manufacturer and maintain temperature throughout pouring operation.

2. Waste all material heated in excess of permissible temperature, and all material remaining in kettles at the end of the day.

E. Sealing:

1. Fill joints from the bottom up.

2. Fill joint to 1/8 inch (3 mm) below the pavement surface.

3. Remove all excess sealer from the pavement surface.

4. Clean and reseal all underfilled, overfilled, or otherwise unsatisfactory joints.

5. Dust surface of joints with sand or other approved material, or cover with tape when required to prevent tackiness or pickup.

F. Approval:

1. Demonstrate that the equipment and procedures used for preparing joints and heating and application of sealant will produce a satisfactory seal before beginning Work.

2. Prepare and apply at least one small batch of each sealant proposed for use.

3. Reject any batches of sealant that do not have a satisfactory consistency for application.

4. Replace any equipment that does not perform satisfactorily.

3.14 Smoothness and Grade

A. Preparation:

   1. Remove all materials used for curing concrete.

   2. Clean surface of pavement by sweeping and power blowing or as required to remove all foreign material from the surface.

B. Testing Equipment:

   1. Furnish rolling straightedge of the "Scortch" type or other mechanical surface testing machine approved by Engineer.

   2. Machine shall be capable of indicating surface deviation from a true plane over 16 ft. (5 m) in length.

C. Tolerance:

   1. Surface smoothness variations shall not exceed 1/4 inch in 16 ft. (6 mm in 5 m).

   2. Maximum absolute deviation from plan grade elevation shall not exceed 1/2 inch (12 mm) and distance from point of maximum deviation to nearest point of zero deviation shall not exceed 100 ft. (30 m).

   3. Remove and replace all sections that exceed the specified deviation.

   4. Grind off localized bumps and high spots. Bush hammering will not be permitted.

3.15 Thickness

A. General:

   1. Construct pavements to the thickness indicated.

B. Measurement:

1. Slab thickness will be measured by at least three caliper measurements of the thickness of cores taken from the slab at locations determined by Owner.

2. Area of any pavement found to be deficient by measurement of cores as specified will be the distance between adjacent cores of satisfactory thickness multiplied by the lane width between longitudinal construction joints.

3. When any core indicates a thickness deficiency of 1/2 inch (13 mm) or greater, additional cores will be taken by Engineer at 20 ft. (6 m) intervals longitudinally along the paving lane in each direction from the deficient core until a section less than 1/2 inch (13 mm) deficient in thickness is found.

4. Contractor may request additional cores be taken if Contractor believes that cores and measurements taken are insufficient to fairly indicate the actual pavement thickness. Cost of additional cores and measurements will be deducted from sums due Contractor unless such measurements indicate that the slab within the area in question is of the specified thickness.

C. Correction and Repair:

1. No deduction will be made for pavement areas within 1/4 inch (6 mm) of the required thickness.

2. No additional payment will be made for pavements found to exceed plan thickness.

3. Engineer may require removal and replacement of all pavements deficient in thickness by greater than 1/2 inch (13 mm) if, in Engineer's judgment, such deficiency will seriously impair the expected service from the pavement. No payment will be made for removal and replacement.

3.16 Pavement Protection

A. General: Close pavement to all traffic, including Contractor vehicles, for a period of at least 20 days after concrete is placed, and a longer period when requested by Engineer.

1. Furnish and maintain all necessary barricades, lights, and signs required to exclude traffic from pavement.

2. Repair any damage to pavement without additional compensation.

3. Seal all joints before opening to traffic.

B. Paving Adjacent Lanes:

1. Do not operate paving equipment on completed lanes for a period of 10 days after placement except as specified.

2. Completed lane may be used to support paving equipment after five days if Contractor can demonstrate by test cylinders that the pavement has attained a strength of at least 3,000 psi (20.7 MPa). Such test cylinders will be made by

Contractor under Engineer's observation, and tested by Engineer at Contractor's expense.

C. Maintenance:

1. Maintain pavement free of all debris from Contractor's operations by sweeping, power blowing, and other methods as required.

2. Remove any aggregates or other foreign material forced into joints and reseal.

END OF SECTION

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section includes chain link fabric fence, gates, and related components.

1.03 Related Requirements

A. Concrete: Division 03.

1.04 Reference Standards

A. Applicable Standards:

1. ASTM International (ASTM):
    - a. ASTM A123 - Zinc (Hot Dip Galvanized) Coatings on Iron and Steel.
    - b. ASTM A153 - Zinc Coating (Hot Dip) on Iron and Steel Hardware.
    - c. ASTM A1011/A1011M - Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
    - d. ASTM F668 - Poly(VinylChloride) (PVC) Coated Steel Chain-Link Fence Fabric.
    - e. ASTM F669 - Strength Requirements of Metal Posts and Rails for Industrial Chain-Link Fence.
    - f. ASTM F1083 - Pipe, Steel, Hot Dipped, Zinc-Coated (Galvanized) Welded, for Fence Structures.

1.05 Submittals

A. Submit as specified in Division 01.

B. Includes, but not limited to, the following:

1. Product data: Manufacturer's technical data, specifications, and installation instructions for fence and gate posts, fabric, gates, and accessories.

2. Shop Drawings: Showing layout, location of fence, gates, posts, and including details illustrating fence height, sizes of posts, rails, braces, gates, hardware list, and accessories.

3. Mill certification that materials meet specifications of member size, strength, wall thickness, and coatings.

1.06 Quality Assurance

A. Provide chain-link fences and gates as complete units, including necessary erection accessories, fittings, and fastenings, from a single source or manufacturer.

B. Contractor shall verify existing gate and fence materials, sizes, coatings, etc. and shall provide new fencing and gate to match existing fence conditions.

PART 2 - Products

2.01 Acceptable Manufacturers

A. Subject to compliance with requirements, provide products of one of the following:

1. PVC-Coated Galvanized Steel Fencing and Fabric:

    a. Anchor Fence, Inc.

    b. Boundary Fence and Railing Systems, Inc.

2.02 General

A. Fence height and gate width(s) shall be as indicated in the Drawings.

B. Dimensions indicated for pipe, roll formed, and H sections are outside dimensions, exclusive of coatings.

2.03 Fabric

A. Steel Fabric:

1. No. 9 gage, 2 inch diamond-mesh steel, chain link fabric. Furnish one-piece fabric widths for fencing up to 12 ft. 0 inches high.

2. PVC-coated: Minimum 0.2 mm (7 mil) polyvinyl chloride (PVC) plastic-resin finish over galvanized steel wire. Color is black as selected by Engineer/Architect from manufacturer's standard colors:

    a. Comply with ASTM F668, Class 2, except provide fabric with diameter (gage) of core wire equivalent to fabric diameter specified when measured prior to application of nonmetallic coating.

3. Bottom selvage twisted and top selvage knuckled for fabric over 5 ft. 0 inches.

B. Privacy Slats:

1. Bottom-locking HDPE slats with heights to match that of the fabric.

2. Slats to provide a minimum of 75% privacy.

3. Color: black to match fabric color.

4. Interlocking tabs to be installed downward to interlock with bottom rail along bottom of fence, as per manufacturer’s specifications.

5. Slats installed in fabric along entire length of fence, including in fabric of gates.

2.04 Framing and Accessories

A. Steel Framework:

1. General: Galvanized steel, ASTM F1083 or ASTM A123, with not less than 1.8 oz. zinc per ft.^{2} of surface, or steel conforming to ASTM A1011 externally triple-coated with hot-dip galvanizing at 1.0 oz./ft.^{2}, chromatic conversion coating and clear acrylic polyurethane and coated internally with zinc-rich coating.

2. Fittings and Accessories: Galvanized, ASTM A153, with zinc weights per Table I.

3. Steel Framework Finish: Provide framework, fittings, and accessories in accordance with manufacturer's standard thermally bonded polyvinyl chloride (PVC) plastic-resin finish over galvanizing, not less than 0.010 inch thick. Color to match chain-link fabric.

2.05 Steel Posts, Top Rail, Tension Wire, And Braces

A. Minimum size and weight of steel components shall be as follows:

1. Posts for Fabric Height Over 1.8 m (6 ft.):

   a. End, Angle, Corner, or Pull Posts: (2.875 inches) od at 5.79 lbs. per ft.

   b. Line Posts 6 ft. to 8 ft. Fabric Height: 2.375 inches od at 3.65 lbs. per ft.

   c. Line Posts over 8 ft. Fabric Height: 2.875 inches of pipe at 5.79 lbs. per ft.

   d. In lieu of pipe specified above, steel pipe conforming to ASTM A1011 of greater strength but less wall thickness, will be acceptable.

2. Posts for Fabric Height 6 ft. or Less:

   a. End, Angle, Corner, or Pull Posts: 2.375 inches od at 3.65 lbs. per ft.
   b. Line Posts: 1.90 inches od at 2.70 lbs. per ft..
   c. In lieu of pipe specified above, steel pipe conforming to ASTM A1011 of greater strength but less wall thickness, will be acceptable.

3. Gate Posts:
   a. Furnish posts for supporting single-gate leaf, or one leaf of a double-gate installation, for nominal gate widths as follows:

Leaf Width	Gate Post	lbs./lin.ft.
Up to 6 ft.	2.875 inches od pipe	5.79
Over 6 ft. to 13 ft.	4.000 inches od pipe	9.11

4. Top Rail:
   a. 2 inches od at 2.27 lbs. per ft.
   b. 18 ft. minimum length of each section.
   c. Expansion type couplings for each joint, approximately 6 inches long.
5. Tension Wire: No. 7 gage coiled spring wire, metal and finish to match fabric. Locate at bottom of fabric.
6. Wire Ties: 9-gage galvanized steel (to match fabric core material).

2.06 Barbed Wire and Supporting Arms

A. Supporting Arms:
   1. One for each post.
   2. Single arm at 45 degrees with vertical, sloping to outside of fence.
   3. Constructed for attaching three rows of barbed wire to each arm and designed as a weathertight closure cap where tubular posts are used.
   4. Designed for 200 lb. minimum pull-down load.
   5. Attached to steel posts or integral with post top.
   6. Provided with openings to receive top rail.
   7. Malleable iron or pressed steel.

B. Barbed Wire:
   1. Three-strand, 12-1/2-gage steel wire with 14-gage, 4-point barbs 5 inches o.c.

2. Metal and finish to match fabric.

3. Three rows required.

2.07 Gates

A. Manual Swing:

1. Framing:

    a. Fabricate perimeter frames of gates from metal and finish to match fence framework.

    b. Provide intermediate horizontal and vertical members for proper gate operation and for attachment of fabric, hardware, and accessories. Space so that frame members are not more than 8 ft. apart unless otherwise indicated.

    c. Frames assembled by welding or watertight galvanized steel rigid fittings.

    d. Provide with same fabric as for fence. Install fabric with stretcher bars at vertical and top and bottom edges.

    e. Diagonal cross bracing of 3/8 inch diameter adjustable truss rods to ensure frame rigidity without sag or twist.

    f. Where barbed wire is indicated or specified, extend gate end members 1 ft. above top members to receive barbed wire.

2. Hardware:

    a. Hinges of pressed or forged steel, or malleable iron, nonlift-off type, offset to permit 180-degree gate opening, 1-1/2 pair per leaf.

    b. Latches and Gate Stops: Double-leaf.

        (1) Plunger-bar type latch, full gate height, designed to engage gate stop of flush-plate type, with anchors.

        (2) Locking device and padlock eyes an integral part of latch.

        (3) Keeper to automatically engage gate leaf and secure free end of gate in open position.

    c. Latches: Single-leaf.

        (1) Forked type to permit operation from either side of gate.

        (2) Padlock eye as integral part of latch.

3. Coating: Galvanize conforming to A153.

2.08 Concrete

A. As specified in Division 03.

2.09 Crushed Rock

A. Gradation of 3/4 inch to 1 inch sizes.

PART 3 - Execution

3.01 Preparation

A. Grading: Perform final grading prior to installation of fence.

B. Placing Crushed Rock:

  1. Place prior to installing fabric.
  2. Place to a depth of 6 inches below grade and 2 ft. width, centered along post lines.

3.02 Installation

A. Fence:

  1. Follow general contour of ground and properly align. Install as indicated.
  2. Posts:
    - a. Set in concrete bases. Trowel-finish tops of footings and dome to direct water away from posts.
    - b. Temporarily brace until concrete in bases has set.
    - c. Install plumb and in straight alignment.
    - d. Space 10 ft. center-to-center maximum.
    - e. Install pull posts every 300 ft. if no corner posts are encountered in that distance.
    - f. Install corner posts at changes in direction of 30 degrees or more.
    - g. Install pull posts at changes in direction of 10 degrees to 30 degrees.
    - h. Install pull posts at all abrupt changes in grade.
  3. Post Bracing:

  a. Install at each end, pull and gate post, and each side of each corner post.

  b. Install after concrete in post bases has set.

  c. Install so posts are plumb when diagonal rod is under tension.

4. Top Rails:

   a. Run continuously through post caps or barbed wire supporting arms.

   b. Install expansion couplings at each joint.

5. Tension Wire: Weave through the fabric and tie to each post with minimum 7-gage galvanized wire to match fabric finish.

6. Fabric:

   a. Stretch taut with equal tension on each side of line posts.

   b. Install fabric on security side of fence and anchor to framework so that fabric remains in tension after pulling force is released.

   c. Use U-shaped wire, conforming to diameter of pipe to which attached, clasping pipe and fabric firmly with ends twisted at least two full turns. Bend ends of wire to minimize hazard to persons or clothing.

   d. Fasten fabric to steel posts with wire ties spaced 12 inches o.c. maximum.

   e. Fasten fabric to top rail with wire ties spaced at 24 inches o.c. maximum.

7. Stretcher Bars:

   a. Thread through or clamp to fabric 4 inches o.c.

   b. Secure to posts with metal bands spaced 15 inches o.c. maximum.

   c. Install at each gate, pull and end post, and each side of corner post.

8. Post Tops and Barbed Wire Supporting Arms: Install on each post.

9. Barbed Wire:

   a. Attach three rows to each barbed wire supporting arm. Pull wire taut and fasten securely to each arm.

   b. Install three rows above fabric and on extended gate end members of swing gates.

10. Fasteners: Install nuts for tension bands and hardware bolts on side of fence opposite fabric side. Peen ends of bolts or score threads to prevent removal of nuts.

B. Manual-Swing Gates:

1. Install plumb and level.

2. Install all hardware, tracks, framing, supports, and appurtenances as required for gate type.

3. Install keepers, ground-set items, and flush plate in concrete for anchorage.

4. Adjust and lubricate as necessary for smooth operation.

C. Repairing Damaged Coatings:

1. Repair any damaged coatings in the shop or field by recoating with compatible and similar coating.

2. Apply per manufacturer's recommendations.

D. Privacy Slats:

1. Installation to be completed in accordance with manufacturer’s specifications.

END OF SECTION

PART 1 - General

1.01 Summary

A. This Section includes preparation of seeded areas, seeding, mulching, fertilizing, and maintenance of areas indicated and/or disturbed by Contractor's construction activities.

B. The work covered by this Section consists of furnishing all labor, equipment and material required to place topsoil, seed, commercial fertilizer, agricultural limestone and mulch material, including seedbed preparation, harrowing, compacting and other placement operations on graded earthen areas as described herein and/or shown on the Drawings. In general, seeding operations shall be conducted on all newly graded earthen areas not covered by structures, pavement or sidewalks; all cleared or grubbed areas which are to remain as finish grade surfaces; and on all existing turf areas which are disturbed by construction operations and which are to remain as finish grade surfaces. Areas disturbed by borrow activities shall also be seeded according to these Specifications.

C. The work shall include temporary seeding operations to stabilize earthen surfaces during construction or inclement weather and to minimize stream siltation and erosion. Temporary seeding shall be performed at the times and locations as directed by the Engineer.

1.02 References

A. Applicable Standards:

1. American Society for Testing and Materials (ASTM): Equivalent AASHTO standards may be substituted as approved.

   a. D977 - Emulsified Asphalt.

   b. TDOT Grassing Schedule

   c. Tennessee Erosion and Sediment Control Handbook.

1.03 Submittals

A. Certificates: Includes, but not limited to, the following:

1. Seed shall be accompanied by certificate from vendor that seed meets requirements of these Specifications, stating botanical name, percentage by weight, percentage of purity, germination, and weed seed for each grass seed species.

2. Fertilizer shall be accompanied by certificate from vendor that fertilizer meets requirements of these Specifications.

3. Acceptance of the seed or fertilizer test reports shall not relieve the Contractor of any responsibility or liability for furnishing seed meeting the requirements of this Section.

B. Prior to topsoil operations, the Contractor shall obtain representative samples and furnish soil test certificates including textural, pH, and organic analysis from the University of Tennessee Extension Services or other certified testing laboratory.

C. Pesticides and Herbicides: Include product label and manufacturer’s application instructions specific to the Project.

1.04 Delivery, Storage, And Handling

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.

B. Bulk Materials

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.

2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

3. Accompany each delivery of bulk fertilizers, lime and soil amendments with appropriate certificates.

1.05 Project Conditions

A. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

PART 2 - Products

2.01 Fertilizer

A. Commercial fertilizer of neutral character, with some elements derived from organic sources, conforming to the standards of the Association of Official Agricultural Chemists and applicable state, local and federal laws concerned with the lime production and use. Provide either grade 4-12-12, 6-12-12, or 5-10-15 at Contractor's option.

B. Provide commercial grade nitrogen conforming to state fertilizer laws. Provide in either granular or liquid form at Contractor's option.

C. Deliver to Site in labeled bags or containers.

2.02 Seed

A. Seed shall conform to all applicable laws of the State of Tennessee.

B. Provide fresh, clean, new crop seed complying with tolerance for purity and germination established by Official Seed Analysts of North America and as required below.

C. Seed shall be labeled according to the U.S. Department of Agriculture Federal Seed Act and shall be furnished in containers with tags showing seed mixture, purity, germination, weed content, name of seller, and date on which seed was tested.

1. Seed Mixture:

    a. Provide seed mixtures per grassing schedule provided in the Project Drawings.

    b. Moldy seed or seed that has been damaged in storage shall not be used. Provide seed from the last crop available at the time of purchase.

    c. Use seed with maximum noxious seeds of 300 seeds per pound subject to limitation of TDOT Standards. Provide seeds with minimum 70 percent germination and hard seed, minimum 90 percent purity, and maximum 2 percent weed seeds. Sow seeds according to Tennessee Erosion and Sediment Control Handbook and TDOT standards. At the discretion of the Engineer, samples of seed may be taken for verification against the grower's analysis.

2.03 Liming Material

A. Material used for soil neutralization, unless otherwise specified, shall be agricultural pulverized dolomitic limestone with not less than 90% passing the a 10-mesh sieve, not less than 25% passing a 100-mesh sieve, and containing not less than 85% carbonates.

B. Manufacturer's certification shall include the minimum pounds of ENM (effective neutralizing material) per ton of the material to be supplied.

2.04 Water

A. Water used to produce grass is to be clean, clear water, free of excess and harmful chemicals, acids, alkalies and all other substances which are hamrful to plant growth.

2.05 Mulch

A. Natural Mulch: At Contractor's option, either threshed rye, oat or wheat straw or grass hay free of noxious weed seeds. Contractor may also choose to mulch trees and vegetation removed along project easements as part of construction operations, and spread mulch along access roads to provide necessary erosion control protections.

B. Tackifiers:

1. Asphalt Emulsion: Conform to ASTM D977, Type SS-1. Provide homogeneous emulsified asphalt with no agents harmful or toxic for plant growth.

2. Cutback asphalt binder shall be Grade RC 70 or RC 250.

3. Organic Glue: Hydrobond as manufactured by Erosion Control Products or approved equal.

C. Wood Cellulose Fiber:

1. Fiber shall be produced from nonrecycled wood such as wood chips or similar wood materials and shall be of such character that the fiber will disperse into a uniform slurry when mixed with water. Fiber shall not be produced from sawdust or from paper, cardboard, or other recycled materials.

2. Mulch shall not contain germination or growth inhibiting ingredients.

3. Mulch shall be dyed an appropriate color to aid in visual inspection.

4. Mulch material shall be easily and evenly dispersed when agitated in water.

5. Supply in packages of not more than 100 pounds gross weight, and be marked by the manufacturer to show the air dry weight content of the wood cellulose fiber.

6. Mulch shall not be water-soluble and shall comply with the following properties:

    a. Moisture content, 9% ± 3%

    b. Organic matter - wood fiber (oven-dried basis), 99.2% ± 0.8%

    c. Ash content, 0.8% ± 0.2%

    d. pH: 4.8 ± 0.5

    e. Water holding capacity (grams of water/100 grams fiber), minimum: 1,150

7. Submit wood cellulose fiber material and application rates for approval by Engineer.

2.06 Pesticides

A. General: Pesticide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

PART 3 - Execution

3.01 General

A. Where grassing is required between curbs and sidewalks or behind sidewalks in areas adjacent to private residential or commercial property, the Contractor shall change the type of grassing as required to match any type of grass which may be planted and growing on the adjacent lawn.

B. Contractor shall match seeding and sodding on private properties to match existing lawn conditions and to restore disturbed areas to preconstruction conditions.

C. No large trees or irrigation systems shall be placed adjacent to newly constructed structures.

D. Do not plant plantings with high water demands near foundations of new construction.

3.02 Soil Preparation

A. Dispose of any growth, rocks, or other obstructions which might interfere with tilling, seeding, sodding, or later maintenance operations. Remove stones over 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter.

B. Thoroughly loosen and pulverize topsoil to a depth of at least 4 inches in soil disturbed by construction operations. Limit disturbances within sensitive areas, and do not till and disturb soils outside of excavation zones in sensitive areas in preparation for grassing.

C. Grade disturbed, seeded areas to a smooth, even surface with loose, uniformly fine texture. Roll and rake, remove ridges and fill depressions to meet finish grades. Limit fine grading to areas which can be planted within immediate future.

D. Moisten prepared seeded areas before planting if soil is dry. Water thoroughly and allow surface to dry off before planting of lawns. Do not create a muddy soil condition.

E. Restore prepared areas to specified condition if eroded or otherwise disturbed after fine grading and prior to planting.

F. Spread planting soil mixture to depth required to meet thicknesses, grades, and elevations indicated after light rolling and natural settlement.

G. Preparation of Unchanged Grades:

1. Where grasses are to be planted in areas that have not been altered or disturbed by excavating, grading, or stripping operations, prepare soil for planting grass by applying soil amendments and initial fertilizers to the surface of the undisturbed soils. Limit soil amendments and fertilizers in areas without erosion control protection and mulching, to prevent excessive runoff of fertilizers.

3.03 Application – Lime and Fertilizer:

A. Lime and fertilizer shall be applied separately, but may be incorporated into the soil in one operation.

B. Lime and fertilizer shall be applied not more than 48 hours before the seeding or sodding unless otherwise authorized by Engineer.

C. Contractor shall take a minimum of three Samples of the topsoil stockpile and, through the services of an independent laboratory, have test run to ascertain the rates of applications of soil amendments required to provide at least the quantity of effective neutralizing material and fertilizers to nourish new growth.

D. Apply lime and fertilizer at the rates recommended by soil analysis in pounds per acre to prepared seedbeds and sodbeds, but at a rate not less than 1,000 lbs/acre. The specified rate of application of limestone may be reduced by the Engineer if pH tests indicate this to be desirable. It is the responsibility of the Contractor to obtain such tests and submit them to the Engineer for adjustment in rates.

E. Incorporate lime and fertilizer into the soil in non-sensitive areas to a depth of at least 2 inches by discing, harrowing, or raking, except where applied hydraulically on slopes steeper than 2 horizontal to 1 vertical.

F. Contractor is responsible for making a minimum of one additional application of maintenance fertilizer to feed grass seed.

3.04 Application - Seed

A. Do not use wet seed or seed which is moldy or otherwise damaged in transit or storage.

B. Do not seed when wind velocity exceeds 5 miles per hour. Distribute seed evenly over entire area by sowing equal quantity in two directions at right angles to each other.

C. Sow seed within 24 hours following completion of placing lime and fertilizer using mechanical equipment that produces uniform application of seed.

D. Rake seed lightly into top 1/8 to 3/8-inch of soil in non-sensitive areas, roll lightly, and water with fine spray.

E. Roll seeded areas prior to placing mulch.

F. Seasonal Limitations: Perform seeding only when weather conditions permit distribution of seed and ground is not frozen, wet, or otherwise non-tillable. Seeding shall be performed during the dates shown on the Drawings unless otherwise approved by the Engineer.

G. Methods of Application:

1. Dry Seeding: Accomplish sowing by use of approved equipment, having drills no more than 4 inches apart. Care should be taken to adjust the seeder for seedings at the proper rate before seeding operations are started and to maintain their adjustment during seeding. Seed in hoppers shall be agitated to prevent segregation of the various seeds in a seeding mixture.

    a. Drill seed to an average depth of 1/2-inch.

    b. Overlap successive seed strips to provide uniform coverage. Repeat where skipped areas appear after a show of green.

    c. Cover seed with soil to an average depth of 1/4-inch by raking or other approved methods.

2. Hydraulic Seeding: Mix seed, fertilizer and pulverized mulch with water and constantly agitate. Do not add seed to water more than 4 hours before application:

    a. On slopes of 2 horizontal to 1 vertical or flatter, apply seed separately from fertilizer. Cover seed with soil to an average depth of 1/2 inch by raking or other approved methods.

    b. On slopes 2 horizontal to 1 vertical and steeper, seed and fertilizer may be applied in a single operation. Incorporation into the soil will not be required.

3.05 Application - Mulch

A. Apply a mulch covering to all seeded areas within 24 hours after seeding, applied in a uniform and continuous blanket immediately after seeding.

B. Apply wood cellulose fiber mulch hydraulically at the rate of 1,500 pounds per acre.

1. Mulch and seed may be applied in a single operation on slopes 2 to 1 or steeper.

2. Apply mulch to achieve a uniform coverage of the soil surface.

3. Apply mulch evenly to permit sunlight to penetrate and air to circulate, while shading the ground, reducing erosion, and conserving soil moisture. Approximately 45 percent of the ground shall be visible through the mulch blanket.

C. Apply natural bituminous treated mulch to a thickness of ¾ inch to 1-1/2 inch deep over entire area with sufficient asphalt material to hold mulch in place. Apply wood cellulose fiber mulch at 1,400 pounds/acre, straw at 4,000 pounds/acre, and stalks at 4,000 pounds/acre.

D. Exercise care at all times to protect the public, adjacent property, bridges, pavements, curbs, sidewalks and all other structures.

E. Remove any mulch placed on facilities or areas other than those authorized for grassing.

F. Immediately following the application of the mulch, water the seeded area in one watering, in sufficient amount to penetrate the seedbed to a minimum depth of 2 inches. Perform so as not to cause erosion or damage to the seeded surface.

G. Protect seeded areas against hot, dry weather or drying winds by applying mulch not more than 24 hours after completion of seeding operations.

H. Mulch on slopes greater than 3 to 1 ratio shall be held in place by the use of approved mulch binder. Binder shall be thoroughly mixed and applied with the mulch. Emulsified asphalt and cutback asphalt shall be applied at the approximate rate of five gallons per 1,000 square feet as required to hold the mulch in place.

3.06 Application - Erosion Control

A. Install netting where indicated immediately following mulching operations.

B. Roll nettingloosely over the required areas. Lifting and stretching of the material will not be permitted.

C. Secure netting by staples spaced every 1 to 2 feet apart along top and bottom ends and no more than 4 feet apart along sides and across remaining unanchored netting forming an “X” pattern.

D. Lap joints in the direction of water flow with at least a 2-inch overlap.

E. After the netting is secured in place by staples, press firmly against the surface of the soil by tamping or by rolling with an approved smooth-wheel hand roller.

F. Repair any seeded or mulched areas disturbed by the installation of the netting.

3.07 Reconditioning Seeded Areas

A. Recondition seeded areas damaged by Contractor's operations, including storage of materials or equipment and movement of vehicles. Also recondition seeded areas where settlement or washouts occur or where minor regrading is required.

B. Provide fertilizer, seed or sod, and soil amendments as specified for new grass and as required to provide satisfactorily reconditioned lawn. Provide new planting soil as required to fill low spots and meet new finish grades.

C. Cultivate bare, compacted, non-sensitive areas thoroughly to provide a good, deep planting bed.

D. Remove diseased or unsatisfactory grassed areas; do not bury into soil. Remove topsoil containing foreign materials resulting from Contractor's operations including oil drippings, stone, gravel, and other construction materials. Replace with new topsoil.

E. Where substantial grass remains (but is thin), mow, rake, aerate if compacted, fill low spots, remove humps and cultivate soil, fertilize, and seed. Remove weeds before seeding or, if extensive, apply selective chemical weed killers as required. Apply a seedbed mulch, if required, to maintain moist condition.

F. Water newly planted areas and keep moist until new grass is established.

3.08 Protection

A. Erect barricades and warnign signs as required to protect newly planted areas from traffic. Maintain barricades throughout maintenance period until grass is established.

3.09 Maintenance

A. Mow grass to a height of 2 inches as soon as there is enough top growth to cut with mower. Remove no more than 40% of grass leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted.

B. Remove weeds by pulling or chemical treatment.

C. Perform maintenance until the date of final acceptance.

D. Seeded Areas:

   1. Water as required by good practices and as necessary to obtain a flourishing cover.

   2. Repair any portion of the seeded surface which becomes gullied or otherwise damaged, or the seeding becomes damaged or destroyed.

E. Apply second fertilizer application after first mowing and when grass is dry. Use fertilizer which will provide not less than a pound of actual nitrogen per 1,000 square feet of seeded area.

3.10 Acceptance of Areas

A. When seeding Work is Substantially Complete, including maintenance, Engineer and Owner will, upon request, make an inspection to determine acceptability:

1. Seed Work may be inspected for acceptance in parts agreeable to Owner, provided Work offered for inspection is complete, including maintenance.

2. Grassed areas will be considered acceptable when a viable stand of grass covers at least 98 percent of the total area with no bare spots exceeding one square foot and the ground surface is fully stabilized against erosion.

B. Replant rejected Work and continue specified maintenance until reinspected by Engineer and Owner and found to be acceptable.

C. Seeded areas will be acceptable provided requirements, including maintenance, have been complied with and healthy, uniform, close stand of specified grass is established free of weeds, bare spots, and surface irregularities.

3.11 Cleanup

A. Promptly remove soil and debris created by seed work from paved areas. Clean wheels of vehicles prior to leaving Site to avoid tracking soil onto road surfaces.

3.12 Measurement And Payment

A. Time of Completion: Completion time for seeding and sodding shall not apply to provisions for liquidated damages with respect to Contract completion time. Payment for seeding and sodding will be withheld until such Work is accepted.

END OF SECTION

PART 1 - General

1.01 Summary:

A. This Section includes furnishing all labor, materials, equipment and services required to perform non-destructive pressure pipe condition assessment and leak survey of sewer pipelines using sonar technology as indicated on the Drawings and as specified herein.

1.02 References:

A. Applicable Standards:

1. National Association of Sewer Service Companies (NASSCO) Specifications.
2. City of Chattanooga Sanitary Sewer System Design & Construction Manual and Construction Standard Specifications.

1.03 Submittals:

A. Submit as specified in Division 01.

B. Includes, but not limited to, the following:

1. Sewer Sonar Inspection Plan.

1.04 Qualification:

A. The sewer inspection Contractor shall be a firm having a minimum of 3 years continuous successful experience in the inspection of sewers similar to that required for this project.

B. The Contractor will provide current certification that operators conducting the sonar inspection have undergone National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP®) training prior to commencement of inspection activities.

PART 2 - Products

2.01 Materials:

A. Sonar Equipment:

1. The sonar equipment shall be capable of assessing multiple pipe materials including ductile iron pipe and concrete pipes.

2. The sonar equipment shall provide 360 degree inspection of the pipe circumference at one (1) inch intervals along the length of the pipe.

3. The Sonar equipment must utilize digital, multi-frequency profiling sonar in order to model the pipe under submerged and partially submerged conditions.

4. Positional sensors or other means of determining position of the sonar equipment shall be used to provide accurate information on the location of sediment and other defects observed during the inspection.

5. The sonar equipment shall be operable while the pipeline is in service. The inspecting equipment shall be capable of inspecting a length of sewer up to at least 2,000 ft. The Contractor shall maintain this equipment in full working order and shall satisfy the Engineer at the commencement of each working shift that all items of equipment have been provided and are in full working order.

6. Where the equipment is towed by winch and bond through the sewer, all winches shall be stable with either lockable or ratcheted drums. All bonds shall be steel or of an equally non-elastic material to ensure the smooth and steady progress of the Sonar equipment. All winches shall be inherently stable under loaded conditions.

7. A reserve unit shall be available to replace the regular unit in the event of a breakdown. Should the reserve equipment malfunction, another unit shall be provided within 24 hours.

8. Operation of the sonar inspection equipment shall be controlled from above ground, with a skilled technician controlling the equipment.

PART 3 - Execution

3.01 Procedure

A. The sonar inspection shall be performed in one section of the sewer force main at a time.

B. The sonar inspection equipment shall be inserted in the upstream entry point as indicated on the Drawings.

3.02 Provisions:

A. The Contractor shall maintain on site at all times a competent field supervisor in charge of the inspection. The field supervisor shall be responsible for the safety of all site workers and site conditions as well as ensuring that all work is conducted in conformance with these specifications and to the level of quality specified.

B. At the start of each force main section being inspected, the length of pipeline from inspection start point shall be recorded and reported in order to obtain a full record of the sewer length. Only one inspection shall be indicated in the final report. Each log shall make reference to a start (ST) and finish (FH) location.

C. If for any reason the sonar equipment becomes disabled inside the force main and cannot further proceed, the Contractor shall be responsible for retrieving the equipment at no additional cost to the Owner.

D. All digital recording shall be continuous with no evidence of gaps in information.

3.03 Data collection:

A. The Contractor shall furnish all equipment and software required for documenting the inspection. Data logging and defect coding conforming to the NASSCO PACP will be required as part of all pipeline inspections.

B. All inspection information shall be captured utilizing NASSCO certified data collection software and following all NASSCO PACP (version 7.0.2 or greater) standard data fields, formats, and conventions provided by the Engineer.

C. All inspection media file naming formats and folder organizational structures must remain consistent throughout all internal inspections.

D. A comprehensive summary inspection report shall be generated for each inspection, and shall be in Portable Document Format (PDF) or other suitable electronic formats. The report shall include the findings on pipe conditions and major defects, including but not limited to:

1. Variations in pipe inside diameter
2. Pipe deflections in excess of 5%
3. Leaks
4. Sediment deposits
5. Air pockets.

E. At each coded observation, the following minimum information shall be displayed: the PACP code and/or PACP code description, the position of the defect, and the “Additional_Info” field in any cases where it is utilized.

F. The Contractor must have an internal quality assurance/quality control system (QA/QC) in place, and all inspection data shall be subjected to the procedures prior to submittal to the Engineer. The Engineer will perform QA/QC audits on submitted data. Any data or files not meeting these specifications or NASSCO standards will be returned to the Contractor for correction. Contractor shall present their proposed QA/QC system to the Engineer prior to the start of the Contract.

3.04 Deliverables:

A. All the supplied data and information will become the property of the Owner.

B. Two (2) hardcopies of the reports and deliverables and two (2) electronic copies of the reports, deliverables, database, and any other pertinent information.

C. All encoded inspection files and inspection reports.

D. A single, consolidated proprietary database containing all inspections for the Contract, as generated by the Contractor's data collection software.

E. Free-issue software to be used for the viewing of the proprietary inspections database and related media from within the database.

F. Electronic files shall be supplied to the Owner in a format appropriate to the size and quantity of files, including on DVD discs, USB flash drives, USB hard drives, or uploaded to a File Transfer Protocol (FTP) service provided by the Owner.

END OF SECTION

PART 1 - General

1.01 Summary

A. This Section includes all pressure pipe, fittings, specials, and appurtenances.

B. Related Work Specified Elsewhere:

1. Section 33 31 50 - Pipe Installation.
2. Section 33 12 16 - Valves and Accessories.
3. Section 09 90 00 - Protective Coatings.

1.02 Reference Standards

A. Applicable Standards:

B. American Association of State Highway and Transportation Officials (AASHTO).

C. American Water Works Association (AWWA):

1. AWWA C104 - Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
2. AWWA C110 - Ductile-Iron and Gray-Iron Fittings.
3. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
4. AWWA C115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
5. AWWA C150 - Thickness Design of Ductile-Iron Pipe.
6. AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast, for Water.
7. AWWA C153 - Ductile-Iron Compact Fittings.
8. AWWA C219 - Bolted, Sleeve-Type Couplings for Plain-End Pipe.
9. AWWA C606 - Grooved and Shouldered Joints.

D. American National Standards Institute (ANSI):

1. ANSI B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

2. ANSI B16.21 – Nonmetallic Flat Gaskets for Pipe Flanges.

E. American Society for Testing and Materials (ASTM):

1. ASTM A193 – Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
2. ASTM A283 – Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
3. ASTM A307 – Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength.
4. ASTM A36 – Standard Specification for Carbon Structural Steel.
5. ASTM A47/A47M – Standard Specification for Ferritic Malleable Iron Castings.
6. ASTM A48/A48M – Standard Specification for Gray Iron Castings.
7. ASTM A536 – Standard Specification for Ductile Iron Castings.
8. ASTM A563 – Standard Specification for Carbon and Alloy Steel Nuts.
9. ASTM A588 – Standard Specification for High-Strength Low-Alloy Structural Steel.
10. ASTM A746 – Standard Specification for Ductile Iron Gravity Sewer Pipe.
11. ASTM D638 – Test Method for Tensile Properties of Plastics.
12. ASTM D790 – Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
13. ASTM D1238 – Measuring Flow Rates of Thermoplastics by Extrusion Plastometer.
14. ASTM D1248 – Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
15. ASTM D1505 – Test Method for Density of Plastics by the Density-Gradient Technique.
16. ASTM D1693 – Test Method for Environmental Stress-Cracking of Ethylene Plastics.
17. ASTM D1785 – Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120.
18. ASTM D2000 – Standard Classification System for Rubber Products in Automotive Applications.

19. ASTM D2657 – Heat Fusion Joining Polyolefin Pipe and Fittings.
20. ASTM D2774 – Underground Installation of Thermoplastic Pressure Piping.
21. ASTM D3035 – Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
22. ASTM D3261 – Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene Plastic Pipe and Tubing.
23. ASTM F477 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
24. ASTM F679 – Standard Poly (Vinyl Chloride) (PV) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
25. ASTM F714 – Standard for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter.
26. ASTM G62 – Standard Test Methods for Holiday Detection in Pipeline Coatings.

F. Plastics Pipe Institute (PPI):

1. TR-31 – Underground Installation of Polyolefin Piping.

G. Society for Protective Coatings (SSPC):

1. SP1 – Solvent Cleaning.
2. SP3 – Power Tool Cleaning.
3. SP5 – White Metal Blast Cleaning.
4. SP7 – Brush-Off Blast Cleaning.
5. SP10 – Near-White Blast Cleaning.

1.03 Submittals

A. Submit as specified in Division 01.

B. Submit producer’s or manufacturer’s technical data and installation instructions (where appropriate) for the following products, including laboratory test reports, notarized certifications, or other data as may be required to show compliance with these Specifications, including specified standards:

1. Pipe and joint details.
2. Special, fitting, and coupling details.
3. Laying and installation schedule.

4. Specifications, data sheets, and affidavits of compliance for protective shop coatings and linings.

5. Manufacturer's design calculations including, but not limited to, wall thickness and deflection under specified live and dead loads.

C. Shop Drawings: For piping connections and installations at pump station.

D. Certificates and Affidavits: Furnish the Following Prior to Shipment:

1. Affidavit of compliance with applicable standard.

2. Certificate of origin for all steel flanges.

3. Test certificates for piping, fittings, joints, valves, couplings, bolts, liners, and coatings. Certificates shall attest that the tests set forth in each applicable referenced publication have been performed, whether specified in that publication to be mandatory or otherwise, and that production control tests have been performed at intervals or frequency specified in the publication. Other tests shall have been performed within 3 years of the date of submittal of certificates on the same type, class, grade, and size of material as is being provided for the project.

1.04 Quality Assurance

A. Manufacturers shall be experienced in the design and manufacture of pipe, fittings, specials, or appurtenances for a minimum period of 5 years.

B. Imperfections: Regardless of tolerances permitted by industry standards specified herein, the Engineer may reject pipe or appurtenances at the manufacturing plant or project site, which have cracks, chips, blisters, lack of smooth interior or exterior surface, evidence of structural weakness, porosity, joint defect, significant variation from theoretical shape, or other imperfection which might, in the opinion of the Engineer, contribute to a reduced functional capability, accelerated deterioration, or reduced structural strength.

C. Repairs: Do not use patched or repaired pipe or appurtenances unless each individual length or element has been approved and marked for repair by the Engineer at the manufacturing plant. Repairs, other than at the manufacturing plant, are not permitted.

PART 2 - Products

2.01 Pipe requirements:

A. Furnish pipe of materials, joint types, and sizes as indicated or specified.

B. Pipe Marking: All pipe and fittings shall be marked conforming to the applicable standard specification under which the pipe is manufactured and as otherwise specified.

2.02 Ductile-Iron Pipe (DIP):

A. Design and Manufacture of Pipe:

1. Ductile-iron pipe shall conform to AWWA C115, C150 and C151 except as otherwise specified.

   a. Provide restrained mechanical joints for buried installations.

   b. Provide flanged joints conforming to ANSI/AWWA C115/A21.15 for pressure class 150 for exterior piping.

   c. Provide piping with minimum working pressure of 150 PSIG.

2. Install pipe with laying condition Type 4 for ductile iron pipe for installations in suitable soils. If unsuitable soils are discovered, replace unsuitable soils with satisfactory soils, and compact as required. For installations in locations with high water tables or unsuitable foundations, provide crushed stone bedding per laying conditions Type 4 and Drawings.

   a. Install pipe with a maximum 3% design deflection limit for trench load calculations, or as specified by manufacturer.

B. Dimensions:

1. Provide minimum pipe dimensions noted in the Drawings. Confirm the size of existing piping systems on site, and adjust new pipe dimensions as necessary to match and connect to existing piping systems.

2. Minimum thickness for ductile-iron pipe threaded for screw-on flanges shall be in accordance with AWWA C115.

3. Pipe with grooved barrel for any type of restrained joint shall have wall thickness increased to provide a minimum wall thickness conforming to AWWA C606.

C. Joints

1. Mechanical (MJ) Type:

   a. Provide mechanical joints for all buried pipe, unless otherwise specified or indicated.

   b. Joints shall conform to AWWA C111/A21.11-12 for a minimum 150 PSIG working pressure rating, lined and coated the same as the connecting pipe.

   c. Use corrosion resistant allow steel bolts and nuts. Provide mechanical joints for direct burial piping or concealed piping within structures.

2. Flanged (FLG):

   a. Provide flanged joints for all interior and exposed exterior pipe except where otherwise specified or indicated.

   b. Flanges for pipe shall be ductile iron and conform to the applicable provisions of AWWA C110 and C115 and shall be drilled ANSI B16.1 Class 125.

   c. Pipe with victaulic-style couplings and rigid joints conforming to AWWA C606 may be substituted for Class 125 flanged pipe where indicated or approved by Engineer.

   d. Use corrosion resistant alloy steel bolts and nuts, and rubber gaskets complying with ANSI/AWWA C115/A21.15.

3. Restrained (RJ):

   a. Furnish for all fittings and where joint restraint is required to offset internal pipeline forces.

   b. Provide restrained joints of following approved types.

      1) Restrained mechanical joint.

      2) Cut grooved type for rigid joint conforming to AWWA C606.

      3) Restrained push-on joint; boltless system of rubber gasket embedded with equally spaced stainless steel segments to grip the pipe, with allowance for deflection.

   c. Mechanical joint retainer glands shall be Megalug manufactured by EBAA Iron, Inc. or approved equal.

4. Dismantling (DJ):

   a. Provide as indicated in Drawings and as needed for installation.

   b. Joints shall be suited for a working pressure of at least 150 psi.

   c. For dismantling joints 14” and larger: flange spool, end ring and body shall be of ASTM A36 and/or ASTM A283C Carbon Steel.

   d. Bolts and nuts shall be of high strength low alloy steel per AWWA A588.

   e. Tie-Rods shall be carbon steel per ASTM A193 B7.

   f. Gaskets shall be compounded for sewer service in accordance with ASTM D2000.

5. For connecting to large diameter pipes:

a. Cut existing pipe flush and smooth, and remove any burrs and imperfections. Field weld a retainer gland ring and socket locking groove to the existing pipe per manufacturer instructions. Connect to the pipe with restrained joint connection.

D. Fittings

1. Fittings shall conform to AWWA C110 or C153 and shall have a pressure rating of not less than that specified for pipe.
2. Fittings shall be ductile iron.
3. Fittings for pipe with mechanical joint shall have mechanical joints.
4. Fittings for pipe with push-on joints shall be mechanical joint or push-on-type joint.
5. Fittings for pipe with grooved type joint shall have cut grooved type rigid joints per AWWA C606.
6. Fittings for pipe with flanges shall be flanged type complying with ANSI B16.1 for Class 125 lbs drilling.
7. Include all specials, taps, plugs, flanges, and wall fittings as required.
8. Provide openings for air valve, drain, sampling, sensing, testing, and other connections with threaded bosses or flange outlets sized and located where indicated.

E. Lining

1. All pipe and fittings shall be lined with Protecto 401 ceramic-modified epoxy lining.
2. See Specification Section 09 90 00 “Protective Coatings”, for non-buried applications and piping subject to submergence in wastewater.
   a. Testing
      1) Lining shall be tested over 100% of the pipe barrel and fitting surface with a nondestructive 4,000-volt test
      2) All holidays shall be repaired per lining manufacturer’s recommendation
      3) A voltage confirmation test shall be performed for each production shift or change in detector operator

2.03 PVC Pipe:

A. Materials:

1. All polyvinyl chloride pipe (PVC) furnished shall be manufactured in strict accordance with ASTM D1785.

2. Pipe wall thickness shall conform to ASTM D1785 and be Schedule 40.

3. Gaskets shall conform to ASTM F477 and be synthetic rubber.

2.04 Sleeves and Couplings:

A. Sleeves:

1. AWWA C110 mechanical joint ductile-iron solid sleeve type:

2. Pipe end space shall not exceed one-third of the sleeve laying length.

3. Interior, exposed, exterior, or buried service as indicated.

B. Couplings:

1. Center sleeve and compression gland-type end ring conforming to AWWA C219.

2. Center sleeve shall be without pipe stop.

3. Couplings for joining direct buried, exposed exterior, vault or pit installations of iron, or PVC pipe up to 12-inch diameter shall be iron. Provide lined and coated steel couplings for larger pipe diameters.

4. Couplings for exposed interior iron or PVC pipe may be steel or iron.

5. Fastener bolts shall be ductile iron or stainless steel for iron couplings. Bolts for direct buried coupling installations shall be stainless steel.

6. Center sleeve and end rings shall be ductile or malleable iron for iron couplings.

C. Flanged Coupling Adapters:

1. Flanged end and body to be one unit conforming to AWWA C219. Coupling end to be compression gland type with follower ring.

2. Adapters for joining direct buried, exposed exterior, vault or pit installations of iron pipe shall be iron.

3. Flanged end bolt circle, bolt size, and spacing shall conform to the applicable provisions of ANSI B16.1 and shall be drilled Class 125 for iron adapters. Bolts and nuts shall be ductile iron for iron adapters. Anchor studs shall not be used where joint restraint is required. Furnish adapters with tie rod harness assemblies where indicated.

D. Insulated Couplings:

1. Couplings shall be insulated to prevent electrical conductivity where indicated.

2. Insulated coupling design shall be otherwise conforming to the standard types and styles specified.

E. Dismantling Joint:

1. Consists of a mechanical joint fitting located between two pipe flanges with restraining rods across the mechanical joint section, providing a restrained system with integral space for removal of adjacent equipment.

2. Shall conform to AWWA C-219.

3. Materials shall be steel.

4. When connected to DIP system, install insulating flange kit.

2.05 Gaskets and Bolting Materials:

A. Provide all gaskets, bolts, lubricant, and other accessories required to install pipe, fittings, and specials complete and ready for service.

B. Gaskets for flanged joints shall conform to ANSI B16.21, 1/8-inch thick full-face synthetic rubber. Provide full-face gaskets for all pump and equipment connections.

C. Gaskets for ductile iron flanged pipe and fittings 12 inch and smaller shall have "nominal" inside diameters, not the larger inside diameters per ANSI B16.21.

D. Bolts for flanged joints shall conform to ASTM A307, Grade B. Nut and bolt heads shall be hexagonal.

E. Gaskets and bolts for other than flanged joints shall be as otherwise specified for pipe and pipe joints.

2.06 Joint Bonding:

A. Joint bonding shall be provided as indicated.

B. Bonding shall be accomplished:

1. With No. 2 insulated, stranded, soft annealed copper wire attached to pipe cylinder by thermic weld.

2. With manufacturer's standard subject to Engineer's approval.

PART 3 - Execution

3.01 Installation:

A. Specified in Section 33 31 50.

3.02 Field Testing:

A. Specified in Section 33 31 50.

3.03 Field Protective Coating:

A. Specified in Section 09 90 00.

END OF SECTION

PART 1 - General

1.01 Summary:

A. This Section includes all valves and accessories.

B. Related Work Specified Elsewhere:

1. Section 33 31 50 – Pipe Installation.
2. Section 09 90 00 – Protective Coatings.

1.02 References:

A. Applicable Standards:

1. American National Standards Institute (ANSI):
    a. B16.1 – Cast-Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800.
2. American Society for Testing and Materials (ASTM):
    a. A126 – Gray Iron Castings for Valves, Flanges and Pipe Fittings.
    b. A276 – Stainless and Heat Resisting Steel Bars and Shapes.
    c. A536 – Ductile Iron Castings.
    d. A564 – Hot-Rolled and Cold-Finished Age-Hardening Stainless and Heat Resisting Steel Bars and Shapes.
3. American Water Works Association (AWWA):
    a. C111 – Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
    b. C207 – Steel Pipe Flanges for Waterworks Service - Sizes 4 Inch Through 144 Inch (100 mm through 3600 mm).
    c. C500 – Metal-Seated Gate Valves for Water Supply Service.
    d. C504 – Rubber-Seated Butterfly Valves.
    e. C507 – Ball Valves, 6 Inch Through 48 Inch (150 mm through 1200 mm).
    f. C508 – Swing-Check Valves for Waterworks Service, 2 Inch (50 mm) through 24 Inch (600 mm) NPS.
    g. C509 – Resilient-Seated Gate Valves for Water Supply Service.

   h. C512 – Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service.
   i. C517 – Resilient-Seated Cast-Iron Eccentric Plug Valves.
   j. C540 – Power-Actuating Devices for Valves and Sluice Gates.
   k. C550 – Protective Epoxy Interior Coatings for Valves and Hydrants.
   l. C600 – Installation of Ductile-Iron Water Mains and Their Appurtenances.
   m. C606 – Grooved and Shouldered Joints.

1.03 Submittals:

A. Submit as specified in DIVISION 1.

B. Include, but not limited to, the following:

   1. Catalog data or illustrations showing principal dimensions, parts, and materials.
   2. Spare parts list referenced to illustration of parts.
   3. Assembly and disassembly or repair instructions.
   4. Dimensions of the clearance required for valve components.

C. Certificates and Affidavits: Furnish prior to shipment. Include the following:

   1. Test certificates.
   2. Affidavit of compliance with applicable AWWA Standard.

1.04 Quality assurance:

A. Manufacturers shall be experienced in the design and manufacture of specific valves and accessories for a minimum period of 5 years.

1.05 Delivery, storage, and handling:

A. Ship all valves with suitable end covers to prevent entrance of foreign material into valve body.

B. Protect valve threads, flanges, stems, and operators from damage.

C. Ship valves 65 mm (2-1/2-inch) and larger to the Project Site tagged with the valve number shown on the Drawings. Tag smaller valves to show the piping system in which it is to be used.

1.06 Responsibility:

A. Actuators, their controls, and accessories shall be the responsibility of the valve manufacturer for sizing, assembly, certification, field testing, and any adjustments necessary to operate the valve as specified.

PART 2 - Products

2.01 Eccentric Plug Valves:

A. Acceptable Manufacturers:

1. DeZurik.
2. Henry Pratt Company.
3. Val-Matic Valve and Manufacturing Corporation.

B. Design: Conform to AWWA C517 and as specified.

1. Quarter-turn nonlubricated eccentric type with resilient faced plug. Valves with vane type seat rings are not acceptable. Shutoff up to scheduled rating with pressure in reverse direction where scheduled.
2. Conform to criteria indicated in Valve Schedule table.
3. Flanged valve ends shall be faced and drilled to conform to ANSI B16.1, Class 125 for thickness and drilling.
4. Mechanical or push-on type rubber-gasketed joint ends shall conform to AWWA C111.
5. Screwed ends shall be to the NPT standard.
6. Grooved ends shall conform to AWWA C606 rigid joint specifications.
7. Port areas of all valves shall be at least 70% of full pipe area.
8. Valves shall be designed for a working pressure of at least 150 psi and provide tight shutoff at rated pressure.
9. Plugs shall be eccentric type with no backing ring or frame.
10. Valve body cavity shall be smooth without protrusions or baffles.

C. Materials and Construction:

1. Bodies shall be of ASTM A126, Class B cast iron.
2. Valve plug shall be ASTM A126, Class B cast iron or ASTM A536 ductile iron. Resilient plug facing or replaceable style body seats shall be synthetic rubber, neoprene, or Buna N compound suitable for use with wastewater applications.

3. Seat rings shall be threaded, or welded of corrosion-resistant 18-8 stainless steel, nickel, or Monel conforming to AWWA C504. Sprayed or plated mating seat surfaces are not acceptable.

4. Bearings shall be replaceable. Sleeve type and thrust bearings in the upper and lower journals shall be corrosion-resistant stainless steel or bronze.

5. Shaft seals shall be multiple O-ring, self-adjusting U-cup or chevron type packing conforming to AWWA C504. Pull-down packing is not acceptable.

6. Shaft seals shall be field adjustable or replaceable without valve disassembly.

7. All exposed fastening hardware shall be zinc plated or stainless steel. Provide stainless steel for buried service.

D. Actuators:

1. Manual Actuators:

a. All valves shall open counterclockwise.

b. Worm gear actuators shall be totally enclosed, grease sealed, gear type furnished with AWWA nut, crank, handwheel, or chainwheel. All buried valves shall be provided with worm gear actuators, AWWA nut, and enclosed cover plate. All valves with reverse pressure capacity requirement shall be provided with worm gear actuators. Worm gear actuators shall be self-locking at all variable opening positions and sized to meet the torque ratings of AWWA C504. The shaft in a worm gear actuator shall have a nonmetallic or bronze sleeve type bearing. Submit manufacturer's parts and materials drawings.

c. Provide indicators to show position of plug except on buried actuators.

d. Square nut operators shall be provided for plug valves in valve boxes on all yard piping (three in total). Square nut operators shall be AWWA 2-inch size for operation by wrench head lever. Furnish one lever for each valve.

e. Handwheels shall be provided in valve vault for two eccentric plug valves immediately downstream of the submersible pumps. Handwheels shall be located in positions indicated or as otherwise determined when manufacturer's drawings are submitted.

2.02 Cushioned Swing Check Valves:

A. Acceptable Manufacturers:

1. APCO, Valve and Primer Corporation.

2. Milliken

B. Operational Requirements:

1. Prevent reverse flow and cushioned to reduce shock or hammer.

2. Seat tightly with internal pipeline forces.

3. Cushioned with air cylinder controls in manner permitting adjustment of speed of closure.

C. Design: Conform to AWWA C508 and as specified.

1. Swing disc type with single shaft and flanged body, full opening. Flanges shall be ANSI B16.1, Class 125.

2. Cushion chamber shall be mounted externally on valve body.

3. Valve disc shall have extended stainless steel hinge pin with external lever and spring or counterweight to initiate closure.

4. Suitable for minimum operating pressure of 120 psi.

D. Materials and Construction:

1. Valve body shall be cast iron or ductile iron.

2. Flanges shall be ANSI B16.1, Class 125.

3. Valve disc shall be cast iron, ductile iron, or stainless steel.

4. Seats and seat ring shall be replaceable. Seats shall be bronze or stainless steel. Seat rings shall be bronze or Buna-N.

2.03 COM Air valves:

A. Acceptable Manufacturers:

1. ARI Valves.

2. APCO, Valve and Primer Corporation .

3. Val-Matic Valve and Manufacturing Corporation.

B. Design: Conform to AWWA C512 and as specified.

1. Valve shall be heavy-duty combination air release and vacuum valve, sewage style.

2. Body and cover shall be cast iron.

3. The height of the installed Combination Air Valve, including one-half the diameter of the 24 inch pump discharge pipe, the length of the connection tee, and the length corporation stop valve shall not exceed 8 feet, or 96 inches.

4. Float shall be stainless steel.
5. All internal parts shall be stainless steel.

C. Manufacturing and Testing:

1. Valve shall be manufactured and tested in accordance with AWWA C512.

D. Operation:

1. Release air when filling line.
2. Admit air when emptying line or when a negative pressure occurs.
3. Close upon liquid entry.
4. Remain closed while pipeline is full and operating under pressure.

E. Connection:

1. Connect air valves through tapped bosses or flanged outlets.
2. Install corporation stop at connection of combination air valve to 24” DIP.
3. Connecting fittings and pipe shall be bronze, brass, or copper rated for 150 psi service.
4. Isolation valves 4 inches and larger shall be AWWA C517 eccentric plug valves.
5. Couplings or unions indicated between pipeline and air valve piping shall be insulated style.

F. Structural Support: Refer to detail in drawings.

1. All support components shall be Dtainless steel.

2.04 Flap valves:

A. Acceptable Manufacturers:

1. Rodney Hunt-Fontaine Inc.
2. Hydro Gate of Mueller Co.

B. Design:

1. Flap valves shall be mounted along the floor of valve vaults to provide for any water in the bottom of Valve Vault an exit through which to drain into Wet Well (refer to Drawings).

2. Valve shall be mounted such that side of flap is in vertical position under normal operating conditions and the bottom lip of the flap shall be at the same elevation as the bottom of the valve vault.

3. Counterweight shall keep valve closed under normal operating conditions sufficient to prevent odors from Wet Well from seeping into Valve Vault.

4. Counterweight shall not be so heavy as to prevent water from draining out of the valve vault.

C. Materials and Construction:

1. Valve shall have a two-part cast iron body.

2. Valve body shall be epoxy-coated cast iron or stainless steel.

3. Flap seating shall be bronze-to-bronze or resilient type.

4. Hinge pin, cotter pins, and all other accessories shall be stainless steel.

2.05 Corporation stops:

A. Provide corporation stops as specified to isolate combination air valves.

B. Mueller Company Style H-10003, H-10013, or H-10045 or Engineer-approved equal as applicable.

2.06 Valve boxes:

A. Acceptable Manufacturers:

1. Tyler Company.

2. Opelika Company.

B. Provide for all buried valves.

C. Design:

1. Boxes shall consist of a cast-iron cover, lid, and base castings with 6-inch ductile-iron pipe shaft.

2. Provide extension stem to bring operating nut within 2 feet of valve box top.

3. Drop cover shall be marked "SEWER."

2.07 Shop painting:

A. Prepare surfaces and paint or coat all valves, fire hydrants, floor stands, valve boxes, corporation stops, and all related accessories standard of the manufacturer unless otherwise specified herein.

B. Paint and coatings shall be suitable for the service intended.

C. Submit type of paint or coating proposed with drawings and data for Engineer approval prior to fabrication.

PART 3 - Execution

3.01 Installation:

A. Comply with provisions of AWWA C600 and as specified.

B. Thoroughly clean and remove all shipping materials prior to setting. Operate all valves from fully opened to totally closed.

C. Install eccentric plug valves in reverse position, flow and pressure against the plug face when closed, in lines with solids or stringy materials. When installed horizontally with shaft in the horizontal, the plug shall rotate open to the top recess of the valve body.

D. Install double-door wafer check valves with hinge pin in the vertical position for horizontal flow applications.

E. Install single-door wafer swing check valves with hinge pin in the horizontal position for horizontal flow applications.

F. Equip with anchorage where indicated.

G. Set fire hydrants with lowest nozzle 450 mm (18 inches) above finished grade. Check and fill stem bonnet lubricant reservoir.

3.02 Field Painting:

A. Surface preparation and finish painting are specified in SECTION 099000.

3.03 Field Testing:

A. Perform on piping and valves as specified in SECTION 333150 and for the following:

1. Check valves.

2. Eccentric plug valves.

3. Air and air/vacuum valves.

END OF SECTION

PART 1 - General

1.01 Summary:

A. This Section includes handling, installation and testing of pipe, fittings, specials, and appurtenances as indicated or specified.

B. Related Work Specified Elsewhere:
   1. Pressure Pipe: SECTION 331100.
   2. Utility Valves and Accessories: SECTION 331216.
   3. Protective Coatings: SECTION 099000.

1.02 References:

A. Applicable Standards:
   1. American Society for Testing and Materials (ASTM):
      a. C12 - Installing Vitrified Clay Pipe Lines.
      b. C828 - Low-Pressure Air Test of Vitrified Clay Pipe Lines.
      c. D2321 - Underground Installation of Flexible Thermoplastic Sewer Pipe.
      d. F1417 - Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air.
   2. American Water Works Association (AWWA):
      a. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
      b. C203 - Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape- Hot-Applied.
      c. C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 Inch and Larger - Shop Applied.
      d. C206 - Field Welding of Steel Water Pipe.
      e. C209 - Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
      f. C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
      g. C651- Disinfecting Water Mains.
      h. M9 - Concrete Pressure Pipe.
      i. M11 - Steel Pipe - A Guide for Design and Installation.
      j. M23 - PVC Pipe - Design and Installation.

3. Federal Specifications (FS):
    a. SS-S-00210 - Sealing Compound, Preformed Plastic, For Expansion Joints and Pipe Joints.

1.03 Delivery, storage and handling:

A. Handle in a manner to provide installation in sound and undamaged condition.
  1. Do not drop or bump.
  2. Use slings, lifting lugs, hooks, and other devices designed to protect pipe, joint elements, linings, and coatings.

B. Ship, move, and store with provisions to prevent movement or shock contact with adjacent units.

C. Handle with equipment capable of work with adequate factor of safety against overturning or other unsafe procedures.

PART 2 - Products

2.01 Specified in respective sections, this division.

PART 3 - Execution

3.01 Installation - General:

A. Use equipment, methods, and materials to install lines and grades as indicated.
  1. Maintain within tolerances specified or acceptable laying schedule.
    a. Alignment: ±1 inch per 100 feet in open cut or tunnel.
    b. Grade: ±1 inch per 100 feet.
  2. Do not lay on blocks unless pipe is to receive total concrete encasement.
  3. Accomplish horizontal and vertical curve alignments with bends, bevels, and joint deflections.
    a. Limit joint deflection with ductile-iron pipe to conform to AWWA C600. Deflection may, with approval, exceed standard deflections by using machined bells.
    b. Use short specials preceding curves as required.
  4. Obtain acceptance of method proposed for transfer of line and grade from control to the Work.

B. Install pipe of size, materials, strength class, and joint type with embedment indicated for plan location.

C. For sections of new pipe (i.e. not including replacement of existing pipe), insofar as possible, commence laying at downstream end of line and install pipe with bell ends in direction of flow. Obtain Engineer approval for deviations therefrom.

D. Clean interior of all pipe, fittings, and joints prior to installation. Exclude entrance of foreign matter during installation and at discontinuance of installation.

1. Close open ends of pipe with snug-fitting closures.
2. Do not let water fill trench. Include provisions to prevent flotation should water control measures prove inadequate.
3. Remove water, sand, mud, and other undesirable materials from trench before removal of end cap.

E. Brace or anchor as required to prevent displacement after establishing final position.

F. Perform only when weather and trench conditions are suitable. Do not lay in water.

G. Observe extra precaution when hazardous atmospheres might be encountered.

3.02 Jointing:

A. General Requirements:

1. Locate joint to provide for differential movement at changes in type of pipe embedment, impervious trench checks, and structures.
   a. Not more than 8 inches from structure wall, or
   b. Support pipe from wall to first joint with concrete cradle structurally continuous with base slab or footing.
   c. As indicated.
2. Perform conforming to manufacturer's recommendations.
3. Clean and lubricate all joint and gasket surfaces with lubricant recommended.
4. Use methods and equipment capable of fully seating or making up joints without damage.
5. Check joint opening and deflection for specification limits.

3.03 Special Provisions for Jointing Ductile-Iron Pipe:

1. Conform to AWWA C600.
2. Visually examine while suspended and before lowering into trench.

    a. Paint bell, spigot, or other suspected portions with turpentine and dust with cement to check for cracks invisible to the eye.
    b. Remove turpentine and cement by washing when test is satisfactorily completed.

3.04 Electrical bonding and insulation:

A. Electrically bond adjacent lengths of pipe and fittings unless otherwise indicated.

B. Use materials specified in SECTION 331100 applied to conform to manufacturer's instructions.

C. Install insulated joints of dielectric materials.
  1. Between dissimilar materials which could cause galvanic action.
  2. Conform to manufacturer's instructions.

3.05 Cutting:

A. Cut in neat manner without damage to pipe.

B. Observe Specifications regarding joint locations.

C. Cut ductile-iron pipe with carborundum saw or other acceptable method per manufacturer's instructions.
  1. Smooth cut by power grinding to remove burrs and sharp edges.
  2. Repair lining as required and approved.

3.06 Temporary plugs:

A. Furnish and install temporary plugs at each end of Work for removal by others when completed ahead of adjacent contract.

B. Remove from pipe laid under adjacent contract in order to complete pipe connection when work by other contractor is finished prior to work at connection point under this Contract.

C. Plugs:
  1. Test plugs as manufactured by pipe supplier.
  2. Fabricated by Contractor of substantial construction.
  3. Watertight against heads up to 20 feet of water.
  4. Secured in place in a manner to facilitate removal when required to connect pipe.

3.07 Connections to existing structures:

A. Connect pipe to existing structures and pipelines where indicated.

B. Prepare structure by making an opening with at least 3 inches clearance all around fitting to be inserted.

C. Observe pertinent articles of Specifications pertaining to joint locations and closures.

D. Repair wall opening with concrete.

3.08 Field Testing:

A. Acceptance Tests for Gravity and Low-Pressure Pipelines:

1. Alignment:
    - a. Sewer shall be inspected by flashing a light between manholes or by physical passage where space permits.
    - b. Contractor shall clean pipe of excess mortar, joint sealant, and other dirt and debris prior to inspection.
    - c. Determine from Illumination or Physical Inspection:
        - (1) Presence of any misaligned, displaced, or broken pipe.
        - (2) Presence of visible infiltration or other defects.
    - d. Correct defects as required prior to conducting leakage tests.
2. Leakage Test:
    - a. Contractor shall perform by exfiltration method on all pipe installed.
    - b. Furnish water and all facilities required including:
        - (1) Necessary piping connections.
        - (2) Test pumping equipment.
        - (3) Water meter.
        - (4) Pressure gauge.
        - (5) Bulkheads.
        - (6) All miscellaneous items required.
    - c. Obtain approval of equipment and acceptance of methods proposed for use.
    - d. Conduct initial test on first section of pipe laid by each crew.
        - (1) Include a minimum of 10 lengths of pipe but not to exceed 300 feet.
        - (2) Perform before backfilling.

    (3) Satisfactorily complete test before crew is permitted to continue pipe installation.

e. Test remaining pipe in sections determined by Contractor and approved by Engineer.

f. Perform at test pressures specified as measured: Ductile iron, 4 feet of water above the invert of the sewer at the upstream manhole nor more than 20 feet of water.

g. Maintain test as necessary to locate all leaks but not less than two hours.

h. Repeat as necessary after repairs of leaks and defects until leakage as measured does not exceed 250 gallons per day per inch of nominal pipe diameter per mile for sewers less than 24-inch diameter. For sewers with diameter 24 inches or greater, leakage shall not exceed 6,000 gallons per day per mile of pipe.

i. Repeat as necessary after repair of leaks and defects until leakage as measured does not exceed limits listed in gallons per inch of internal diameter per hour per 100 feet of pipe length:

	(<u>Gallons</u>)
(1) Sanitary and industrial waste sewer..............................	0.15

j. Protect manholes and other structures by means of bulkheads to prevent bursting pressures from being applied inside the structure.

k. Exfiltration testing of all manholes shall be performed by Contractor and shall be tested separately from the pipe.

    (1) Manholes shall be tested by plugging all openings in a watertight manner which will withstand the hydrostatic pressure when manhole is filled with water.

    (2) Testing shall commence 12 hours after manhole has contained the test water.

    (3) Manholes having a depth greater than 25 feet shall be tested for only 25 feet head of water. Manholes 25 feet deep or less shall be tested full of water.

    (4) Exfiltration shall not exceed 1.14 gallons per day per vertical foot of manhole.

l. Dewater pipe and manholes upon completion of testing.

3. Air Testing: Perform air tests per ASTM C828 for clay or F1417 for plastic pipe at Contractor's option in lieu of exfiltration test for pipe sizes up to and including 42 inches in diameter.
    a. Furnish all facilities required including:
        (1) Necessary piping connections.
        (2) Test pumping equipment.
        (3) Pressure gauges or manometers.
        (4) Bulkheads.
        (5) All miscellaneous items required.
    b. Obtain approval of equipment and acceptance of methods proposed for use.
    c. Conduct initial test on first section of pipe laid by each crew.
        (1) Include a minimum of 10 lengths of pipe but not to exceed 300 feet.
        (2) Perform before backfilling.
        (3) Satisfactorily complete test before crew is permitted to continue pipe installation.
    d. Test remaining pipe in sections determined by Contractor and approved by Engineer.
    e. A wetted interior pipe surface on clay pipe is desirable and will produce more consistent test results.
    f. Plug ends of line and cap or plug all connections to withstand internal test pressures.
    g. Introduce low-pressure air until internal air pressure is 4.0 psi greater than the average back pressure of ground water above the pipe invert.
    h. Allow two to five minutes for air pressure to stabilize. Adjust pressure to 3.5 psi and start test.
    i. Time required for pressure to decrease 1.0 psi from 3.5 to 2.5 psig greater than the average back pressure of any ground water above the pipe invert shall not be less than the minimum test time in the following table for the given diameters:

Minimum Test Times (Minutes) in Plastic Pipe

Nominal Pipe Diameter	Minimum Time (min.)*	Length for Min. Time	Time for Longer Length(s)*

100 mm (4 in.)	3:46	597 ft.	0.380 L
150 mm (6 in.)	5:40	398 ft.	0.854 L
200 mm (8 in.)	7:34	298 ft.	1.520 L
250 mm (10 in.)	9:26	239 ft.	2.374 L
300 mm (12 in.)	11:20	199 ft.	3.418 L
375 mm (15 in.)	14:10	159 ft.	5.342 L
450 mm (18 in.)	17:00	133 ft.	7.692 L
525 mm (21 in.)	19:50	114 ft.	10.470 L
600 mm (24 in.)	22:40	99 ft.	13.674 L
675 mm (27 in.)	25:30	88 ft.	17.306 L
750 mm (30 in.)	28:20	80 ft.	21.366 L
825 mm (33 in.)	31:10	72 ft.	25.852 L
900 mm (36 in.)	34:00	66 ft.	30.768 L

* 0.5 psi pressure test drop, required test times shall be exactly one-half the values shown.

j. Repeat test as necessary after all leaks and defects have been repaired.

B. Acceptance Tests for Pressure Pipelines:
  1. Perform hydrostatic pressure and leakage tests.
    a. Conform to AWWA C600 procedures.
      (1) As modified herein.
      (2) Shall apply to all pipe materials specified.
    b. Perform after backfilling.
  2. Test separately in segments between sectionalizing valves, between a sectionalizing valve and a test plug, or between test plugs.
    a. Select test segments such that adjustable seated valves are isolated for individual checking.
    b. Contractor shall furnish and install test plugs.
      (1) Including all anchors, braces, and other devices to withstand hydrostatic pressure on plugs.
      (2) Be responsible for any damage to public or private property caused by failure of plugs.

3. Limit fill rate of line to available venting capacity. Fill rate shall be regulated to limit velocity in lines when flowing full to not more than 0.05 to 1 fps.
4. Owner shall make water for testing available to Contractor at nearest source (at Owner's lowest rate step).
5. Pressure and Leakage Test:
    a. Test pressure shall not be less than 1.25 times the working pressure at the highest point along the test section.
    b. Be at least 2-hour duration. Maintain pressure throughout test ±5 psi of test pressure.
    c. Leakage test shall be conducted concurrently with the pressure test.
    d. Acceptable when leakage does not exceed that determined by the following formula:
        (1) In English units:
        $L = 0.0000075\ SD(P)^{1/2}$, in which
        L = allowable leakage, in gallons per hour
        S = length of pipe tested, in feet
        D = nominal diameter of the pipe, in inches
        P = average actual leakage test pressure in psig
    e. These formulas are based on an allowable leakage of 11.65 gpd/mile/in of nominal diameter at a pressure of 150 psi.
    f. When testing against closed metal-seated valves, an additional leakage per closed valve of 0.0078 gal/hr/in of nominal valve size shall be allowed.
    g. When hydrants are in the test section, the test shall be made against the main valve in the hydrant.
    h. Repeat test as necessary.
        (1) After location of leaks and repair or replacement of defective joints, pipe, fittings, valves or hydrants. All visible leaks are to be repaired regardless of the amount of leakage.
        (2) Until satisfactory performance of test.
    i. Owner will witness pressure and leakage test.

C. Soil Corrosion Testing:
1. Perform electrical conductivity test on bonded pipe segments.
2. Perform pipe-to-soil potential surveys.
3. Submit 3 copies of test and survey reports to Engineer.

3.09 Field Painting

A. Specified in Section 099000.

END OF SECTION

Part 1 General

1.01 Summary

A. This Section covers furnishing all labor, materials, Equipment, tools, and incidentals required for a complete and operable installation for the pumps and installing submersible pumps as indicated and specified. All Equipment shall be installed, tested, and placed in operation in accordance with these Specifications and the manufacturer's recommendations.

B. Submersible pumps shall be furnished complete with pump casings, shafts, bearings, seals, lubrication, piping assemblies, guide rails, lifting chains, discharge base plates, anchor bolts, motors, power cable, controls, and all other parts and accessories indicated, specified, or required for proper installation, operation, and maintenance.

C. Pump controls shall be provided by the Contractor as part of the new control system, in accordance with Specification Division 26 and 40. Pump manufacturer shall provide components necessary for connections to work under Division 26 and 40.

D. Pumps shall be capable of pumping the following fluids:

1. Wastewater and sewage.

E. Related Work Specified Elsewhere:

1. Division 01 for Manufacturer's Field Services.
2. Division 09 for Protective Coatings.
3. Division 40 for Instruments and Control Systems.
4. Division 46 for Motor Requirements.
5. Division 26 for Motors and Drive Systems.
6. Division 33 for Piping and Accessories.

1.02 References

A. Applicable Standards:

1. American National Standards Institute (ANSI):
    a. B16.1 – Cast Iron Pipe Flanges and Flanged Fittings.
2. American Society for Testing and Materials (ASTM):
    a. A36 – Carbon Structural Steel.
    b. A48 - Gray Iron Castings.

    c. A126 – Gray iron Casting for Valves, Flanges, and Pipe Fittings.

3. A283 - Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality.
4. American Iron and Steel Institute (AISI):
5. American Institute of Steel Construction (AISC):
    a. Steel Construction Manual.
    b. Quality Criteria and Inspection Standards.
6. American Bearing Manufacturer's Association (ABMA).
7. Hydraulic Institute Standards (HI) and (HIS).
8. National Electrical Manufacturer's Association (NEMA).
9. Institute of Electrical and Electronics Engineers (IEEE).
10. National Fire Protection Association (NFPA):
    a. 70 - National Electrical Code (NEC).
11. American Welding Society (AWS).
    a. D1.1 – Structural Welding Code.
12. American Water Works Association (AWWA).
    a. C150 – Thickness Design of Ductile Iron Pipe.
    b. C110 – Cast Iron Fittings 2-inch Thru 48-inch For Water and Other Liquids.
    c. C111 – Rubber Gasket Joints for Cast-Iron Pressure Pipe and Fittings.
13. Society for Protective Coatings (SSPC).

1.03 Submittals

A. Submit as specified in Division 01.

B. Submittals shall include, but not be limited to, the following:

1. Equipment Submittals as specified in Division 01.
2. Shop Drawings and engineering data indicating: manufacturer’s name, pump component sizes and dimensions, model number, description of the pump to be furnished, rpm, weights, motor information, minimum submergence, materials, coatings, diagram power, signal, and control wiring, control panel and terminal blocks, rated horsepower, electrical and instrumentation requirements, wiring

diagrams, general arrangement, installation details, parts list and spare parts list for Equipment.

3. Standard performance curves for each pump model furnished. Curves shall cover range from shutoff to 120% of design flow rate at the conditions specified, and shall be submitted for the following parameters as a function of pump capacity and speed at design temperature:
    a. Total developed head.
    b. Capacity
    c. Minimum head.
    d. Rated and shut-off conditions.
    e. VFD turn-down curves.
    f. Required brake horsepower.
    g. Pump efficiency.
    h. Required NPSH.

C. Report of factory tests.

D. Warranty.

E. Operation and maintenance manuals in accordance with Division 01.

1.04 Quality Assurance

A. Factory Tests and Reports - The pump manufacturer shall perform the following inspections and tests on the pump, before shipment from the factory:

1. Perform tests on each pump in accordance with Hydraulic Institute Standards except as otherwise specified.
2. Statically balance pump impellers and dynamically balance all pump/motor units such that Equipment vibration velocity is less than 0.12 inch per second. Perform standard tests on all motors in accordance with IEEE. Vibration testing shall meet HI standards.
3. Perform pump performance tests including HI standard acceptance criteria.
4. Perform a motor and cable test for moisture content and insulation defects.
5. Perform leak testing of all piping and seals.
6. Perform tests of any automatic control systems.

7. Perform tests for faults in auxiliary Equipment.

8. Prior to submergence, the pumps shall be run dry to establish correct rotation and mechanical integrity.

9. The motor and cable shall then be tested a second time for moisture content and insulation defects.

B. Submit results of factory tests in accordance with Division 01. A written certification that these tests have been performed shall be provided with the pump at the time of shipment.

C. After testing, the pump cable end shall be suitably protected for shipment and installation.

D. Obtain pump system from vendors having an established sales and service office within the Chattanooga area, whose representatives actively conduct business in that area. Such office must include staffing by a service technician authorized to service any component furnished by the vendor, without voiding warranties or guarantees.

E. UL Compliance: Comply with UL 778 for motor-operated wastewater pumps.

F. Manufacturer Experience: Furnish pump Equipment produced by firms regularly engaged in the manufacture of pump Equipment suitable for the specific application, and which have a minimum of five years’ experience in the production of Equipment of the same size and type proposed for this project.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

H. Vendors furnishing pumps for the Project are required to satisfy themselves as to the suitability of their Equipment to function properly and dependably as an element in the specific system of which they are a part. The act of furnishing the Equipment is interpreted to mean that the vendor recommends the Equipment for the specific installation and application, and guarantees its proper functioning as a system element.

   1. Manufacturer shall provide Contractor with any additional recommendations on baffling modifications and installation of vortex breakers or hydrocones as required to improve pump performance.

I. Upon completion of pump installations on the Project, Contractor shall engage services of manufacturer’s representative to train personnel on operation and maintenance of pumps, to inspect and test the installed pump components, and to conduct a simulated service condition.

1.05 Factory Assembly

A. Pump/motor units shall be completely shop assembled and aligned prior to shipping.

B. After completion of the specified factory tests, pumps shall be prepared for shipment with the minimum amount of disassembly, and such that no field disassembly, cleaning, or flushing is required.

C. Any components removed for shipping shall be match-marked prior to removal and shipment.

D. Submit paint type and manufacturer's specification with Submittals. Provide coating system per Section 09 90 00.

1.06 Delivery, Storage, and Handling:

A. Shall be as specified in Division 01.

1.07 Warranty

A. Warranty Period for pumps and components shall be manufacturer’s standard, but not less than one year from the date of Equipment start-up or as specified in Section 01 43 33.

Part 2 Products

2.01 Acceptable Pump Manufacturers:

A. ABS.

B. Flygt (A Xylem Brand).

C. KSB.

D. Engineer approved equal.

2.02 General Requirements

A. Furnish and install two (2) submersible pumps (EBPS-P-101, EBPS-P-102) and accessories to operate in parallel to each other in the new Emergency Backup Pump Station (EBPS) as indicated in the Drawings. Both pumps operating together in parallel shall deliver 45 MGD (32,250 gpm) at 21 ft TDH.

B. Provide totally sealed submersible electrically operated pumps capable of pumping raw unscreened sewage and wastewater.

C. Provide pumps capable of operating continuously for extended periods of time without damage.

D. Pump controls shall be integrated into a single system per requirements of the Electrical and Piping and Instrumentation Drawings and Division 26, 40, and 46 of the Specifications.

E. Pumps shall operate at or near maximum efficiency at operating conditions.

F. Pump head capacity curves shall be continuously falling from shutoff head, unless noted otherwise.

G. Pump discharge connection elbows and discharge piping shall be installed such that pumps will automatically connect and seal to discharge connection elbow when lowered into place.

H. Pumps shall be easily removable for inspection or service.

I. Provide guide rail systems and pump rail guide brackets to raise or lower pump units by chain.

J. Guide entire weight of each pump unit with a minimum of two guide bars per unit.

K. Seal interface of the pumps and discharge elbows by metal to metal contact or diaphragm-type sealing flange with necessary gaskets to prevent leakage. Motor shall be variable speed.

L. Pump(s) shall be able to pump 3 inch diameter solids, without allowance for deforming, cutting, or chopping solid materials to pass size requirement.

2.03 Design Requirements:

A. Each pump shall be designed for the following conditions:

1. Design Capacity: 15,625 gpm (22.5 MGD).
2. Turn Down Capacity with VFD: as specified by manufacturer.
3. Design Heads:
    a. Minimum: 13.5 ft static.
    b. Rated (at Design Capacity with one pump running): 17 ft.
    c. Rated (at Design Capacity with two pumps running): 21 ft.
    d. Shutoff (minimum): 45 ft.
4. Maximum Motor Speed: 720 rpm.
5. Minimum Efficiency: 75% at design point (reducing with VFD turndown).
6. Maximum Motor Horsepower: 175 hp.
7. Pump Settings: Pump(s) ON, OFF, HIGH ALARM, and LOW ALARM levels as indicated in the Drawings.
8. Maximum Required NPSH at Design Point: 22.3 feet.
9. Pump Discharge: 24-inch diameter.

10. Maximum Pump Assembly Weight (Including All Components to Be Lifted): 10,000 lbs

11. Maximum Pump Height (Including All Components to be Lifted): 108 inches.

12. Electric Service: 480V, 3 Phase, 60 Hz.

13. Brake horsepower of motors furnished shall not be exceeded at any point on the head capacity performance curves.

14. Pumps shall be designed to generally operate as described in Division 40 Specifications, Piping and Instrumentation Drawings.

2.04 Materials and Construction

A. Construct motor housing, pump casing, and major pump components of cast iron conforming to ASTM A48, Class 30 or higher cast iron, and of sufficient thickness to ensure long life and accurate alignment.

B. Casings shall be watertight and machined to fit interfaces with nitril or Buna-N O-rings for watertight seals.

C. Provide bolts, nuts, fasteners, and washers of type 316 stainless steel.

D. Impeller:

1. Nonclog design, single suction impellers made of close-grained cast iron, conforming to ASTM A48, Class 30B or higher cast iron.

2. Secured to shaft with key and self-locking device to prevent slipping in either direction, not screwed or pinned to the motor pump shaft.

3. Balanced statically and dynamically to eliminate vibration and minimize hydraulic end thrust.

4. Castings shall not have been repaired by plugging, welding, or other means.

5. Removable without the use of special tools.

E. Volutes:

1. Shall be single-piece heavy cast-iron construction, conforming with ASTM A48, Class 30B or higher cast iron.

2. Shall be free from openings or projections that might cause clogging or interference with flow through the pump.

3. All mating surfaces requiring watertight seals shall be machined and fitted with Viton or Nitrile O-rings.

4. Flanged and drilled for ANSI B16.1, 125 lb connections.

F. Shaft:

1. Ample diameter to assure first critical speed will occur at not less than 150% of rated pump speed.

2. Common pump and motor shaft shall be solid stainless steel, accurately machined and of sufficient size to transmit full driver output. Shaft shall be one-piece construction from top of motor to the impeller.

3. Shaft shall be constructed with adequate strength and stiffness for the intended service.

4. Shall be of sufficient size to handle vibratory forces that occur when impeller passes solids.

G. Wear Rings (if applicable):

1. Provided a design with wear rings, the impeller shall be provided with a duplex stainless steel wear ring which is drive fitted to suction eye of the impeller.

2. The casing shall be provided with a stainless steel wear ring which is drive fitted to the bottom suction inlet.

H. Bearings:

1. Minimum ABMA L10 bearing life of 50,000 hours and 5 years.

2. Bearing shall be designed for combined thrust and radial loading.

3. Provide permanently lubricated ball, cylindrical, or tapered type roller bearings.

4. Use single row upper bearing and single row, double row, or deep groove ball lower bearings.

I. Shaft Seal:

1. Dual mechanical, rotating shaft seals in oil bath reservoir shall seal pumped liquid from motor compartment. Provide constantly oil lubricated upper and lower seal units.

2. Seal faces shall be made of tungsten carbide, carbon, ceramic, or silicon-carbide.

3. Furnish accessible casing tap and plug (with positive anti-leak seal) at oil chamber for draining and inspecting oil.

4. Select highly polished stationary and rotating seals in each unit of compatible face materials for long seal life in raw sewage, sludge, and grit slurry.

5. Equip each seal with its own independent stainless steel spring retainer system or a common stainless steel spring system between the upper and lower seals.

2.05 Accessories

A. Pump Discharge Connection:

1. Connected to discharge piping and anchored to sump floor with stainless-steel anchor bolts.

2. Designed to receive pump discharge connection without bolts.

3. Integral with guide rail.

4. Each base shall have an integrally cast, upturned 90 degree elbow outlet end.

5. Size base and discharge elbow so that no portion of the pump bears directly on the floor and supplemental concrete pad is not required.

6. Cast or ductile iron.

7. Flanges shall conform to ANSI B16.1. Flange shall be connected to the discharge piping and anchored to the floor of the Wet Well.

8. Discharge base elbow shall be ASTM A48, Class 30B or higher cast iron.

9. Base assembly and components shall be designed to support the assembled weight of each pump, motor, and shafting; and to safely withstand all stresses of static and dynamic loads imposed.

B. Rail Guides:

1. Fasten stainless-steel guide supports to pump so that no lifting loads are applied to pump or motor housing.

C. Lifting Chain:

1. Provide one stainless steel chain for each pump.

2. Design to raise and lower pump with additional safety factor for overcoming force of pump hang ups.

3. Provide hook for chain when not in use.

D. Guide Rails:

1. Stainless-steel pipe.

2. All 316 stainless steel, including rails, brackets, and anchor bolts. All materials associated with Guide Rail system shall be non-sparking.

3. Size as recommended by pump manufacturer.

4. Shall not support any portion of the pump weight.

5. Provide a minimum of two guide rails per pump.

6. Provide guide rail system and pump rail guide bracket to raise and lower pump unit by chain, without requiring entry into the wetwell.

7. Provide with all required hardware to firmly attach pump to rail assembly and rail assembly to concrete sump.

8. Manufacturer shall confirm that the size and material of guide rail is sufficient to support removal and installation of the pumps without requiring additional support or reinforcement. Otherwise, Contractor shall provide any necessary additional supports to prevent guide rail deflection.

E. Cable Holder:

1. Provide grip holders for pump and control cables.

2. Cables shall be easily adjusted to pumping level without splices.

3. Provide minimum of 75 feet of continuous power and control cables from motor. Contractor shall coordinate cable length with manufacturer.

F. Pump Identification: Metal nameplates shall be provided on each pump and in the appropriate place on the control panel with identifying information including:

1. Manufacturer.

2. Type of unit and model number.

3. Serial number.

4. Rated capacity, discharge head, horsepower, voltage, and other pertinent information.

5. The nameplate horsepower rating of each motor at 1 service factor shall equal or exceed the horsepower required to drive the pump at 120% of the design conditions specified and within normal operating ranges. For each motor furnished, the nameplate horsepower rating multiplied by the service factor shall equal or exceed the horsepower required to drive the pump under any condition in which the pump is capable of operating.

2.06 Electrical Equipment

A. Conform to NEC, NEMA, IEEE and DIVISION 26 on all electrical Equipment and controls.

B. Pump junction box, variable frequency drive, and pump controls are specified in DIVISION 26.

C. Motors shall be equipped with thermal sensors attached to or imbedded in the motor windings and connected to pump controls via the pump monitoring unit.

D. Moisture detector probe with sensor electrodes and conductors shall be installed in oil seal chamber between the mechanical seals, and connected to pump controls via the pump monitoring unit. Sensors shall provide sufficient early warning of outer seal failure to fully protect electrical components.

E. Furnish pump monitoring unit as indicated on pump control diagrams for installation at each pump junction box. Contractor shall coordinate space requirements.

F. Refer to Section 46 05 13 for motor requirements.

Part 3 Execution

3.01 Installation, Start-Up, and Testing:

A. All Work shall conform to manufacturer's recommendations and the requirements of Division 01.

B. Install pumps, components, and accessories in accordance with written instructions furnished by manufacturer.

C. After checking such items as lubrication, alignment, rotation, etc., and having determined that each unit is ready for service, report such fact to the Engineer together with any condition that might be adverse to proper functioning of any unit.

3.02 Manufacturer's Field Service:

A. Provide installation, start-up, and testing services for all Equipment as specified in DIVISION 01. Provide services of manufacturer approved technical representative for period required to prepare Equipment for proper operation. A minimum of one day (eight hours) for installation, startup, and testing services shall be provided by the manufacturer.

B. A minimum of one day (eight hours) shall be provided by manufacturer for training operators on proper operation and maintenance of the pumps.

3.03 Installation

A. Make all electrical and control connections.

B. Provide all necessary lubrication for initial start-up, testing and as required for final acceptance.

C. Place all fill concrete and install concrete pump bases and baffle walls in Wet Well prior to installation of pumps. Do not place pedestal grout for pump pedestal bases until pumps are completely aligned, level, and balanced.

D. Provide a complete unit with all materials, components and adjustments as required for successful operation.

E. Installation, start-up and testing of all Equipment and associated construction shall conform to manufacturer's recommendations.

F. Install pipe and pipe appurtenance supports to minimize stresses being placed on pump nozzles.

G. Protect Equipment against damage from freezing.

H. Protect Equipment and components from damage and accelerated wear or deterioration during project construction and until project Substantial Completion.

I. Align and install pumps, components, access hatches, guide rails, and bridge crane hoist to allow for ease of maintenance, including removal of motors, pumps, valves, and other accessories.

J. Adjust pumps to function smoothly, without excessive noise, vibration, amperage draw, or motor heating.

K. Control Panel:

1. Install pump controls, control panel, variable frequency drives, and other electrical and instrumentation control Equipment within the Equipment Room as noted in the Electrical Drawings and Division 26, 40, and 46.

2. Provide all required supports and mounting hardware to provide a rigid mounting.

L. Electrical Wiring:

1. Install and wire all devices and Equipment as specified in Division 26 and as noted in the Electrical Drawings.

3.04 Spare Parts

A. Furnish all manufacturer standard spare parts, keys, and tools, and deliver to site designated by City representatives. Ship spare parts in a single container, labeled “Spare Parts”.

B. At minimum, spare parts shall include:

1. Two complete shaft mechanical seal assemblies with complete installations instructions.

2. One spare volute gasket.

3. One spare float switch.

4. O-Ring sets.

3.05 Performance Tests

A. As specified in DIVISION 01.

B. Conduct in the presence of General Contractor, Owner, and/or Engineer.

C. Equipment Tests:

  1. Check performance of all components as a functioning unit.

  2. Check alignment of each unit.

D. Operational Tests:

  1. Conduct such operational tests as necessary to determine that the performance of Equipment and controls is as specified.

  2. Tests will generally consist of placing Equipment in operation under varying conditions and observing performance.

E. Make all necessary Equipment adjustments and corrective work indicated by tests.

F. Submit a written test report to Owner with copies to Engineer in a letter form stating operations performed and results obtained for each unit.

G. Contractor shall demonstrate the correct response for all monitors and devices installed by this Contract.

H. Demonstrate pump functions generally as specified, and is free of excessive vibration, noise, amperage draw and winding, and insulation resistances at the time of start-up.

I. Establish that all related safety devices, including but not limited to safety valves, switches, moving machinery guards, etc. are in place and working properly before leaving any Equipment in operation.

J. In the event any Equipment unit, system or component fails to meet specified requirements or proves to be unreliable in service, make all necessary changes required to correct such deficiencies. Should the Equipment unit remain unable to reliably meet specified requirements, remove the unit and replace it with Equipment that will reliably meet specified requirements.

3.06 End of Warranty Inspection

A. Inspection:

  1. Perform on Equipment unit by manufacturer's representative.

  2. Perform within 60 days prior to date of warranty expiration.

  3. Ascertain or appraise the following:

    a. Status of Equipment and installation after normal usage.

    b. Adherence to manufacturer's recommended maintenance and operation of Equipment.

4. Include the following:

    a. Alignment checks.

B. Make adjustments necessary to restore Equipment within original tolerances.

C. Submit a written letter report to Owner with copies to Engineer covering the inspection items and including recommendations where applicable.

3.07 Painting:

A. Prepare surface of damaged and uncoated areas and touch up as required for complete protection. Provide protective coatings per Section 09 90 00.

END OF SECTION

PART 1 - General

1.01 Summary

A. This Section covers furnishing all labor, materials, Equipment, tools, and incidentals required for a complete and operable installation for the submersible sump pump and installing the sump pump as indicated and specified. All Equipment shall be installed, tested, and placed in accordance with these Specifications and the manufacturer’s recommendations.

B. The sump pump shall be furnished complete with pump casing, bearings, seals, lubrication, piping assemblies, guide rails, anchor bolts, motor, controls, power cable, and all other parts and accessories indicated, specified, or required for proper installation, operation, and maintenance.

C. Pump controls shall be provided by the Contractor as part of the new control system, in accordance with Specification Division 26 and 40. Pump manufacturer shall provide components necessary for connections to work under Division 26 and 40.

D. The pump shall be capable of pumping the following fluids:

1. Wastewater and sewage.

E. Related Work Specified Elsewhere:

1. Division 01 for Manufacturer’s Field Services
2. Division 09 for Protective Coatings
3. Division 26 for Motors and Drive Systems.
4. Division 33 for Piping and Accessories.
5. Division 40 for Instruments and Control Systems.
6. Division 46 for Motor Requirements.

1.02 References

A. Applicable Standards:

1. American National Standards Institute (ANSI):

    a. B16.1 – Cast Iron Pipe Flanges and Flanged Fittings.

2. American Society for Testing and Materials (ASTM):

   a. A36 – Carbon Structural Steel.
   b. A48 - Gray Iron Castings.
   c. A126 – Gray iron Casting for Valves, Flanges, and Pipe Fittings.

3. A283 - Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality.
4. American Iron and Steel Institute (AISI):
5. American Institute of Steel Construction (AISC):
   a. Steel Construction Manual.
   b. Quality Criteria and Inspection Standards.
6. American Bearing Manufacturer's Association (ABMA).
7. Hydraulic Institute Standards (HI) and (HIS).
8. National Electrical Manufacturer's Association (NEMA).
9. Institute of Electrical and Electronics Engineers (IEEE).
10. National Fire Protection Association (NFPA):
    a. 70 - National Electrical Code (NEC).
11. American Welding Society (AWS).
    a. D1.1 – Structural Welding Code.
12. American Water Works Association (AWWA).
    a. C150 – Thickness Design of Ductile Iron Pipe.
    b. C110 – Cast Iron Fittings 2-inch Thru 48-inch For Water and Other Liquids.
    c. C111 – Rubber Gasket Joints for Cast-Iron Pressure Pipe and Fittings.
13. Society for Protective Coatings (SSPC).

1.03 Submittals

A. Submit as specified in Division 01.

B. Submittals shall include, but not be limited to, the following:

   1. Equipment Submittals as specified in Division 01.

2. Shop Drawings and engineering data indicating: manufacturer's name, pump component sizes and dimensions, model number, description of the pump to be furnished, rpm, weights, motor information, minimum submergence, materials, coatings, diagram power, signal, and control wiring, control panel and terminal blocks, rated horsepower, electrical and instrumentation requirements, general arrangement and installation details for Equipment.

3. Standard performance curves for each pump model furnished. Curves shall cover range from shutoff to 120% of design flow rate at the conditions specified, and shall be submitted for the following parameters as a function of pump capacity and speed at design temperature:

   a. Capacity
   b. Rated and shut-off conditions.
   c. Pump efficiency.
   d. NPSH required.
   e. Minimum submergence.

C. Report of factory tests.

D. Operation and maintenance manuals in accordance with Division 01.

1.04 Quality assurance

A. Factory Tests and Reports - The pump manufacturer shall perform the following inspections and tests on the pump, before shipment from the factory:

1. Perform tests on pump in accordance with Hydraulic Institute Standards except as otherwise specified.

2. Statically balance pump impellers and dynamically balance all pump/motor units such that Equipment vibration velocity is less than 0.12 inch per second. Perform standard tests on all motors in accordance with IEEE.

3. Perform pump performance tests including HI standard acceptance criteria.

4. Perform a motor and cable test for moisture content and insulation defects.

5. Perform leak testing of all piping and seals.

6. Perform tests for faults in auxiliary Equipment.

7. Prior to submergence, the pumps shall be run dry to establish correct rotation and mechanical integrity.

8. The motor and cable shall then be tested a second time for moisture content and insulation defects.

B. Submit results of factory tests in accordance with Division 01. A written certification that these tests have been performed shall be provided with the pump at the time of shipment.

C. After testing, the pump cable end shall be suitably protected for shipment and installation.

D. Obtain pump system from vendors having an established sales and service office within the Chattanooga area, whose representatives actively conduct business in that area. Such office must include staffing by a service technician authorized to service any component furnished by the vendor, without voiding warranties or guarantees.

E. UL Compliance: Comply with UL 778 for motor-operated wastewater pumps.

F. Manufacturer Experience: Furnish pump Equipment produced by firms regularly engaged in the manufacture of pump Equipment suitable for the specific application, and which have a minimum of five years' experience in the production of Equipment of the same size and type proposed for this project.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

H. Vendors furnishing pumps for the Project are required to satisfy themselves as to the suitability of their Equipment to function properly and dependably as an element in the specific system of which they are a part. The act of furnishing the Equipment is interpreted to mean that the vendor recommends the Equipment for the specific installation and application, and guarantees its proper functioning as a system element.

    1. Manufacturer shall provide Contractor with any additional recommendations on baffling modifications and installation of vortex breakers or hydrocones as required to improve pump performance.

I. Upon completion of pump installation on the Project, Contractor shall engage services of manufacturer's representative to train personnel on operation and maintenance of pumps, to inspect and test the installed pump components, and to conduct a simulated service condition.

1.05 Factory assembly

A. Pump/motor units shall be completely shop assembled and aligned prior to shipping.

B. After completion of the specified factory tests, pumps shall be prepared for shipment with the minimum amount of disassembly, and such that no field disassembly, cleaning, or flushing is required.

C. Any components removed for shipping shall be match-marked prior to removal and shipment.

D. Prepare surfaces and provide paint system standard of the manufacturer and suitable for service intended. Submit paint type and manufacturer's specification with Submittals. Provide coating system per Section 09 90 00.

1.06 Delivery, storage, and handling

A. Shall be specified in Division 01.

PART 2 - Products

2.01 Acceptable Manufacturers:

A. Ebara.

B. Engineer approved equal.

2.02 General Requirements

A. Furnish and install one sump pump and accessories to operate when the two submersible pumps in the new Emergency Backup Pump Station (EBPS) have stopped running. The sump pump will pump the stand by water from the new wet well to the new diversion chamber as indicated in the Drawings. Under operation, the sump pump shall deliver 200 gpm at 31 ft TDH.

B. Provide a totally sealed submersible electrically operated pump capable of pumping raw unscreened sewage and wastewater.

C. Provide a pump capable of operating continuously for extended periods of time without damage.

D. Pump controls shall be integrated into a single system per requirements of the Electrical and P&ID Drawings and Division 26, 40, and 46 Specifications.

E. Pump shall operate at or near maximum efficiency at operating conditions.

F. Pump head-capacity curve shall be continuously falling from shutoff head.

G. Pump discharge connection elbow and discharge piping shall be installed such that pump will automatically connect and seal to discharge connection elbow when lowered into place.

H. Pump shall be easily removable for inspection or service.

I. Provide guide rail system and pump rail guide bracket to raise or lower pump unit by chain.

J. Seal interface of the pumps and discharge elbows by metal to metal contact or diaphragm-type sealing flange with necessary gaskets to prevent leakage. Motor shall be constant speed.

K. Pump(s) shall be able to pump 1 inch diameter solids, without allowance for deforming, cutting, or chopping solid materials to pass size requirement.

2.03 Design Requirements

A. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.

B. Pump Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, vertical discharge for piping connection , and discharge fittings for connection to guide-rail support.

C. Pump shall be designed for the following:

1. Design Capacity: 200 gpm
2. Design Heads:
    a. Rated (at Design Capacity): 31 feet
    b. Shutoff (minimum): 65 feet
3. Maximum Motor Speed: 1740 rpm
4. Minimum Efficiency: 40 percent
5. Maximum Motor Horsepower: 7.5 hp
6. Voltage/Hz: 460V/60
7. Pump Settings: OFF level as indicated in Drawings.
8. Pump Discharge: 4-inch diameter

2.04 Materials and Construction

A. Construct motor housing, pump casing, and major pump components of cast iron conforming to ASTM A48, Class 30 or higher cast iron, and of sufficient thickness to ensure long life and accurate alignment.

B. Casings shall be watertight and machined to fit interfaces with nitril or Buna-N O-rings for watertight seals.

C. Provide bolts, nuts, fasteners, and washers of 304 Stainless steel.

D. Impeller:

1. Nonclog design, multi-vane semi-open design made of close-grained cast iron, conforming to ASTM A48, Class 30B or higher cast iron for solids handling.
2. Secured to shaft with key and self-locking device to prevent slipping in either direction, not screwed or pinned to the motor pump shaft.

3. Balanced statically and dynamically to eliminate vibration and minimize hydraulic end thrust.

4. Castings shall not have been repaired by plugging, welding, or other means.

5. Removable without the use of special tools.

E. Shaft:

1. Ample diameter to assure first critical speed will occur at not less than 150% of rated pump speed.

2. Common pump and motor shaft shall be solid stainless steel, accurately machined and of sufficient size to transmit full driver output. Shaft shall be one-piece construction from top of motor to the impeller.

3. Shaft shall be constructed with adequate strength and stiffness for the intended service.

4. Shall be of sufficient size to handle vibratory forces that occur when impeller passes solids.

F. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.

G. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.

H. Bearings:

1. Minimum ABMA L10 bearing life of 50,000 hours and 5 years.

2. Bearing shall be designed for combined thrust and radial loading.

3. Provide permanently lubricated ball, cylindrical, or tapered type roller bearings.

I. Shaft Seal:

1. Two mechanical seals in oil bath reservoir shall seal pumped liquid from motor compartment.

2. Moisture detector shall be installed in oil seal chamber and connected to pump controls.

3. Seal faces shall be made of tungsten carbide, carbon, ceramic, or silicon carbide.

4. Select highly polished stationary and rotating seals in each unit of compatible face materials for long seal life in raw sewage, sludge, and grit slurry.

5. Equip each seal with its own independent stainless steel spring retainer system or a common stainless steel spring system between the upper and lower seals.

2.05 Accessories

A. Pump Discharge Connection:

1. Connected to discharge piping and anchored to sump floor with stainless-steel anchor bolts.
2. Designed to receive pump discharge connection without bolts.
3. Integral with guide rail.
4. Cast or ductile iron.
5. Flanges shall conform to ANSI B16.1.

B. Rail Guides:

1. Fasten stainless-steel guide supports to pump so that no lifting loads are applied to pump or motor housing.

C. Lifting Chain:

1. Provide stainless-steel lifting chain of adequate length for removing and installing the pump.
2. Chain shall have a round link with a 2 ¼” inside diameter every two ft.
3. Design to raise and lower pump with additional safety factor for overcoming force of pump hang-ups.
4. Provide hook for chain when not in use.

D. Guide Rails:

1. Standard: SWPA’s "Submersible Sewage Pumping Systems (SWPA) Handbook."
2. Guide Rails: Vertical pipes or structural members, made of 316 stainless steel, attached to baseplate and basin sidewall or access hatch; standard weight or heavier.
3. Non-sparking.
4. Size as recommended by pump manufacturer.
5. Shall not support any portion of the pump weight.
6. Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.

7. Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.

8. Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.

9. Lifting Cable: Stainless steel; attached to pump and access hatch.

10. Provide a minimum of two guide rails.

11. Provide guide rail system and pump rail guide bracket to raise and lower pump unit by chain, without requiring entry into the wetwell.

12. Provide with all required hardware to firmly attach pump to rail assembly and rail assembly to concrete sump.

13. Manufacturer shall confirm that the size and material of guide rail is sufficient to support removal and installation of the pumps without requiring additional support or reinforcement. Otherwise, Contractor shall provide any necessary additional supports to prevent guide rail deflection.

E. Cable Holder:

1. Provide grip holders for pump and control cables.

2. Cables shall be easily adjusted to pumping level without splices.

3. Provide continuous cables from control panel to pumps and level controls.

F. Pump Identification: Each pump shall be identified with metal nameplates including:

1. Manufacturer.

2. Type of unit and model number.

3. Serial number.

4. Rated capacity, discharge head, horsepower, voltage, and other pertinent information.

5. The nameplate horsepower rating of each motor at 1 service factor shall equal or exceed the horsepower required to drive the pump at 120% of the design conditions specified and within normal operating ranges. For each motor furnished, the nameplate horsepower rating multiplied by the service factor shall equal or exceed the horsepower required to drive the pump under any condition in which the pump is capable of operating.

2.06 Electrical Equipment

A. Conform to NEC, NEMA, IEEE and DIVISIONS 26 and 40 on all electrical Equipment and controls.

B. Provide watertight electric float switches, complete with accessories, in accordance with DIVISION 40.

C. Provide electrical control panel, motor starters, and pump controls in accordance with DIVISIONS 40.

D. Control panels shall be equipped with externally operable disconnect switch that is lockable in the open position.

E. Motors shall be equipped with thermal sensors attached to or imbedded in the motor windings and connected to pump controls.

2.07 Controls

A. Enclosure: NEMA 250, Type 4X.

B. Switch Type: Pedestal-mounted float switch with float rods and rod buttons or as specified in DIVISION 40.

C. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches.

D. Sump pump control panel shall provide pushbutton or selector switch operator for manually starting and stopping the sump pump from the face of the control panel. The sump pump shall stop automatically on low wetwell level as actuated by the integral low level float switch control.

PART 3 - Execution

3.01 Installation, start-up, and testing

A. All Work shall conform to manufacturer's recommendations and the requirements of Division 01.

B. Install pumps, components, and accessories in accordance with written instructions furnished by manufacturer.

C. After checking such items as lubrication, alignment, rotation, etc., and having determined that each unit is ready for service, report such fact to the Engineer together with any condition that might be adverse to proper functioning of any unit.

3.02 Manufacturer's field service

A. Provide installation, start-up, and testing services for all Equipment as specified in DIVISION 01. Provide services of manufacturer approved technical representative for period required to prepare Equipment for proper operation.

3.03 Installation

A. Make all electrical and control connections.

B. Provide all necessary lubrication for initial start-up, testing and as required for final acceptance.

C. Provide a complete unit with all materials, components and adjustments as required for successful operation.

D. Installation, start-up and testing of all equipment and associated construction shall conform to manufacturer's recommendations.

E. Do not place grout for pump pedestal base(s) until pump(s) is (are) completely aligned.

F. Install pipe and pipe appurtenance supports to minimize stresses being placed on pump nozzles.

3.04 Performance tests

A. As specified in Division 01.

B. Conduct in the presence of General Contractor, Owner, and/or Engineer.

C. Equipment Tests:

1. Check performance of all components as a functioning unit.

2. Check alignment of each unit.

D. Operational Tests:

1. Conduct such operational tests as necessary to determine that the performance of Equipment and controls is as specified.

2. Tests will generally consist of placing Equipment in operation under varying conditions and observing performance.

E. Make all necessary Equipment adjustments and corrective work indicated by tests.

F. Submit a written test report to Owner (with one copy to Engineer) in a letter form stating operations performed and results obtained for each unit.

3.05 End of warranty inspection

A. Inspection:

1. Perform on Equipment unit by manufacturer's representative.

2. Perform within 60 days prior to date of warranty expiration.

3. Ascertain or appraise the following:
    a. Status of Equipment and installation after normal usage.
    b. Adherence to manufacturer's recommended maintenance and operation of Equipment.
4. Include the following:
    a. Alignment checks.

B. Make adjustments necessary to restore Equipment within original tolerances.

C. Submit a written letter report to Owner (with copy to Engineer) covering the inspection items and including recommendations where applicable.

3.06 Painting

A. Prepare surface of damaged and uncoated areas and touch up as required for complete protection. Provide protective coatings per Section 09 90 00.

END OF SECTION

Part 1 General

1.01 Summary

A. This Section covers furnishing all labor, materials, Equipment, tools, and incidentals required for a complete and operable installation for the grinders and installing grinders as indicated and specified. All Equipment shall be installed, tested, and placed in operation in accordance with these Specifications and the manufacturer's recommendations.

B. Grinders shall be furnished complete with grinder housing assemblies, drive and shaft assemblies, bearings, seals, lubrication, guide rails, lifting chains, channel frames, anchor bolts, motors, power cable, and controls, and all other parts and accessories indicated, specified, or required for proper installation, operation, and maintenance.

C. An individual control panel shall be supplied with each grinder in accordance with Division 26 and 40. The control panels shall be provided with components necessary to interface with the EBPS PLC control panel, as indicated and specified under Division 26 and 40.

D. Grinders shall be capable of processing the following fluids:

1. Wastewater and sewage.

E. Related Work Specified Elsewhere:

1. Division 01 for Manufacturer's Field Services.
2. Division 09 for Protective Coatings.
3. Division 40 for Instruments and Control Systems.
4. Division 46 for Motor Requirements.
5. Division 26 for Motors and Drive Systems.
6. Division 33 for Piping and Accessories.

1.02 References

A. Applicable Standards:

1. American National Standards Institute (ANSI):

B11.9 – Safety Requirements for Grinding Machines.

B16.1 – Cast Iron Pipe Flanges and Flanged Fittings.

2. American Society for Testing and Materials (ASTM):

A36 – Carbon Structural Steel.

A48 - Gray Iron Castings.

A126 – Gray iron Casting for Valves, Flanges, and Pipe Fittings.

A536-84 – Standard Specification for Ductile Iron.

3. A283 - Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality.

4. American Iron and Steel Institute (AISI):

AISI 4140 – Heat Treated Hexagon Steel.

5. American Institute of Steel Construction (AISC):

Steel Construction Manual.

Quality Criteria and Inspection Standards.

6. American Bearing Manufacturer's Association (ABMA).
7. Hydraulic Institute Standards (HI) and (HIS).
8. National Electrical Manufacturer's Association (NEMA).
9. Institute of Electrical and Electronics Engineers (IEEE).
10. National Fire Protection Association (NFPA):

70 - National Electrical Code (NEC).

11. American Welding Society (AWS).

D1.1 – Structural Welding Code.

12. American Water Works Association (AWWA).

C150 – Thickness Design of Ductile Iron Pipe.

13. Society for Protective Coatings (SSPC).

1.03 Submittals

A. Submit as specified in Division 01.

B. Submittals shall include, but not be limited to, the following:

   1. Equipment Submittals as specified in Division 01.
   2. Shop Drawings and engineering data indicating: manufacturer’s name, grinder component sizes and dimensions, model number, description of the grinder to be furnished, rpm, weights, motor information, materials, coatings, connection and schematic diagrams for power, signal, and control wiring, control panel and terminal blocks, field wiring terminations, rated horsepower, electrical and instrumentation requirements, general arrangement and installation details for Equipment.

C. Report of factory tests.

D. Operation and maintenance manuals in accordance with Division 01.

1.04 Quality Assurance

A. Factory Tests and Reports - The grinder manufacturer shall perform the following inspections and tests on the grinder before shipment from the factory:

   1. Perform grinder performance tests.
   2. Perform a motor and cable test for moisture content and insulation defects.
   3. Perform leak testing of all piping and seals.
   4. Perform tests of any automatic control systems.

5. Perform tests for faults in auxiliary Equipment.
6. Prior to submergence, the grinders shall be run dry to establish correct rotation and mechanical integrity.
7. The motor and cable shall then be tested a second time for moisture content and insulation defects.

B. Submit results of factory tests in accordance with Division 01. A written certification that these tests have been performed shall be provided with the grinder at the time of shipment.

C. After testing, the grinder cable end shall be suitably protected for shipment and installation.

D. Obtain grinder system from vendors having an established sales and service office within the Chattanooga area, whose representatives actively conduct business in that area. Such office must include staffing by a service technician authorized to service any component furnished by the vendor, without voiding warranties or guarantees.

E. Manufacturer Experience: Furnish grinder Equipment produced by firms regularly engaged in the manufacture of grinder Equipment suitable for the specific application, and which have a minimum of five years' experience in the production of Equipment of the same size and type proposed for this project.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

G. Vendors furnishing grinders for the Project are required to satisfy themselves as to the suitability of their Equipment to function properly and dependably as an element in the specific system of which they are a part. The act of furnishing the Equipment is interpreted to mean that the vendor recommends the Equipment for the specific installation and application, and guarantees its proper functioning as a system element.

1. Manufacturer shall provide Contractor with any additional recommendations on baffling modifications and installation of screens or flow diversion devices as required to improve grinder performance.

H. Upon completion of grinder installations on the Project, Contractor shall engage services of manufacturer's representative to train personnel on operation and maintenance of the Equipment, to inspect and test the installed grinder components, and to conduct a simulated service condition.

1.05 Factory Assembly

A. Grinder/motor units shall be completely shop assembled and aligned prior to shipping.

B. After completion of the specified factory tests, grinders shall be prepared for shipment with the minimum amount of disassembly, and such that no field disassembly, cleaning, or flushing is required.

C. Any components removed for shipping shall be match-marked prior to removal and shipment.

D. Prepare surfaces and provide paint system standard of the manufacturer and suitable for service intended. Submit paint type and manufacturer's specification with Submittals. Provide coating system per Section 09 90 00.

1.06 Delivery, Storage, and Handling:

A. Shall be as specified in Division 01.

1.07 Warranty

A. Warranty Period for grinders and components shall be manufacturer’s standard, but not less than one year from the date of Equipment start-up or as specified in Section 01 43 33.

Part 2 Products

2.01 Acceptable Grinder Manufacturers:

A. JWC Environmental.

B. Engineer approved equal.

2.02 General Requirements

A. Furnish and install three (3) grinders (EBPS-GR-101, EBPS-GR-102, and EBPS-GR-103) and accessories to operate in parallel to each other in the new EBPS as indicated in the Drawings. Each grinder shall be hydraulically capable of passing at least 22.5 MGD (15,625 gpm) of sewage.

B. Provide totally sealed, electrically operated grinders capable of grinding solids to less than 1/2 inch in diameter.

C. Provide totally sealed guide frames for mounting grinders in wet well.

D. Provide grinders capable of operating continuously for extended periods of time without damage.

E. Furnish and install an individual controller for each grinder designed to control the motors of each grinder and screen drum assembly. The controller shall have an Operator Interface Terminal, indicator lights, switches and other control devices.

1. Controller enclosure shall:

Be 304 stainless steel NEMA 4X.

House the OIT, control devices, motor starters, and PLC.

2. Operator interface terminal shall:

Display equipment status, alarm and fail conditions.

Provide operational information on reversals, jams, overloads and over temps.

3. Grinder ON-OFF-REMOTE three-position 22mm type, NEMA 4X selector switch:

In the OFF position, the grinder shall not run.

In the ON position, the grinder shall run continuously.

In the REMOTE position, the grinder shall start and stop as controlled by an external device.

4. Screen Drum ON-OFF-AUTO three-position 22mm type, NEMA 4X selector switch.

In the OFF position, the screen drum shall not run.

In the ON position, the screen drum shall run continuously.

In the AUTO position, the screen drum shall start and stop as controlled by grinder operation.

5. Reset pushbutton shall:

Be momentary type 22 mm, rated NEMA 4X.

Be the only method of resetting the controller after failure.

6. Pilot lights shall:

Be LED type 22 mm, rated NEMA 4X.

Indicate GRINDER RUN, SCREEN DRUM RUN, and FAIL.

7. Programmable Logic Controller (PLC) shall be VersaMax Control by GE Automation.

PLC shall provide discrete input/output points for interface with EBPS PLC control panel.

Each grinder unit shall provide dry contact output for “Run Status”, “Alarm”, and grinder selector switch “IN REMOTE”.

Each grinder shall accept Start/Stop relay output command from the EBPS PLC for control of grinder operation when in REMOTE.

8. Motor starters:

Starters shall be a full-voltage reversing type with 120 volt operating coils.

Overload relays shall be adjustable and sized to full load amperes (FLA) of the motor.

9. Main Circuit Breaker Disconnect and Motor Branch Circuit Protection Circuit Breakers

Circuit breakers shall be molded case type 3-pole, 480 volt.

Circuit breakers shall be sized to applicable NEC and UL standards.

10. Control transformer:

Shall be a minimum 250VA.

Primary and secondary shall be fused over for current protection.

11. Current transducers shall:

Be manufactured by Veris Industries.

Have adjustable set point from 1-135A with a 200ms or less response time.

12. Control relays shall be rated for 10A (resistive load), DPDT, 120V with indicator light.

F. Performance

1. When a grinder jam condition occurs, the controller shall stop the grinder and reverse the grinder rotation to clear the obstruction. If the jam is cleared, the

controller shall return the grinder to normal operation. If three (3) reverses occur within a 30 second interval, the controller shall stop the grinder motor and activate the grinder FAIL indicator and relay.

2. When a Screen Drum jam condition occurs, the controller shall stop the screen drum and reverse the screen drum rotation to clear the obstruction. If the jam is cleared, the controller shall return the screen drum to normal operation. If two (2) reverses occur within a 30 second interval, the controller shall stop the screen drum motor and activate the FAIL indicator and relay. The grinder and other screen drum shall continue to operate.
3. When a power failure occurs while the grinder and screen drum is operating, the grinder and screen drums will resume operation once power is restored.
4. When a power failure occurs while the grinder or screen drum(s) is in a fail condition, once power is restored the fail indicator shall reactivate and remain until reset. Reset of the grinder and drums shall be accomplished from the controller only.

G. Grinder controls shall be integrated with the EBPS control system per requirements of the Electrical and P&ID Drawings and Division 26 and 40 Specifications.

H. Grinder frames and bases shall be installed such that grinders slide down guiderails until coming into contact with base and automatically connecting and sealing to the frames when lowered into place.

I. Grinders shall be easily removable for inspection or service.

J. Provide guide rail systems and grinder rail guide brackets to raise or lower units by chain.

K. Guide entire weight of each grinder unit with a minimum of two guide bars per unit.

L. Seal interface of the grinders and grinder frames by metal to metal contact.

M. Grinders shall be able to grind solids to 1/2-inch or smaller sized particles, .

2.03 Grinder Design Requirements:

A. Each grinder shall be designed for the following conditions:

1. Design capacity: 15,625 gpm (22.5 MGD).
2. Grinder shall be capable of passing specified flowrate without the use of diverter screens.
3. Grinder shall install into a straight-through rectangular channel with frame dimensions: 42” wide by 84” tall.
4. Chamber configuration is open-channel.
5. Cutting action shall take place over entire height of the cutter section of the grinder.
6. Cutting device shall be self-cleaning via mechanical motion of cutter.
7. Grinder shall be designed for continuous 24 hour a day service and shall use an efficient low speed, high torque gear reducer.
8. Grinder shall be designed for long intervals (i.e. multiple months) of no service.

9. Grinder shall be easily removed for periodic servicing without need to enter the sewage stream.
10. Flow diverters, provided by manufacturer, shall direct flow into the grinder.
11. Rotating shaft(s) shall be supported on roller bearings protected by mechanical seals and permanently lubricated with oil.
12. Motor shall be immersible and explosion proof.
13. Gear reducer shall be fully sealed and capable of operating submerged continuously.
14. Grinders shall be designed to generally operate as described in Division 40 Specifications, P&ID Drawings.

2.04 Materials and Construction

A. Construct grinder housing and major grinder components of cast ductile iron conforming to ASTM A536, Class 30 or higher cast iron, and of sufficient thickness to ensure long life and accurate alignment.

B. Provide bolts, nuts, fasteners, and washers of AISI Series 300 or 18-8 stainless steel.

C. Cutters:

   1. Constructed of hardened steel resistant to corrosion and abrasive contaminants.
   2. Precision ground for uniformity.
   3. Shall be easily removable and replaceable without the use of special tools.
   4. Balanced statically and dynamically to eliminate vibration and minimize hydraulic end thrust.
   5. Cutters shall not have been repaired by plugging, welding, or other means.

D. Shaft:

   1. Grinder drive and driven shafts shall be made of heat treated steel.
   2. Shafts shall be at least 2.5 inches in diameter.

E. Bearings and Seals:

   1. Seal cartridges shall be rated to a maximum of 90 PSI.
   2. Face materials shall be tungsten carbide vs. tungsten carbide and not require an external flush.
   3. Radial and axial loads shall be borne by sealed, oversized, deep-grooved ball bearings.
   4. Components subject to wear shall be designed into replaceable elements and not be a part of the main housing.
   5. O-rings shall be made of Buna-N elastomers.

F. Reducer:

   1. Reducers shall be internal planetary mechanism with trochoidal curved tooth profile.
   2. Reducers shall be grease lubricated.

3. The reducer’s reduction ratio shall be optimized to reduce energy consumption of the grinder’s motor.

G. Motor:

1. The unit shall incorporate an immersible, explosion-proof motor coupled to a reducer comprising a sealed assembly suited for continuous or intermittent submerged service.
2. The motor shall have a horsepower rating as recommended by manufacturer and shall operate with 460 Volts, 3-Phase at 60 Hz. Manufacturer shall provide a minimum of 75 feet of continuous power and control cables from motor. Contractor shall coordinate cable length with manufacturer.
3. A coupling adapter shall be used having registers for accurate alignment and smooth operation. The coupling adapter shall be sealed to prevent water contamination. The adapter shall be firmly connected to the input of the reducer and shall rigidly support the motor weight.
4. The reducer shall have a rigid input shaft supported by heavy bearings capable of handling thrust and radial loads and shock conditions. It shall be sealed for submerged operation.
5. Motor shall not utilize fan cooling at any time during operation.

H. Coil Steel Drums

1. Coil steel drums shall be constructed of helical wound ½-inch diameter AISI 304 stainless steel with ½-inch spacing between coils.
2. Coil screen drums shall have vertical supports, center ring supports, end flanges, and stub shafts to properly support the coils.
3. Coil screen drums shall have no shaft in center of drum.

2.05 Accessories

A. Grinder Connection:

1. Frame shall fit into the downstream side of the concrete wall openings as in Drawings. Frame shall be anchored to sole plate with stainless-steel anchor bolts.
2. Designed to receive grinder connection without bolts.
3. Integral with guide rail.
4. Size base and frame so that no portion of the grinder bears directly on the base and supplemental concrete pad is not required.
5. Base and frame shall be cast or ductile iron.
6. Base assembly and components shall be designed to support the assembled weight of each grinder, motor, and shafting; and to safely withstand all stresses of static and dynamic loads imposed.

B. Rail Guides:

1. Fasten stainless-steel guide supports to grinder so that no lifting loads are applied to grinder or motor housing.

C. Lifting Chain:

  1. Provide one stainless steel chain for each grinder.
  2. Design to raise and lower grinder with additional safety factor for overcoming force of grinder hang ups.
  3. Provide hook for chain when not in use.

D. Guide Rails:

  1. Stainless-steel pipe.
  2. All 316 stainless steel, including rails, brackets, and anchor bolts.
  3. Size as recommended by grinder manufacturer.
  4. Shall not support any portion of the grinder weight.
  5. Provide a minimum of two guide rails per grinder.
  6. Provide guide rail system and grinder rail guide bracket to raise and lower grinder unit by chain, without requiring entry into the wet well.
  7. Provide with all required hardware to firmly attach grinder to rail assembly and rail assembly to concrete sump.
  8. Manufacturer shall confirm that the size and material of guide rail is sufficient to support removal and installation of the grinders without requiring additional support or reinforcement. Otherwise, Contractor shall provide any necessary additional supports to prevent guide rail deflection.

E. Cable Holder:

  1. Provide grip holders for grinder and control cables.
  2. Cables shall be easily adjusted to grinder level without splices.
  3. Provide minimum of 75 feet of continuous power and control cables from motor. Contractor shall coordinate cable length with manufacturer.

F. Grease line:

  1. Provide grease line from each grinder to hatch at grade with grease zirks mounted to hatch frame inside hatch and facing upward for greasing without removing grinder.
  2. Line should be flexible so as to not rupture as grinder is pulled from vault.
  3. Provide fastening assembly to guide lines from grade to grinder which does not interfere with removal of grinder from vault.
  4. Contractor shall coordinate grease line length with manufacturer.

G. Grinder Identification: Each grinder shall be identified with metal nameplates including:

  1. Manufacturer.
  2. Type of unit and model number.
  3. Serial number.
  4. Rated capacity, horsepower, voltage, and other pertinent information.

5. The nameplate horsepower rating of each motor at 1 service factor shall equal or exceed the horsepower required to drive the grinder at 120% of the design conditions specified and within normal operating ranges. For each motor furnished, the nameplate horsepower rating multiplied by the service factor shall equal or exceed the horsepower required to drive the grinder under any condition in which the grinder is capable of operating.

2.06 Electrical Equipment

A. Conform to NEC, NEMA, IEEE and DIVISION 26 on all electrical Equipment and controls.

B. Grinder junction box and controls are specified in DIVISION 26.

C. Refer to Section 46 05 13 for motor requirements.

Part 3 Execution

3.01 Installation, Start-Up, and Testing:

A. All Work shall conform to manufacturer's recommendations and the requirements of Division 01.

B. Install grinders, components, and accessories in accordance with written instructions furnished by manufacturer.

C. After checking such items as lubrication, alignment, rotation, etc., and having determined that each unit is ready for service, report such fact to the Engineer together with any condition that might be adverse to proper functioning of any unit.

3.02 Manufacturer's Field Service:

A. Provide installation, start-up, and testing services for all Equipment as specified in DIVISION 01. Provide services of manufacturer approved technical representative for period required to prepare Equipment for proper operation. A minimum of one day (eight hours) for installation, startup, and testing services shall be provided by the manufacturer.

B. A minimum of one day (eight hours) shall be provided by manufacturer for training operators on proper operation and maintenance of the pumps.

3.03 Installation

A. Make all electrical and control connections.

B. Provide all necessary lubrication for initial start-up, testing and as required for final acceptance.

C. Place all fill concrete and install concrete grinder bases and grinder frames in Wet Well prior to installation of grinders.

D. Provide a complete unit with all materials, components and adjustments as required for successful operation.

E. Installation, start-up and testing of all Equipment and associated construction shall conform to manufacturer's recommendations.

F. Protect Equipment against damage from freezing.

G. Protect Equipment and components from damage and accelerated wear or deterioration during project construction and until project Substantial Completion.

H. Align and install grinders, components, access hatches, guide rails, and bridge crane hoist to allow for ease of maintenance, including removal of motors, grinders, valves, and other accessories.

I. Adjust grinders to function smoothly, without excessive noise, vibration, amperage draw, or motor heating.

J. Control Panel:

  1. Install grinder controls, control panel, and other electrical and instrumentation control Equipment within the Equipment Room as noted in the Electrical Drawings and Division 26, 40, and 46.

  2. Provide all required supports and mounting hardware to provide a rigid mounting.

K. Electrical Wiring:

  1. Install and wire all devices and Equipment as specified in Division 26 and as noted in the Electrical Drawings.

3.04 Spare Parts

A. Furnish all manufacturer standard spare parts, keys, and tools, and deliver to site designated by City representatives. Ship spare parts in a single container, labeled “Spare Parts”.

B. At minimum, spare parts shall include:

  1. Two complete shaft mechanical seal assemblies with complete installations instructions.

  2. O-Ring sets.

3.05 Performance Tests

A. As specified in DIVISION 01.

B. Conduct in the presence of General Contractor, Owner, and/or Engineer.

C. Equipment Tests:

  1. Check performance of all components as a functioning unit.

  2. Check alignment of each unit.

D. Operational Tests:

  1. Conduct such operational tests as necessary to determine that the performance of Equipment and controls is as specified.

  2. Tests will generally consist of placing Equipment in operation under varying conditions and observing performance.

E. Make all necessary Equipment adjustments and corrective work indicated by tests.

F. Submit a written test report to Owner with copies to Engineer in a letter form stating operations performed and results obtained for each unit.

G. Contractor shall demonstrate the correct response for all monitors and devices installed by this Contract.

H. Demonstrate grinder functions generally as specified, and is free of excessive vibration, noise, amperage draw and winding, and insulation resistances at the time of start-up.

I. Establish that all related safety devices, including but not limited to safety valves, switches, moving machinery guards, etc. are in place and working properly before leaving any Equipment in operation.

J. In the event any Equipment unit, system or component fails to meet specified requirements or proves to be unreliable in service, make all necessary changes required to correct such deficiencies. Should the Equipment unit remain unable to reliably meet specified requirements, remove the unit and replace it with Equipment that will reliably meet specified requirements.

3.06 End of Warranty Inspection

A. Inspection:

1. Perform on Equipment unit by manufacturer's representative.
2. Perform within 60 days prior to date of warranty expiration.
3. Ascertain or appraise the following:

Status of Equipment and installation after normal usage.

Adherence to manufacturer's recommended maintenance and operation of Equipment.

4. Include the following:

Alignment checks.

B. Make adjustments necessary to restore Equipment within original tolerances.

C. Submit a written letter report to Owner with copies to Engineer covering the inspection items and including recommendations where applicable.

3.07 Painting:

A. Prepare surface of damaged and uncoated areas and touch up as required for complete protection. Provide protective coatings per Section 09 90 00.

END OF SECTION

PART 1 - General

1.01 Summary

A. This Section includes slide gates, electric motor operators, manual operators, and accessories.

B. Furnish the number and type of gates and operators as specified and indicated.

1.02 Reference standards

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

B. Applicable Standards:

1. ASME International (ASME):
    a. ASME B1.1 - Unified Inch Screw Threads (UN and UNR Thread Form).
    b. ASME B1.5 - Acme Screw Threads.
2. American Water Works Association (AWWA):
    a. AWWA C542 - Electric Motor Actuators for Valves and Slide Gates - First Edition.
    b. AWWA C560 - Cast-Iron Slide Gates.
    c. AWWA C561 - Fabricated Stainless Steel Slide Gates.
    d. AWWA C563 - Fabricated Nonmetal Slide Gates.
3. ASTM International (ASTM):
    a. ASTM A36/A36M – Standard Specification for Carbon Structural Steel.
    b. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
    c. ASTM A193/A193M - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
    d. ASTM A276/A276M REV A - Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes.
    e. ASTM B21/B21M - Standard Specification for Naval Brass Rod, Bar, and Shapes.

- f. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

- g. ASTM B308/B308M - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.

- h. ASTM B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

- i. ASTM D635-81 – Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.

- j. ASTM D648-82 – Test Method for Deflection Temperature of Plastics Under Flexural Load

- k. ASTM D2000 – Standard Classification System for Rubber Products in Automotive Applications.

- l. ASTM F594 - Standard Specification for Stainless Steel Nuts.

4. Society for Protective Coatings (SSPC):

    - a. SSPC SP5 - White Metal Blast Cleaning.

5. National Aeronautics and Space Administration (NASA)

    - a. NASA CR1457 – Manual for Structural Stability Analysis of Sandwiched Plates and Shells.

1.03 Submittals

A. Submit as specified in Division 01.

B. Include, but not limited to, the following:

1. Catalog data and certified shop and erection drawings showing principal parts and materials.

2. Spare parts list.

3. Assembly and disassembly or repair instructions.

4. Detailed layout dimensions.

5. Design data illustrating operating thrust and stem design with applicable safety factors for components.

6. Protective coating system.

7. Leakage testing procedures.

8. Actuator testing procedures.

9. Schematic and wiring drawings.

10. Instruction books and installation, operation, and maintenance manuals.

1.04 Quality assurance

A. Manufacturers shall be experienced in the design and manufacture of Equipment and accessories for a minimum period of 5 years.

B. Manufacturer shall have proof of design test records in accordance with AWWA on file available for submittal.

C. Manufacturer shall be experienced and in regular production of gates and water control equipment.

D. The gate shall be fully shop assembled, adjusted, inspected, and tested for operation and leakage before shipment.

E. All welds to be performed by an AWS-certified welding technician.

1.05 Warranty

A. Special Assembly Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of assemblies that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Structural failures including, but not limited to, excessive deflection.

    b. Deterioration of metals and other materials beyond normal wear and weathering.

    c. Excessive leakage when gate is closed.

2. Leakage shall be no more than that allowed by AWWA C561 or AWWA C563 Standard, as appropriate, during the Warranty Period.

3. Gate shall be free of sticking or binding as judged by Engineer (move freely via operator provided) with no exercising required. Gate operators are to be warranted by the operator manufacturer.

4. Warranty Period: Ten years from date of Substantial Completion.

1.06 Delivery, storage, and handling

A. Shipment Preparation: Prepare Equipment and Materials for shipment in a manner to facilitate unloading and handling, and to protect against damage or unnecessary exposure in transit and storage. Include:

1. Crates or other suitable packaging materials.

2. Covers and other means to prevent corrosion, moisture damage, mechanical injury, and accumulation of dirt in motors, electrical equipment, and machinery.

3. Suitable rust-preventive compound on exposed machined surfaces and unpainted iron and steel.

4. Grease packing or oil lubrication in all bearings and similar items.

5. Deliver, store, and handle gate and components in accordance with manufacturer requirements.

B. Marking:

1. Tag or mark each item of Equipment or Material as identified in the delivery schedule or on Submittals and include complete packing lists and bills of material with each shipment. Each piece of every item need not be marked separately provided that all pieces of each item are packed or bundled together and the packages or bundles are properly tagged and marked.

2. Mark partial deliveries of component parts of Equipment to identify the Equipment, to permit easy accumulation of parts, and to facilitate assembly.

PART 2 - Products

2.01 Manufacturers

A. Fabricated Slide Gates:

1. Rodney Hunt.

2. Ashbrook Simon-Hartley.

3. Waterman Industries, Inc.

4. Hydro Gate Corporation.

5. Whipps, Inc.

6. Golden Harvest, Inc.

7. Plasti-Fab, Inc.

8. Engineer-approved equal.

B. Motorized Actuators

1. Beck.

2. Rotork.

3. Limitorque.

4. EIM.

2.02 Fabricated composite and fabricated stainless steel slide gates

A. Design:

1. Size, seating and unseating heads, pedestal elevations, gate centerline elevations, and operator types shall be in accordance with Table 1:

    a. Suitable for operation after periods of inactivity of a year or more.

    b. Stem guides on 10-foot centers maximum.

    c. Design shall be suitable for installation as indicated.

    d. All flush bottom type gates indicated in Table 1 shall be designed so that the neoprene bottom seal may be replaced without removing any concrete.

    e. Suitable for operation in a corrosive atmosphere of domestic sewage.

TABLE 1 – SLIDE GATES

Tag No.	Service[(1)]	Opening Size (WxH)	Slide C.L. El. (ft msl)	Max Seating Head[(2)] (ft)	Max Unseating Head[(2)] (ft)	Operating Floor Elevation (ft msl)	Frame Type [(4)]	Operator Type [(5)]	Operator Mounting [(6)]	Closing Direction	Flush Bottom?	Rising Stem?
EBPS-SG-001	SO/WS	42”x84”	637.50	4.5	4.5	626.6	NSC	E	FS	Up	No	Yes
EBPS-SG-002	SO/WS	42”x84”	637.50	4.5	4.5	626.6	NSC	E	FS	Up	No	Yes
EBPS-SG-003	SO/WS	42”x84”	637.50	4.5	4.5	626.6	NSC	E	FS	Up	No	Yes
EBPS-SG-004	SO	72”x72”	629.60	12.4	12.4	626.6	NSC	E	FS	Down	Yes	Yes

Notes:

(1) SO = shut off, WS = weir service

(2) Measured from centerline elevation.

(3) Gate manufacturer responsible for providing wall thimbles. See drawings for wall thickness. Wall thimble abbreviations:
    F = Flanged with water collar and plain end.
    E = Flanged with water collar and flanged end.
    FMJ = Flange and mechanical joint.
    ABM = Anchor Bolt Mounted, no thimble.

(4) Frame type abbreviations:
    FB- = Flat back.
    FL- = Flange.
    NSC = Non-self contained.
    FMSC = Face mounted, self contained.
    -R = Rectangular.
    -C = Circular.

(5) Operator type abbreviations:
    CO = crank operated.
    HW = Handwheel.
    E = Electric.

(6) Operator mounting abbreviations:
    FS = floor stand.
    BGFS = Bevel geared floor stand.
    YM = Yoke mounted.
    BGBS = Bevel geared, bench stand.
    -WB = Wall bracket required.

B. Materials:

1. If slide, reinforcing, and frame are all of Fabricated Stainless Steel Type (not Composite):
    a. Stainless steel, ASTM A276/A276M REV A, Type 316.
2. If slide is of Fabricated Composite Type:
    a. Slide shall be Fiberglass Reinforced Polyester (FRP) totally encapsulating an internal reinforcing structure.
    b. Reinforcing, and frame shall be Stainless Steel, ASTM A276/A276M REV A, Type 316.
    c. Total minimum slide thickness should not be less than 2”.
    d. The slide outer surface skins shall be a homogeneous plastic material having extremely high tensile and impact strength, be nontoxic and shall be stabilized against ultraviolet light.
    e. The plastic material shall be an Aramid fiber from the KEVLAR family of fibers. No substitute of fiber type shall be acceptable.
    f. Structural characteristics for a 1/8-inch glass mat laminate shall meet the following minimum physical properties.
        (1) Tensile strength 15,400 psi.
        (2) Flexural Modulus 1,497,000 psi.
        (3) Flexural Strength 28,000 psi.
        (4) Compressive Strength 30,200 psi.
        (5) Impact Strength 9.65 ft-lbs/inch.
        (6) Water absorption 0.09% (in 24 hours).
3. Stem: Stainless Steel, ASTM A276/A276M REV A, Type 316, rising type.
4. Seals: Neoprene, ASTM D2000, Grade 1BE625.
    a. “P-Bulb” or “J-Bulb” type seals attached to the Disc or mounted to the frame, or any seals requiring periodic maintenance and adjustments to maintain specified leakage rates shall not be acceptable.
    b. Any seal with a manufacturer’s recommended replacement period of less than 20 years shall not be accepted.
5. Fasteners and anchor bolts: Stainless steel, Type 316.

6. Actuator lift nut: Bronze, ASTM B584.

7. Seats: Ultra-high molecular weight polyethylene (UHMWPE), ASTM D4020.

8. Stop collar: Naval Bronze, ASTM B21/B21M.

C. Construction:

1. Integral slide, seat, and frame unit.

2. Guide extrusions shall act as guides for the slide and shall have high-density polymer seats securely fastened to the guides in contact with both edges of the slide or disc.

3. Deflection of slide under full load head shall be limited to 1/360 of the span. Reinforce slide with structural shapes, if required.

4. Provide stem and connector:

    a. Provide a connector welded to the slide assembly to receive the stem.

    b. Bolt stem to connector.

    c. Design connector pocket to take the full thrust developed during gate operation.

5. All welds on the slide shall be continuously welded and no stitch welding shall be accepted.

6. Provide solid-neoprene seals anchored to bottom sill:

    a. Self-adjusting UHMWPE.

    b. Slide shall make uniform contact with seal when it is closed without damaging seal surface.

7. Allowable leakage rate under design seating head and unseating head shall not exceed limits allowed by AWWA C561 or AWWA C563, as appropriate. Additional seals shall be provided as required to meet leakage requirement.

8. Frames and guides shall be installed in a true vertical plane and shall be installed with 90 degree corners.

9. Size stem to be of adequate diameter to safely withstand twice the force created by the gate actuator; minimum diameter of 1 3/4 inches.

    a. Provide Acme or rolled threads on stem.

    b. Supported by stainless steel guides spaced to provide a L/r ratio of less than 200, with UHMW or bronze bushings.

    c. Provide single stem.

   d. Provide clear butyrate plastic stem cover with Mylar tape to indicate slide "open" and "closed" positions. Attach securely to operator with noncorrosive materials.

D. Slide Operators (Actuators):

1. Provide operator type and mounting as indicated in Table 1. Actuator shall be sized to provide gate closure at the specified pressures and at temperatures from 0°F to 110°F and up to 100% relative humidity.

2. For floor stand mounted operators, pedestal height shall be approximately 3 feet from bottom of pedestal to centerline of driver.

3. Weatherproof construction.

4. Provide ac electric motor operators in accordance with AWWA C542 for stop-close-open service for all designated motorized gates to operate on 480Vac, 3-phase, 60 Hz, with position indicators.

5. Provide integral full-voltage reversing magnetic starters with separate nonfused disconnects. Disconnects shall be operable from outside the enclosure, and shall be pedestal or rack mounted. Include control power transformer sized for all control features specified.

6. Electric motor operator shall open and close gate at a minimum speed of 12 inches per minute.

7. Furnish auxiliary handwheel for manual operation of electric motor operators to open counterclockwise for each operator. Design for maximum required effort of 40 pounds.

   a. Handwheel shall engage when the motor is declutched by a lever or similar means.

   b. Drive shall be restored to electrical operation automatically by starting the motor.

   c. Handwheel or selection bar shall not move on restoration of motor drive.

8. Furnish limit switches for electric motor operators mounted in the assembly containing the motor and gearing as follows:

   a. Torque responsive limit switch:

      (1) To be operative during the entire opening and closing travel of the gate and shall stop the gate travel upon over torque condition.

      (2) Of adjustable type not requiring auxiliary relays or devices.

   b. Intermittent gear type limit switch:

      (1) Governed by rotation of the driving mechanism.

        (2) Adjustable in both the opening and closing directions.

        (3) Provided to stop gate travel in both directions, and operate local indicating lights.

        (4) Provide contacts wired to customer terminal blocks for remote indication of open and closed position.

9. Furnish enclosure, mounted on the pedestal for electric motor operators, with the following:
    - a. Push buttons marked "open," "stop," and "close" on all operators.
    - b. Strip heaters to prevent condensation.
    - c. Switches for local and remote green and red indicating lights.
    - d. Unless otherwise specified or indicated, provide operators with the following NEMA enclosure:
        - (1) Weatherproof/hosedown - NEMA 4X.
10. Totally enclosed gearing with lubrication fittings. Electrical and mechanical disconnection should be possible without draining the lubricant from the actuator gearcase.
11. Provide pedestal shop prime coated and painted in accordance with AWWA C560.
12. Mechanical seals or grease lubrication system.
13. Self-locking at any position of the stem travel.

E. Slide Painting:

1. Exposed and enclosed machined or bearing surfaces shall be shop coated with manufacturer's standard water-resistant grease or rust-preventive compound before shipment.
2. Coat any aluminum surfaces in contact with concrete with a heavy coat of bituminous paint.
3. Wheel operator shall be primed and painted in accordance with AWWA C561 or AWWA C563 as appropriate.
4. See Specification 09 90 00 for additional coating requirements.

PART 3 - Execution

3.01 Installation

A. Comply with provisions of AWWA C542, AWWA C561, and AWWA C563, and as specified.

B. Provide manufacturer's field services as specified in Division 01.

C. Perform equipment tests during and after start-up to determine if equipment is performing as specified.

D. Furnish temporary source of electrical power of the type and capacity required to test operation of electric motor-operated slide gates.

E. Furnish and dispose of water required for leakage tests in a manner approved by Engineer.

F. Lubricate all bearings and gears before placing gates in operation.

G. Leakage Test: Perform field leakage test and submit certified test results per Division 01. Leakage test shall be performed after operating of the gate through no less than one complete cycle from fully-closed to fully-open and back to fully-closed. Leakage shall not exceed a leakage rate of 0.05 gpm per foot of seal perimeter.

1. Furnish bulkheads as required.
2. Minimum seating and unseating head shall be as specified.
3. Minimum test duration shall be two hours.

H. Perform electric actuator performance test as according to AWWA C542.

3.02 Manufacturers field services

A. The services of a manufacturer’s qualified technical representative shall be required at the Project Site for start-up, testing, and training of the system.

B. The manufacturer’s field personnel shall demonstrate experience with installation, start-up, and operating of systems of comparable size, application, and complexity.

C. Manufacturer shall provide instruction to the Contractor’s personnel about the proper installation technique of all equipment and materials.

END OF SECTION

Part 1 General

1.01 Related Documents:

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

1.02 Summary:

A. This Division includes instruments, control devices, control panels, computer hardware and system programming as specified in Sections 40 60 00 – 40 70 00.

B. Related Work Specified Elsewhere:

1. Interconnections and control of equipment: All applicable Divisions.

1.03 Related Requirements:

A. Division 26: All applicable Sections.

1.04 Reference Standards:

A. National Fire Protection Association (NFPA):

1. NFPA 70 – National Electrical Code (NEC).

B. Other standards as specified in applicable Sections.

1.05 Submittals:

A. Submit as specified in Division 01.

B. Manufacturer with prime responsibility shall assume responsibility for all Compliance Submittals.

C. As specified in each applicable Section, this Division.

1.06 Quality Assurance:

A. General:

1. The Contractor shall provide the services of a single System Integrator (SI), to provide the material, equipment, labor, and services specified in Sections 40 60 00 – 40 70 00. The SI shall be subcontracted and under the direct supervision of the Contractor.

B. System Integrator Qualifications:

1. The instrumentation, control and communications system shall be furnished by a System Integrator (SI) who shall assume responsibility for the satisfactory performance of the entire plant control system. Only those SI who can demonstrate that they possess the prerequisite capabilities and experience shall be considered. The System Integrator subcontractor must meet the following minimum criteria:

    a. The SI Company shall have been in business for a minimum of five (5) years performing SI work on water and wastewater treatment projects, and have control systems technicians with 5 years minimum experience with installation, testing, calibrating and startup of industrial control and automation systems.

    b. The SI Company shall be local to the Chattanooga, TN area and capable of responding to a control system issue during construction within a 2-hour timeframe, and capable of offering a 2-hour response for future maintenance and support agreements.

    c. The SI Company shall have specific training and experience with the following:

        i. GE Programmable Automation Controllers, Operator Interface Terminals (OIT), and associated programming software.

        ii. Ethernet network setup and configuration including managed switch configuration.

        iii. Motorola SCADA RTU hardware and associated programming software.

        iv. Instrumentation setup and calibration.

    d. The SI shall be capable of providing control panels produced in a UL 508 authorized manufacturing facility and listed accordingly.

1.07 Sequencing and Scheduling:

A. Coordinate the installation of Equipment and Materials specified in this Division with construction schedule.

Part 2 Products

2.01 General:

A. Products as specified in Sections 40 60 00 – 40 70 00.

Part 3 Execution

3.01 Examination:

A. Verify site conditions are suitable for installation of equipment and systems specified in this Division.

3.02 Installation:

A. System Integrator shall be responsible for all cabling terminations at instruments, control panels and devices supplied by the System Integrator.

B. Refer to Section 26 05 19 for additional cable termination requirements.

3.03 Field Quality Control:

A. Manufacturer’s field services:

  1. As specified in each applicable Section, this Division.

B. Field Testing:

  1. General Requirements:

    a. Conform to requirements as specified in Division 01.

    b. Conduct all tests in the presence of Engineer under the supervision of Equipment manufacturer's field engineer.

    c. Notify Engineer two weeks prior to the commencement of all tests.

    d. Include all tests recommended by the Equipment manufacturer unless specifically waived by Engineer.

    e. Include all additional tests recommended by Engineer that he deems necessary because of field conditions, to determine that Equipment and Materials and systems meet requirements of Contract Documents.

    f. Be responsible for all damage to Equipment and Materials due to improper test procedures or test apparatus handling.

  2. Test Reports:

    a. Submit test reports as specified in Division 01.

    b. Maintain a written record of all tests showing date, personnel making tests, equipment or material tested, tests performed, and results.

3.04 Training:

A. The System Integrator shall provide formal training for operators, maintenance and service personnel.

B. A training schedule and log shall be developed. The training schedule shall identify scheduled dates and times for all training sessions specified in this Division. The training log shall identify dates for training and record training session attendees.

C. Training sessions shall be scheduled with the Owner a minimum of two weeks prior to occurrence and a training schedule shall be maintained and communicated to the Owner on a routine basis.

D. Owner may make digital video recordings of all on-Site training for training purposes. Any charges for this video recording shall be included.

E. Provide training as specified in each applicable Section, this Division.

END OF SECTION

Part 1 General

1.01 Related Documents

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

1.02 Summary

A. This Section includes control descriptions and requirements for PLC and existing SCADA System programming. Requirements for specific upgrades are also specified in this section.

B. The System Integrator shall be responsible for all PLC and SCADA programming.

C. Upgrades at the Citico Pump Station and Citico Emergency Backup Pump Station (EBPS) include, but are not limited to, the following:

1. Provide new PLC for the Citico EBPS Emergency Pumps, Grinders, and other instrumentation and controls as specified.
2. Provide and install a new Ethernet network connection to the existing Citico Pump Station PLC as indicated on the Contract Drawings.
3. Integrate existing instrumentation into the new PLC and provide and install new instrumentation as indicated.
4. Integrate new PLC and associated I/O points into the SCADA network where indicated or specified.

D. For additional requirements refer to the Contract Drawings and associated specification sections.

E. Reference drawings for the existing control panels and equipment interfaces are not included in the bid package, but are available upon Contractor request.

F. The Systems Integrator shall be required to visit the project site to assess the existing conditions prior to submitting a bid.

G. Related Work Specified Elsewhere:

1. All applicable Divisions.

1.03 Related Requirements

A. SECTION 406700 – Process Control Panels and Hardware.

B. SECTION 407000 – Instrumentation for Process Systems.

1.04 Submittals

A. Submit as specified in DIVISION 01.

B. Manufacturer with prime responsibility shall assume responsibility for all Compliance Submittals.

C. Product Data: Submit for each type of product specified and included the following as minimum:

1. A complete listing of all proposed HMI screens and the corresponding points and parameters that will be displayed.

2. Proposed standard HMI and PLC objects for the project (i.e. pump control, gate control, etc.). Inputs and outputs that will be developed for each object shall be identified.

3. Submit a minimum of two (colored copies) sample screens developed for similar projects.

4. Complete list of IP Addresses for all network devices.

D. Special Procedure Submittals:

1. Power Failure and Restoration:

   a. Provide a complete description of the power failure and restoration mode programming.

2. Test Plan:

   a. Provide a complete and detailed testing plan for the control system.

3. Syllabus for Owner training.

E. Closeout Submittals: Final documentation shall include the following as minimum:

1. Operation and Maintenance Manuals including the following:

   a. Provide O&M manuals in electronic and hardcopy format including as a minimum the above information and the following:

2. Soft copies of complete PLC program including all program comments.

3. Soft copies of all final HMI screens and applications.

F. Maintenance Material Submittals:

1. Software:

   a. Assemble and submit all software and program copies.

2. Organize and submit in a 3-ring binder.

1.05 Quality Assurance

A. Programmer Qualifications:

1. Programming shall be by a System Integrator specializing in SCADA system integration for the water/wastewater industry.

2. The Programmer shall be trained on the software specified for this project.

Part 2 Products

2.01 General

A. Products as specified in DIVISION 40.

B. Refer to SECTION 406700 – Process Control Panels and Hardware for new control panel requirements.

C. Refer to SECTION 407000 – Instrumentation for Process Systems for new instrumentation requirements.

Part 3 Execution

3.01 General

A. The intent of the control system specified and indicated is to provide complete control and monitoring capabilities for the Citico EBPS Effluent Pumping and related systems.

B. The PLC shall be programmed to communicate the required data to and from the Citico Pump Station PLC for all control and monitoring requirements.

C. The system shall communicate indicated I/O points to the Moccasin Bend Wastewater Treatment Plant control system as alarms via the existing SCADA radio network.

D. All setpoints and time delays described in the sequence of operation are initial values and shall be adjustable via an HMI screen by the System Administrator at the operator HMI.

E. Screen Development Details:

1. HMI Screens shall be developed for monitoring of systems and facilities and related equipment.

2. All screens shall be developed using high resolution graphics and icons.

3. All HMI screens shall be developed with input from the Owner and all screens shall be approved by the Owner prior to startup of the system.

4. The System Integrator shall schedule necessary meetings with the Owner to properly coordinate screen development, layout, and other required work to ensure the developed screens and systems best meet the needs and desires of the Owner for operating the facility.

5. All analog values shall be trended and recorded in HMI historian.

6. Low, low-low, high and high-high and loss of signal alarm points shall be programmed and available to set for all analog points. The operators shall be able to set values for or disable the alarm points from the HMI screens. If alarm range settings are not provided the alarm settings shall be adjustable over the entire range of the associated the analog value.

7. A minimum of one decimal point of accuracy shall be provided for all analog points displayed on the HMI. Additional decimal places shall be provided where applicable.

8. All automatic control such as start/stop, speed control, flow control, and similar shall be programmed into the nearest local PLC processor. All manual controls such as start/stop, open/close, speed control, etc. shall be incorporated into the PLC programming and screens as described this section. All control shall take place in the PLC with the applicable workstations maintained for operator interface only.

9. The screen symbology shall show equipment running (green) or not running (red) to match existing symbology.

10. Provide run time totalization for all equipment in the nearest local PLC processor and display the current value on the relevant screen(s).

11. Screens shall be developed to allow the operator to inhibit alarm points. Protocol shall be established which animates alarms prior to being acknowledged and maintains alarm display until the alarm condition is removed or the alarm is inhibited. Alarms, alarm acknowledgement, and inhibits shall be recorded to an event log.

12. HMI screen access levels shall match that of the existing system.

13. As a minimum the following screens shall be developed:

    a. System Overview Screen:

        i. Diagrammatically indicates the overall effluent pumping system including gates, pumps, instrumentation and interconnecting piping.

        ii. Displays for this screen shall at a minimum include the status of pumping system, pump flow rates, and daily flow totals for the facility.

        iii. Allow the operator to point and click to open a detailed screen for the associated pump system.

b. Detailed Pump System Screens:

    i. A detailed screen shall be developed for pumping system.

    ii. The detailed screens shall display all monitored parameters and allow for the adjustment of the control and alarm associated with the system and/or associated equipment.

    iii. If a particular system requires additional screens to clearly identify and display all control and status points for the system equipment the Detailed Screen and Overview Screen shall include links to the additional subsystem screens.

c. Alarm and Event Management Screens:

    i. Shall display alarms and events.

    ii. Shall list the discrete alarm points and allow the operator to inhibit the alarm and select whether the alarm point causes the audible alarm to sound.

    iii. Shall allow the operator to set the parameters associated with the audible alarms.

    iv. Shall allow the operator to place the associated equipment alarms into “Out Of Service” mode to prevent out of service equipment from triggering alarms.

d. Event Notification:

    i. The following methods shall be used for notification of alarms:

        (a) Remote alarms via radio network.

3.02 Network Configuration

A. The System Integration shall be responsible for programming and verifying the IP Addresses, Subnet, and Default Gateways, when applicable, for all devices on the network.

3.03 Programmable Logic Controller (PLC) Programming

A. The PLC program shall be thoroughly documented with explanations in the PLC program of the operation performed in each program line or rung.

B. The PLC shall be programmed to perform the required logic for proper operation of the associated equipment.

C. The PLC shall monitor communications status on the network and alarm if communication failures occur.

D. The PLC shall monitor power status of the building or structure power supply. Logic shall be implemented that shall clear run contacts or shut down equipment when power to the facility is lost and perform a sequential startup of equipment after power restoration. Operator adjustable time delays shall be established between the restarting of motor driven equipment.

E. Each alarm point shall have a programmed 2 second time delay to prevent “nuisance” or “false” alarms.

F. Momentary start contacts shall be programmed to close for 2 seconds and then open. Momentary stop contacts shall be programmed to open and stay open until shutdown of the motor is detected.

G. All required field programming and tuning of the control loops shall be included.

3.04 Emergency Backup Pump Station Diversion Chamber Level

A. System Components and Functions:

1. Level Transmitter EBPS-LIT-101.

    a. Guided wave radar level transmitter to measure the diversion chamber level.

2. Level Switch EBPS-LSH-101.

    a. Float switch provides a high level alarm for the diversion chamber level.

B. Description of Operation:

1. The diversion chamber level shall be measured by level transmitter EBPS-LIT-101.

    a. The level transmitter EBPS-LIT-101 shall serve as the level measuring instrument for control of the EBPS grinders and slide gates.

    b. All in-service grinders shall start when EBPS-LIT-101 reaches a level equal to the weir gate elevation, Starting elev. of 636.00’)

2. The diversion chamber level shall be displayed in feet to the nearest tenth of a foot on the operator HMI screens. High level, low level, and loss of signal alarms shall be programmed for the system.

3. The diversion chamber level shall be trended.

C. Setpoints and Ranges:

1. Level Transmitter EBPS-LIT-101:

    a. Guided wave radar level transmitter.

    b. Range shall be configured for 0-20 feet.

  2. Level Switch EBPS-LSH-101:

    a. High float level switch.

    b. Float shall activate at level of 637.75’, or approximately 11.2 feet above the diversion chamber floor.

  3. Operator Workstation:

    a. Display diversion chamber level with range of 0-20 feet (Elev 626’-646’).

    b. High level alarms adjustable between 8-16 feet initially set at 11 feet.

D. System Upsets and Procedures for Recovery:

  1. If the diversion chamber level signal is lost or out of range, the control system shall alarm the operator via the operator workstation.

  2. If the high level switch (EBPS-LSH-101) is activated the control system shall alarm the operator via the operator workstation.

3.05 Emergency Backup Pump Station Diversion Chamber Gate Operation

A. System Components and Functions:

  1. Slide Gate and Actuator: EBPS-SG-001

    a. Operates as a weir allowing flow into the EBPS via grinder EBPS-GR-101.

  2. Slide Gate and Actuator: EBPS-SG-002

    a. Operates as a weir allowing flow into the EBPS via grinder EBPS-GR-102.

  3. Slide Gate and Actuator: EBPS-SG-003

    a. Operates as a weir allowing flow into the EBPS via grinder EBPS-GR-103.

  4. Slide Gate and Actuator: EBPS-SG-004

    a. Allows or prevents flow from entering the Citico Pump Station Wet Well.

B. Description of Operation:

  1. Slide Gate Actuator:

    a. Upon receipt of an open command the actuator shall open the gate until the open limit has been accomplished. The open limit shall be adjustable at the actuator.

b. Upon receipt of a close command the actuator shall close the gate until the close limit has been accomplished.

C. Setpoints and Ranges:

1. The open limit shall be adjustable at the actuator. The actuator for slide gates EBPS-SG-001, EBPS-SG-002, and EBPS-SG-003 shall be calibrated with an initial top of gate height of 636’.

D. System Upsets and Procedures for Recovery:

1. If an open/close command is sent to the actuator and the corresponding limit switch indication is not received within the normal transition time to open or close the gate the control system shall alarm the operator via the operator HMI.

3.06 Emergency Backup Pump Station Grinders Operation

A. System Components and Functions:

1. Channel Grinder: EBPS-GR-101

    a. Grinds flow from EBPS-SG-001 prior to entering wet well.

2. Channel Grinder: EBPS-GR-102

    a. Grinds flow from EBPS-SG-002 prior to entering wet well.

3. Channel Grinder: EBPS-GR-103

    a. Grinds flow from EBPS-SG-003 prior to entering wet well.

B. Description of Operation:

1. The PLC shall monitor the “In Remote” position of the selector switch at each grinder control panel. A “Start” command shall be provided to all grinders in remote mode when EBPS-LIT-101 reaches a level equal to the weir gate elevation, Starting elev. of 636.00’).
2. Upon receipt of the start command, the grinder control panel will start the corresponding grinder unit. The grinder will continue to operate until the level signal from EBPS-LIT-101 drops below the elevation of the weir and the start command has been removed.

3. The OIT shall provide a screen for display of the grinder system, including “Run Status”, “Alarm”, and grinder “In Remote” for each grinder unit.

4. Provide a common alarm output if any one of the grinder control panel alarm conditions is received.

C. Setpoints and Ranges:

1. As defined for EBPS-LIT-101.

D. System Upsets and Procedures for Recovery:

1. A grinder can be placed in “out-of-service” mode. This will:

    a. Prevent the signal from being sent to the out-of-service grinder.

    b. Send a close signal to the corresponding slide gate.

3.07 Emergency Backup Pump Station Wet Well Level

A. System Components and Functions:

1. Level Transmitter EBPS-LIT-111:

    a. Guided wave radar level transmitter to measure the EBPS wet well level.

2. Level Switch EBPS-LSH-111:

    a. Float switch provides a high level alarm for the wet well.

3. Level Switch EBPS-LSL-112:

    a. Float switch provides a low level pump-off alarm for the wet well.

B. Description of Operation:

1. The EBPS wet well level shall be measured by level transmitter EBPS-LIT-111.

    a. The level transmitter EBPS-LIT-111 shall be used to measure the water level downstream of the weir and grinders which will be used to control the EBPS effluent pumps.

2. Level switches EBPS-LSH-111 and EBPS-LSL-112 shall be used to alarm a high and low water level condition.

3. The disinfection chamber wet well level shall be displayed in feet to the nearest tenth of a foot on the operator HMI screens. High level and loss of signal alarms shall be programmed for the system.

4. The disinfection chamber wet well level shall be trended when the CSO treatment system is in operation.

C. Setpoints and Ranges:

1. Level Transmitter EBPS-LIT-111:

    a. Guided wave radar level transmitter.

    b. Range shall be configured for 0-25 feet and confirmed with the existing instrument calibration ranges.

2. Level Switch EBPS-LSH-111:
    a. High float level switch.
    b. Float switch shall activate at a wet well level of 638.00, or approximately 17.0 feet above the wet well floor.
3. Level Switch EBPS-LSL-112:
    a. Low float level switch.
    b. Float switch shall activate at a wet well level of 630.00, or approximately 9.0 feet above the wet well floor.
4. Touchscreen OIT:
    a. Display wet well level with a range of 0-25 feet (Elev 621'-646').
    b. Low level alarms adjustable between 0-10 feet initially set at 9 feet.
    c. High level alarms adjustable between 14-21 feet initially set at 17 feet.

D. System Upsets and Procedures for Recovery:

1. If the wet well level signal is lost or out of range, the control system shall alarm the operator via the operator workstation.

3.08 EBPS Effluent Pumping

A. System Components and Functions:

1. EBPS Effluent Pump EBPS-P-101.
    a. Submersible pump installed in the EBPS wet well.
2. EBPS Effluent Pump EBPS-P-102.
    a. Submersible pump installed in the EBPS wet well.
3. Level Transmitter EBPS-LIT-111.
    a. Level transmitter to measure the wet well level.
4. Level Switch EBPS-LSH-111.
    a. Float switch provides a high level alarm for the EBPS wet well.
5. Level Switch EBPS-LSL-112.
    a. Float switch provides a low level alarm for the EBPS wet well.

B. Description of Operation:

1. EBPS Wet Well Level:
    a. The EBPS wet well level shall be measured by level transmitter EBPS-LIT-111.
        i. The level transmitter EBPS-LIT-111 shall serve as the level measuring instrument for starting, stopping and speed control of the EBPS effluent pumps.
    b. Activation of level switch EBPS-LSL-112 shall stop pumps and alarm the operator that a low wet well level shutdown occurred. The alarm shall not require reset for subsequent pump operation to occur.
2. EBPS Effluent Pumps:
    a. The pumps shall be capable of being controlled locally at the associated VFD or automatically by control system (PLC) when the LOCAL/OFF/REMOTE switch is in REMOTE.
    b. Local Control:
        i. When the pumps are in LOCAL control, starting, stopping, and speed control of the pumps shall be controlled at the associated VFD operator interface.
    c. Remote Control:
        i. When the pumps are in REMOTE control, starting, stopping, and speed control of the pumps shall be controlled by the PLC.
        ii. When the start/stop signal associated with a pump is enabled, the corresponding pump shall start. When the start/stop signal associated with a pump is disabled, the corresponding pump shall stop.
        iii. For the pumps to operate in REMOTE control, the following permissive conditions shall be met:
            (a) The level transmitter EBPS-LIT-101 reads a level above the weir gate elevation, or 636’ elev.
            (b) All grinders which are in service, EBPS-GR-101, EBPS-GR-102, or EBPS-GR-103 shall be running.
        iv. HMI screen shall be developed to allow the operator to view the status and operation of the pumps.
        v. Remote Automatic Control Mode:
            (a) The control system shall automatically start, stop and control the speed of the pumps to maintain the EBPS wet well level.

(b) The pump assignments shall rotate each time any or all of the pumps go through an operating cycle that results in no pumps running. Two (2) pump sequence assignments shall be programmed.

(c) The pump sequence assignments shall be as follows:

1). Sequence 1: Pumps shall operate in the order SP-1, SP-2.

2). Sequence 2: Pumps shall operate in the order SP-2, SP-1.

(d) The pumps shall operate in a sequential manner to maintain the level in the wet well.

(e) In the following control description a time delay shall be incorporated for each on and off level setpoint. The level must be maintained above or below, as applicable, for the time delay (initially set at 30 seconds) prior to starting or stopping pumps. This time delay shall be adjustable at the operator workstation. In each case if the level falls below or above the setpoint level prior to the time delay expiring the delay timer shall be reset.

(f) Stage 1 Operation: (Pump Control for Sequence 1 - Typical for Sequence 2):

1). When the wet well level rises to the pump start level setpoint, initially set at Elev. 635.00’, the system shall start pump SP-1 and ramp the pump up to 100% speed.

2). The control system shall adjust the speed of pump SP-1 to maintain the wet well level setpoint, initially set at Elev. 635.00’.

3). With pump SP-1 operating at minimum speed, if the level decreases below the pump off setpoint, initially set at Elev. 630.00’ the pump SP-1 shall be shut down and the pump sequence shall rotate.

(g) Stage 2 Operation:

1). With pump SP-1 operating, if the level increases to the pump start level setpoint, the system shall start pump SP-2 and ramp the pump up to match the speed of SP-1.

2). The control system shall adjust the speed of both pumps SP-1 and SP-2 to maintain the wet well level setpoint.

3). With pumps SP-1 and SP-2 operating at minimum speed, if the level decreases below the pump off setpoint, pump SP-2 shall be shut down and the control system shall revert back to Stage 1 Operation with pump SP-1 controlled to maintain the wet well level setpoint.

vi. Refer to System Upsets and Procedures for Recovery this Section for additional programming requirements.

d. The pump status points and alarms shall be displayed on the operator workstation. Refer to the I/O list at the end of this section and corresponding control drawings for I/O status and alarm points.

C. Setpoints and Ranges:

1. Level Instrumentation:

a. Refer to Emergency Backup Pump Station Level description this Section for additional setpoints and ranges.

D. System Upsets and Procedures for Recovery:

1. If a pump failure occurs the control system shall alarm the operator via the touchscreen OIT.

2. System in Remote control mode:

a. Loss of Level Signal:

i. If the level signal is lost or out of range the system shall alarm the operator via the touchscreen OIT. Any running pumps will maintain last known operation speed until EBPS-LSL-112 calls for shut down. If the level signal is restored normal operation shall resume.

ii. If the level signal is lost or out of range and the high level float switch EBPS-LSH-111 is activated the control system shall start all pumps (with a delayed start for each pump). The low level float switch EBPS-LSL-112 shall cause the pumps to stop. The pumps shall continue to operate in this fashion until the level signal is restored or the operator intervenes.

b. In the event that a lead pump becomes unavailable, fails to start, or drops off-line, the next pump in the starting sequence shall be automatically selected to operate as the lead pump.

3.09 Main Switchgear Auto-Transfer System

A. System Components and Functions:

1. The programming of the auto-transfer system shall be the responsibility of the switchgear manufacturer’s integrator. All status and alarm signals shall be coordinated with the PCS system integrator for monitoring purposes.

2. Automatic Transfer Equipment:

a. Switchgear (SWG) mounted programmable controller providing automatic throw-over capabilities of the main power circuit breakers.

B. Description of Operation:

1. Automatic Transfer System (ATS):

a. The ATS shall be capable of being controlled in MANUAL at its HMI located on the switchboard or automatically by the controller when the MANUAL/AUTO function is in AUTO.

b. Manual Control:

i. When the ATS is in MANUAL control, opening and closing of the primary, secondary source circuit breakers and the tie breaker shall be controlled at the switchgear HMI or by push buttons and switches located on the face of the switchgear.

(a) The software shall provide OPEN/CLOSE push buttons on the switchgear HMI screen for opening and closing the primary, secondary, and tertiary source, main breakers and the tie breaker.

(b) There shall be an interlock programmed into the software of the controller and a hardwired interlock between the existing and future utility and generator main breakers to prevent more than one source breakers from being closed at the same time when in manual control.

(c) Push buttons and switches shall be provided on the switchgear face to disengage the controller and to allow the main breakers to be controlled manually if the HMI or controller fails.

(d) Additional manual operations shall be provided as recommended by the manufacturer and as specified.

c. Automatic Control:

i. When the ATS is in AUTO control, opening and closing of the primary, secondary, and tertiary main breakers shall be controlled by the ATS controller.

ii. Note: The tie breaker is for maintenance purposes only and is not required to be interlocked with the utility and generator main switchover controls. The tie breaker is normally closed.

iii. Note: The tertiary main breaker is allocated for a future redundant utility source. It shall be programmed in the automatic transfer control sequencing but the source will not be available during this contract.

iv. Sequence of Operation:

(a) Normal Conditions:

  1). The primary utility main breaker is closed.

  2). The generator breaker is open.

  3). The future redundant utility main breaker is open.

  4). The MANUAL/AUTO switch is in the “AUTO” position.

  5). The Generator stop/start switch is in the “STOP” position.

(b) Primary Utility Power Failure:

  1). If an undervoltage, phase imbalance, or phase reversal is detected by the ATS equipment the primary utility main breaker shall open after an operator adjustable time delay, initially set at 3 seconds.

  2). If proper voltage and frequency is detected on the redundant utility breaker shall close.

(c) Redundant Utility Power Failure:

  1). If an undervoltage, phase imbalance, or phase reversal is detected by the ATS equipment and the primary utility source is still unavailable the redundant utility breaker shall open after an operator adjustable time delay, initially set at 3 seconds.

  2). After the time delay the ATS will signal the generator to start.

  3). After the generator is running and proper voltage and frequency is detected the generator breaker shall close after an operator adjustable time delay, initially set at 10 seconds.

(d) Utility Power Returns:

  1). When normal utility voltage is detected by the ATS system on either utility source, the ATS controller shall perform a open-transition retransfer from generator source to the available utility source.

  2). If the redundant utility source is active and normal utility voltage is detected by the ATS system on the primary utility source, the ATS controller shall perform a open-transition retransfer from redundant utility source to the primary utility source.

3). The generator start signal shall remain for an operator adjustable time delay following successful retransfer, initially set for 10 minutes, to allow a generator cool down period.

(e) Refer to System Upsets and Procedures for Recovery this Section for additional programming requirements.

d. The ATS equipment status points and alarms shall be displayed on the operator HMI. Refer to the I/O list at the end of this section for I/O status and alarm points.

2. Plant Control System Emergency Power Functions:

a. Upon the transfer and retransfer of power, the Plant Control System shall provide a sequenced restart-up of plant equipment.

b. The power failure and restart sequences shall be as specified under PARAGRAPH 3.13 – Sequenced Transfer Under Generator Power.

C. System Upsets and Procedures for Recovery:

1. In the event the ATS controller fails or senses a failure of the system the associated alarms shall be displayed on the switchgear HMI.

3.10 Sequenced Transfer Under Generator Power

A. System Components and Functions:

1. Refer to I/O list and drawings for electrical equipment and associated components.

B. Description of Operation:

1. Refer to Main Switchgear Auto-Transfer System this Section for generator and associated switchgear automatic transfer descriptions.

2. Monitored run status, fail status, and all associated alarms shall be displayed on the operator workstation for the generator. Analog points shall be trended. Run times for the generator shall be calculated and displayed on the operator workstation and recorded to the historical database.

3. Power Failure Restart Sequence (Engine Generator Power):

a. When a power failure is detected at the main switchgear the run commands for all motor starters and variable frequency drives that are being controlled by the plant control system shall be cleared.

i. Switchgear breaker status and nominal voltage shall be monitored to determine power availability.

b. During a power failure all alarms generated by VFD’s, PLC’s, and associated equipment due to loss of power shall be programmed to automatically clear to prevent unnecessary interruption after emergency power becomes available or normal power has been restored.

c. Power restored by Engine Generator (Utility Main Circuit Breakers Opened and Generator Source Breaker Closed):

   i. When power is restored to the plant under generator, the following equipment controlled by manufacturer supplied control panels shall automatically restart, but in a programmed step sequence.

   ii. If operating prior to the power failure, the following equipment/systems shall be restarted by the plant control system in the order indicated. Operator adjustable time delays shall be programmed between the enabling of the equipment to operate.

      (a) Step One Loads:

         1). Building loads will start automatically.

         2). One Pump Station Pump, One EBPS Pump, or One CSO Effluent Pump

         3). All control panels

         4). CSOTF MCC will start automatically.

      (b) Step Two Loads:

         1). One Pump Station Pump, One EBPS Pump, or One CSO Effluent Pump, if needed.

      (c) Step Three Loads:

         1). One Pump Station Pump or One CSO Effluent Pump, if needed.

      (d) Only three Pump Station Pumps, two EBPS pumps, or three CSO Effluent Pumps shall be allowed to operate while the plant is under generator power.

   iii. System override:

      (a) A system override screen shall be developed to allow the operator to manually enable loads that are automatically shut down during generator operation. The screen shall display the percent load for the generator and allow the operator to manually enable equipment that is specified to be shut down while on generator power. A pop-up windows shall be displayed which reads as follows: “Warning: Generator Capacity Must Be

Verified Prior To Enabling Loads And Starting Equipment On Generator Power."

iv. Restart Time delays:

(a) HMI screens shall be developed to allow the time delays described for restart of equipment to be adjusted by a Supervisor. All restart time delays shall be adjustable from 0-600 seconds.

d. Transfer Back to Utility Power (Utility Main Circuit Breaker Closed and Generator Source Breaker Opened):

i. When utility power is restored and the switchgear ATS transitions back to a utility source, normal plant operation shall be restored. The operator shall be signaled via the operator workstation that Utility Power is restored and all equipment can be restarted. The PCS shall return to normal operation.

C. Set Points and Ranges:

1. Not applicable.

D. System Upsets and Procedures for Recovery:

1. If a power failure, generator failure, or switchgear failure occurs, the control system shall alarm the operator via the touchscreen OIT.

3.11 Field Quality Control

A. Field Testing:

1. As specified in SECTION 409000.

2. A testing plan shall be developed and submitted for approval prior to testing of the control system.

3. Each mode of operation shall be tested along with fault conditions for proper system response.

4. Prior to and during initial startup period Systems Integrator shall demonstrate all modes of operation and step through various operating and failure scenarios.

a. Startup and operation mode testing shall be witnessed by the Engineer.

b. Contractor shall notify the Engineer a minimum of 2 weeks prior to the specified startup testing.

B. Test Reports:

1. Submit test reports as specified in DIVISION 01.

2. Maintain a written record of all tests showing date, personnel making tests, equipment or material tested, tests performed, and results.

3.12 Training

A. The System Integrator shall provide formal training for operators, maintenance and service personnel.

B. The training session shall include classroom discussion on the theory of operation of the control system as well as maintenance and service methods for the system. Topics covered shall include functionality of the system, system navigation, data management and recommended backup procedures.

C. Operator Training Sessions:

   1. Prior to the startup of the new control system a training session shall be provided for all operators. The training session shall clearly explain how to utilize the new system. HMI screens for the new system shall be presented and operators shall have the opportunity to utilize the new system in a demonstration mode and navigate all the screens. The training session shall also explain and demonstrate customized features such as report generation, alarm review and acknowledgment procedures.

   2. Two complete training sessions for all specified training shall be provided for the operators, one session for each plant.

   3. One month after the completion of the project a 4 hour refresher training session shall be provided to review the operations of the entire plant control system and answer any questions operators have developed on the system.

   4. Eleven months after the completion of the project a 4 hour refresher training session shall be provided to review the operations of the entire plant control system and answer any questions operators have developed on the system.

D. Maintenance and Service Personnel Training :

   1. Prior to the startup of the new control system one day of hands on training shall be provided for all maintenance and service personnel. The training session shall include the following:

      a. Clearly explain the architecture of the new system and explain how the network is configured and managed. Personnel shall be trained on network troubleshooting and available diagnostic tools.

      b. Cover all system software operation and configuration.

      c. Introduce basic PLC programming and explain methods for troubleshooting and identifying system issues.

      d. Cover system hardware and functionality.

  - e. Cover database management and trending.
  - f. Cover report template creation and report generation.
  - g. Cover I/O database management and modifications including how points are added to the control system and managed.
  - h. Cover PLC programming layout and logic associated with the pumping system. Programming logic shall be reviewed with the Owner and explanations shall be provided on programming methodologies and how the programs are organized and notated.
  - i. Programming comments and documentation shall be reviewed with the Owner to provide a clear understanding of how the system functions.
  - j. Additional topics as required to provide Owner with the ability to manage, troubleshoot, modify and maintain the plant control system.

2. Eleven months after the completion of the project a one day refresher training session shall be provided to review all of the topics covered in the original training session and answer any questions personnel have developed.

E. The Owner at their option shall be allowed to video record all training sessions for future reference.

END OF SECTION

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TAG NUMBER	ASSOCIATED PLC	FIELD DEVICE	DESCRIPTION	FUNCTION	TYPE	OUTPUT/INPUT (NORMAL STATE)	RANGE/ SET POINT	ENGINEERING UNIT	XMTR TYPE	POWER (SEE NOTE 1)	SPECIAL NOTES
EBPS-LSH-LAH-111	EBPS-PLC-060	EBPS-LSH-111	EBPS WET WELL HIGH LEVEL	ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	SYSTEM	6
EBPS-LSL-LAL-112	EBPS-PLC-060	EBPS-LSL-112	EBPS WET WELL LOW LEVEL	ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	SYSTEM	6
EBPS-LIT-LI-101	EBPS-PLC-060	EBPS-LIT-101	EBPS DIVERSION CHAMBER	LEVEL	AI	4-20mA	0 - 40	FEET	2-WIRE	SYSTEM	5
EBPS-LIT-LI-102	EBPS-PLC-060	EBPS-LIT-102	EBPS WEIR DOWNSTREAM	LEVEL	AI	4-20mA	0 - 30	FEET	2-WIRE	SYSTEM	5
EBPS-LIT-LI-111	EBPS-PLC-060	EBPS-LIT-111	EBPS WET WELL	LEVEL	AI	4-20mA	0 - 40	FEET	2-WIRE	SYSTEM	2
EBPS-P-HS-001	EBPS-PLC-060	EBPS-P-101	EBPS SUBMERSIBLE PUMP 101	IN-REMOTE	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-MN-001	EBPS-PLC-060	EBPS-P-101	EBPS SUBMERSIBLE PUMP 101	RUN STATUS	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-YA-001	EBPS-PLC-060	EBPS-P-101	EBPS SUBMERSIBLE PUMP 101	ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-MD-001	EBPS-PLC-060	EBPS-P-101	EBPS SUBMERSIBLE PUMP 101	START/STOP	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-SI-001	EBPS-PLC-060	EBPS-P-101	EBPS SUBMERSIBLE PUMP 101	SPEED	AI	4-20mA	0 - 100	%	N/A	N/A	
EBPS-P-SC-001	EBPS-PLC-060	EBPS-P-101	EBPS SUBMERSIBLE PUMP 101	SPEED CONTROL	AO	4-20mA	0 - 100	%	N/A	N/A	
EBPS-P-HS-002	EBPS-PLC-060	EBPS-P-102	EBPS SUBMERSIBLE PUMP 102	IN-REMOTE	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-MN-002	EBPS-PLC-060	EBPS-P-102	EBPS SUBMERSIBLE PUMP 102	RUN STATUS	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-YA-002	EBPS-PLC-060	EBPS-P-102	EBPS SUBMERSIBLE PUMP 102	ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-MD-002	EBPS-PLC-060	EBPS-P-102	EBPS SUBMERSIBLE PUMP 102	START/STOP	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-SI-002	EBPS-PLC-060	EBPS-P-102	EBPS SUBMERSIBLE PUMP 102	SPEED	AI	4-20mA	0 - 100	%	N/A	N/A	
EBPS-P-SC-002	EBPS-PLC-060	EBPS-P-102	EBPS SUBMERSIBLE PUMP 102	SPEED CONTROL	AO	4-20mA	0 - 100	%	N/A	N/A	
PS-GEN-MN-001	EBPS-PLC-060	PS-GEN-090	GENERATOR CONTROL PANEL	RUN STATUS	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-GEN-YA-001	EBPS-PLC-060	PS-GEN-090	GENERATOR CONTROL PANEL	COMMON WARNING	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-GEN-YA-002	EBPS-PLC-060	PS-GEN-090	GENERATOR CONTROL PANEL	COMMON ALARM	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-SG-ZSO-001	EBPS-PLC-060	EBPS-SG-001	SLIDE GATE OPEN	POSITION	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-SG-ZSC-001	EBPS-PLC-060	EBPS-SG-001	SLIDE GATE CLOSED	POSITION	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-SG-ZSO-002	EBPS-PLC-060	EBPS-SG-002	SLIDE GATE OPEN	POSITION	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-SG-ZSC-002	EBPS-PLC-060	EBPS-SG-002	SLIDE GATE CLOSED	POSITION	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-SG-ZSO-003	EBPS-PLC-060	EBPS-SG-003	SLIDE GATE OPEN	POSITION	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-SG-ZSC-003	EBPS-PLC-060	EBPS-SG-003	SLIDE GATE CLOSED	POSITION	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-SG-ZSO-004	EBPS-PLC-060	EBPS-SG-004	SLIDE GATE OPEN	POSITION	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-SG-ZSC-004	EBPS-PLC-060	EBPS-SG-004	SLIDE GATE CLOSED	POSITION	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	

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TAG NUMBER	ASSOCIATED PLC	FIELD DEVICE	DESCRIPTION	FUNCTION	TYPE	OUTPUT/INPUT (NORMAL STATE)	RANGE/ SET POINT	ENGINEERING UNIT	XMTR TYPE	POWER (SEE NOTE 1)	SPECIAL NOTES
EBPS-GRCP-YA-101	EBPS-PLC-060	EBPS-GRCP-101	GRINDER CONTROL PANEL 101	ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-GRCP-MS-101	EBPS-PLC-060	EBPS-GRCP-101	GRINDER CONTROL PANEL 101	RUN STATUS	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-GRCP-HS-101	EBPS-PLC-060	EBPS-GRCP-101	GRINDER CONTROL PANEL 101	IN-REMOTE	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-GRCP-MD-101	EBPS-PLC-060	EBPS-GRCP-101	GRINDER CONTROL PANEL 101	START/STOP	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-GRCP-YA-102	EBPS-PLC-060	EBPS-GRCP-102	GRINDER CONTROL PANEL 102	ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-GRCP-MS-102	EBPS-PLC-060	EBPS-GRCP-102	GRINDER CONTROL PANEL 102	RUN STATUS	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-GRCP-HS-102	EBPS-PLC-060	EBPS-GRCP-102	GRINDER CONTROL PANEL 102	IN-REMOTE	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-GRCP-MD-102	EBPS-PLC-060	EBPS-GRCP-102	GRINDER CONTROL PANEL 102	START/STOP	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-GRCP-YA-103	EBPS-PLC-060	EBPS-GRCP-103	GRINDER CONTROL PANEL 103	ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-GRCP-MS-103	EBPS-PLC-060	EBPS-GRCP-103	GRINDER CONTROL PANEL 103	RUN STATUS	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-GRCP-HS-103	EBPS-PLC-060	EBPS-GRCP-103	GRINDER CONTROL PANEL 103	IN-REMOTE	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-GRCP-MD-103	EBPS-PLC-060	EBPS-GRCP-103	GRINDER CONTROL PANEL 103	START/STOP	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
OCS-YA-001	EBPS-PLC-060	OCS-STR-001	ODOR CONTROL SYSTEM	ALARM	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-HVAC-YA-001	EBPS-PLC-060	PS-HVAC-CP-001	PUMP STATION HVAC	ALARM	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-BACP-YA-001	EBPS-PLC-060	PS-BACP-001	GAS DETECTION SYSTEMS	ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-BACP-YA-002	EBPS-PLC-060	PS-BACP-001	GAS DETECTION SYSTEMS	FAULT	DI	N.C. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-MN-001	PS-PLC-XXX	EBPS-PLC-060	EBPS SUBMERSIBLE PUMP 101	RUN STATUS		COMM	N/A	N/A	N/A	N/A	
EBPS-P-YA-001	PS-PLC-XXX	EBPS-PLC-060	EBPS SUBMERSIBLE PUMP 101	COMMON ALARM		COMM	N/A	N/A	N/A	N/A	
EBPS-P-MN-002	PS-PLC-XXX	EBPS-PLC-060	EBPS SUBMERSIBLE PUMP 102	RUN STATUS		COMM	N/A	N/A	N/A	N/A	
EBPS-P-YA-002	PS-PLC-XXX	EBPS-PLC-060	EBPS SUBMERSIBLE PUMP 102	COMMON ALARM		COMM	N/A	N/A	N/A	N/A	
PS-GEN-MN-001	PS-PLC-XXX	EBPS-PLC-060	EMERGENCY GENERATOR	RUN STATUS		COMM	N/A	N/A	N/A	N/A	
PS-GEN-YA-001	PS-PLC-XXX	EBPS-PLC-060	EMERGENCY GENERATOR	COMMON WARNING		COMM	N/A	N/A	N/A	N/A	
PS-GEN-YA-002	PS-PLC-XXX	EBPS-PLC-060	EMERGENCY GENERATOR	COMMON ALARM		COMM	N/A	N/A	N/A	N/A	
OCS-YA-001	PS-PLC-XXX	EBPS-PLC-060	ODOR CONTROL SYSTEM FAIL	ALARM		COMM	N/A	N/A	N/A	N/A	
EBPS-GRCP-YA-100	PS-PLC-XXX	EBPS-PLC-060	GRINDER SYSTEM ALARM	COMMON ALARM		COMM	N/A	N/A	N/A	N/A	
PS-BACP-YA-100	PS-PLC-XXX	EBPS-PLC-060	GAS DETECTION SYSTEMS ALARM	COMMON ALARM		COMM	N/A	N/A	N/A	N/A	
PS-HVAC-YA-001	PS-PLC-XXX	EBPS-PLC-060	PUMP STATION HVAC	ALARM		COMM	N/A	N/A	N/A	N/A	
EBPS-P-MN-001	PS-PLC-XXX	PS-RTU-XXX	EBPS SUBMERSIBLE PUMP 101	RUN STATUS	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-YA-001	PS-PLC-XXX	PS-RTU-XXX	EBPS SUBMERSIBLE PUMP 101	COMMON ALARM	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-MN-002	PS-PLC-XXX	PS-RTU-XXX	EBPS SUBMERSIBLE PUMP 102	RUN STATUS	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-YA-002	PS-PLC-XXX	PS-RTU-XXX	EBPS SUBMERSIBLE PUMP 102	COMMON ALARM	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-GEN-MN-001	PS-PLC-XXX	PS-RTU-XXX	EMERGENCY GENERATOR	RUN STATUS	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-GEN-YA-001	PS-PLC-XXX	PS-RTU-XXX	EMERGENCY GENERATOR	COMMON WARNING	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-GEN-YA-002	PS-PLC-XXX	PS-RTU-XXX	EMERGENCY GENERATOR	COMMON ALARM	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
OCS-YA-001	PS-PLC-XXX	PS-RTU-XXX	ODOR CONTROL SYSTEM	FAIL	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-GRCP-YA-100	PS-PLC-XXX	PS-RTU-XXX	GRINDER SYSTEM	COMMON ALARM	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-BACP-YA-100	PS-PLC-XXX	PS-RTU-XXX	GAS DETECTION SYSTEM	COMMON ALARM	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-HVAC-YA-001	PS-PLC-XXX	PS-RTU-XXX	PUMP STATION HVAC	COMMON ALARM	DO	N.O. CONTACT	N/A	N/A	N/A	N/A	

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TAG NUMBER	ASSOCIATED PLC	FIELD DEVICE	DESCRIPTION	FUNCTION	TYPE	OUTPUT/INPUT (NORMAL STATE)	RANGE/ SET POINT	ENGINEERING UNIT	XMTR TYPE	POWER (SEE NOTE 1)	SPECIAL NOTES
EBPS-LSH-LAH-101	PS-RTU-XXX	EBPS-LSH-101	EPBS DIVERSION CHAMBER HIGH LEVEL	ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	6
EBPS-P-MN-001	PS-RTU-XXX	PS-PLC-XXX	EBPS SUBMERSIBLE PUMP 101	RUN STATUS	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-YA-001	PS-RTU-XXX	PS-PLC-XXX	EBPS SUBMERSIBLE PUMP 101	COMMON ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-MN-002	PS-RTU-XXX	PS-PLC-XXX	EBPS SUBMERSIBLE PUMP 102	RUN STATUS	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-P-YA-002	PS-RTU-XXX	PS-PLC-XXX	EBPS SUBMERSIBLE PUMP 102	COMMON ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-GEN-MN-001	PS-RTU-XXX	PS-PLC-XXX	EMERGENCY GENERATOR	RUN STATUS	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-GEN-YA-001	PS-RTU-XXX	PS-PLC-XXX	EMERGENCY GENERATOR	COMMON WARNING	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-GEN-YA-002	PS-RTU-XXX	PS-PLC-XXX	EMERGENCY GENERATOR	COMMON ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
OCS-YA-001	PS-RTU-XXX	PS-PLC-XXX	ODOR CONTROL SYSTEM	FAIL	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
EBPS-GRCP-YA-100	PS-RTU-XXX	PS-PLC-XXX	GRINDER SYSTEM	COMMON ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-BACP-YA-100	PS-RTU-XXX	PS-PLC-XXX	GAS DETECTION SYSTEM	COMMON ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	
PS-HVAC-YA-001	PS-RTU-XXX	PS-PLC-XXX	PUMP STATION HVAC	COMMON ALARM	DI	N.O. CONTACT	N/A	N/A	N/A	N/A	

NOTES:

1. "SYSTEM" - POWER FROM ASSOCIATED PANEL. "FIELD" - POWER FROM OTHER SOURCE INDICATED ELSEWHERE.
2. PROVIDE TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS) FOR I/O POINT.
3. RANGE SHALL BE COORDINATED WITH THE EQUIPMENT SUPPLIER.
4. PROVIDE 120VAC POWER SOURCE FROM RTU PANEL FOR INSTRUMENT.
5. COORDINATE RANGES FOR EXISTING DEVICES TO PROVIDE DESIRED FUNCTIONALITY.
6. PROVIDE INTRINSICALLY SAFE BARRIER RELAY IN RTU OR PLC PANEL.

Part 1 General

1.01 Related Documents:

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

1.02 Summary:

A. This Section includes requirements for control panels including, but not limited to, the following:

1. Equipment manufacturer supplied control panels.
2. PLC Cabinets.

1.03 Related Requirements:

A. Section 40 60 00 – Process Control and Instrumentation - General Requirements.

B. Section 40 61 96 – Process Control System Programming and Reports.

C. Section 40 70 00 – Instrumentation for Process Systems.

1.04 Reference Standards:

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

B. Institute of Electrical and Electronic Engineers (IEEE):

1. IEEE C37.90.1 – Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.
2. IEEE C62.11 – Metal Oxide Surge Arresters for AC Power Circuits.
3. IEEE C62.33 – Test Specifications for Varistor Surge-Protective Devices.
4. IEEE C62.36 – Surge Protectors Used in Low-Voltage Data, Communications, and Signaling Circuits
5. IEEE C62.41.1 – Surge Environment in Low-Voltage (1000 Volts and less) AC Power Circuits.
6. IEEE C62.41.2 – Characterization of Surges in Low-Voltage (1000 Volts and less) AC Power Circuits.

7. IEEE C62.45 – Surge Testing on Equipment Connected to Low Voltage (1000 Volts and less) AC Power Circuits.

8. IEEE C62.62 – Test Specification for Surge Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1000 Volts and less) AC Power Circuits.

9. IEEE 802.1 – Local and Metropolitan Area Networks.

10. IEEE 802.3 – Ethernet.

C. National Fire Protection Association (NFPA):

   1. NFPA 70 – National Electrical Code (NEC).

   2. NFPA 79 – Electrical Standard for Industrial Machinery.

D. National Electrical Manufacturers Association (NEMA):

   1. NEMA 250 – Enclosures for Electrical Equipment (1,000V maximum).

   2. NEMA ICS 1 – Industrial Control and Systems - General Requirements.

   3. NEMA ICS 2 – Industrial Control and Systems - Controllers, Contactors, and Overload Relays Rated 600 Volts.

   4. NEMA ICS 4 – Application Guideline for Terminal Blocks.

   5. NEMA ICS 5 – Industrial Control and Systems - Control Circuit and Pilot Devices.

   6. NEMA ICS 6 – Industrial Control and Systems - Enclosures.

E. Underwriters Laboratories (UL):

   1. UL 50 – Enclosures for Electrical Equipment.

   2. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.

   3. UL 508 – Industrial Control Equipment.

   4. UL 508A – Industrial Control Panels.

   5. UL 698A – Industrial Control Panels Relating to Hazardous (Classified) Locations.

   6. UL 869A – Service Equipment.

   7. UL 1449 – Surge Protective Devices.

   8. UL 1778 – Uninterruptible Power Systems.

1.05 Submittals:

A. Submit as specified in Division 01.

B. Manufacturer with prime responsibility shall assume responsibility for all Compliance Submittals.

C. Product Data: Submit the following for each type of product specified and included as minimum:

  1. Data sheets for all control panel components furnished.

D. Qualification Statements:

  1. Fabricator's qualifications.

E. Shop Drawings: Provide the following as minimum:

  1. Fabrication drawings, front elevation, wiring diagrams, and bills of material for control panels.

  2. Electrical connection diagrams showing termination locations for all field wiring. External connection diagrams shall indicate cable number and wire color for field cables terminated at the panel.

  3. Engraving schedule and physical dimensions for nameplates.

  4. Provide heat dissipation calculations for all panels containing programmable logic controllers. Include calculation for ventilation fans if required.

F. Special Procedure Submittals:

  1. Test Plan:

    a. Provide a complete and detailed test plan for the supplied control panels.

    b. Include procedures for certification, validation, and testing.

  2. Syllabus for Owner training.

G. Test and Evaluation Reports:

  1. Factory test reports.

  2. Field test reports.

H. Closeout Submittals: Final documentation shall include the following as minimum:

  1. Operation and Maintenance Manuals including the following:

    a. Operation and maintenance manuals for all components furnished.

b. Certified “As-Built”/“As-Installed” drawings.

c. Copies of all approved Product Data.

d. Copies of all approved Test Reports.

e. Spare parts and supply list.

f. Warranty Information.

g. Contractor Information.

I. Maintenance Material Submittals:

1. Spare Parts:

a. Two spare LED indicating lamps for each type and color used.

b. Two spare indicating light assemblies.

c. Ten spare control fuses of each voltage and current rating used.

d. One aerosol cans of manufacturer’s touch-up paint for each color used. Color shall match the original factory applied color.

2. Software:

a. Soft copy of PLC and OIT programs including programming comments.

b. Original CD/DVD-ROM disks and/or flash drives containing all software associated with the supplied managed Ethernet switches, UPS.

c. Organize and submit all software copies in a 3-ring binder.

1.06 Quality Assurance:

A. Materials and Equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall be the manufacturer’s latest standard design that has been in satisfactory use for at least 1 year prior to Bid opening.

B. Fabricator Qualifications:

1. Prior to assembly and installation, submit data of fabricator's experience and qualifications.

2. Fabrication shall be by a manufacturer or a particular division of a manufacturing firm specializing in control panel construction.

3. Shall have a minimum of 10 years experience in control panel fabrication.

4. Panel shall be fabricated in a UL listed panel shop.

C. Factory Tests:

1. The manufacturer shall conduct tests according to industry standard requirements.
2. Perform factory tests on all control panels and components and subassemblies to assure that all devices and systems are in proper working order before delivery to jobsite.
3. Test all power, control and communication systems for proper operation.
4. Simulate actual system operation.
5. Submit test reports as specified in Division 01.

D. All control panels and associated equipment shall conform to the requirements of NEMA ICS and UL 508A standards.

1.07 Delivery, Storage, and Handling:

A. Control panels and associate equipment shall be packaged and shipped to the project site in such a manner as to avoid damage.

B. All control panels shall be stored according to the manufacturer’s instructions and in a conditioned space to avoid condensation, dust, and other environmental contaminants.

1.08 Project Site Conditions:

A. Do not store or install the control panel equipment specified herein until designated installation spaces are suitable for intended service.

B. For indoor control panels final or temporary HVAC systems shall be in place and operational to maintain the ambient temperatures and humidity conditions at occupancy levels prior to energizing panel and shall be maintained for the remainder of the construction period.

1.09 Warranty:

A. Surge Protective Devices shall be provided with a minimum 5-year manufacturer’s warranty from the date of Equipment start-up or as specified in Section 01 43 33.

B. Ethernet switches shall be provided with a minimum 5-year manufacturer’s warranty from the date of Equipment start-up or as specified in Section 01 43 33.

C. All other equipment shall be provided with a minimum one-year warranty period from the date of Equipment start-up or as specified in Section 01 43 33.

Part 2 Products

2.01 Manufacturers:

A. Enclosures:

1. B-Line, Eaton.
2. Hoffman, Pentair PLC.
3. Wiegmann, Hubbell, Inc.
4. Milbank Manufacturing Company.
5. Saginaw Control & Engineering.

B. Motor Starters, Circuit Breakers, and Transformers:

1. Acme Electric.
2. Eaton.
3. General Electric Company.
4. Phoenix Contact.
5. Square D, Schneider Electric.

C. Surge Protective Devices:

1. Advanced Protection Technologies, Inc.
2. Citel, Inc.
3. EDCO, Emerson Electric Company
4. Ferraz Shawmut, Mersen.
5. MCG Surge Protection, Inc.
6. MTL Instruments, Eaton.
7. Phoenix Contact.
8. Square-D, Schneider Electric.
9. Eaton – Innovative Technology

D. Terminal Blocks:

1. Allen-Bradley, Rockwell Automation, Inc.

2. Buchanan, Tyco Electronics Corporation.
3. Phoenix Contact.
4. Square-D, Schneider Electric.
5. Weidmuller.

E. Push buttons, Selector Switches and Pilot Lights:

1. General Electric.
2. Eaton.
3. Square-D, Schneider Electric.

F. Control and Timing Relays:

1. General Electric.
2. Potter & Brumfield, Tyco Electronics Corporation.
3. Square-D, Schneider Electric.

G. Intrinsically Safe Barriers:

1. MTL Instruments, Eaton.
2. Pepperl+Fuchs.
3. Square-D, Schneider Electric.
4. Turck, Inc.

H. DC Power Supplies:

1. Allen-Bradley, Rockwell Automation, Inc.
2. IDEC Corporation.
3. Phoenix Contact.
4. SolaHD, Emerson Electric Company.

I. Uninterruptible Power Supplies (UPS):

1. American Power Conversion Corporation, Schneider Electric.
2. Liebert, Emerson Electric Company.
3. Powerware, Eaton.

4. Tripp Lite.

J. Convenience and UPS Receptacles:

1. Cooper Industries, Eaton.
2. Hubbell, Inc.
3. Leviton Manufacturing Co., Inc.
4. Phoenix Contact.

K. Interior Illumination:

1. Acuity Brands, Inc.
2. Hoffman, Pentair Inc.
3. Hubbell, Inc.
4. Stego, Inc.

L. Programmable Logic Controllers (PLC):

1. General Electric RXI.

M. Operator Interface Terminal (OIT):

1. General Electric.
2. Allen-Bradley.

N. Ethernet Switches:

1. Antaira Technologies, LLC.

O. Wiring Duct:

1. Panduit Corporation, H-Type.
2. Thomas and Betts Corporation, ABB Group.

P. Wire Markers:

1. Brady Worldwide, Inc.
2. Panduit Corporation.
3. Thomas and Betts Corporation, ABB Group.

Q. Wire Terminals and Connectors:

1. Refer to Section 26 05 19 – Low Voltage Electrical Conductors and Cables.

2.02 Enclosures:

A. Totally enclosed panel with gasketed doors, continuous hinge, and three point latching mechanism with lockable handle.

B. Sized to house all equipment and devices required, provide sufficient space for conduit entry, and provide sufficient heat dissipation for the installed components.

C. Unless specified or indicated otherwise provide the following NEMA 250 approved enclosure type(s):

  1. NEMA Type 4X 316 stainless steel enclosures for the following areas:

    a. Outdoor locations.

  2. NEMA Type 12 painted steel enclosures for the following areas:

    a. Indoor conditioned spaces.

D. Unless specified or indicated otherwise provide the following enclosure design:

  1. Wall Mount Design:

    a. Provide for enclosures with a vertical dimension less than 50-inches.

    b. Formed and welded construction, minimum 14-gauge.

    c. Interior 12-gage minimum steel mounting panel(s).

    d. Provide mounting tabs and required hardware for installation of enclosures.

  2. Free Standing Design:

    a. Provide for enclosures with vertical dimensions of 50-inches or greater.

    b. Formed and welded construction, minimum 12-gauge for single door enclosures. For multi-door enclosures provide a 10-gauge back.

    c. Interior 10 or 12-gage steel mounting panel(s).

    d. Provide door mounted folding shelf for support of instruments and test equipment. Shelf shall be mounted on the interior of the door. For multi-door enclosures provide a shelf for each pair of doors.

    e. Provide with lifting eyes.

E. Provide lockable design.

F. Painted enclosures shall have a light gray polyester powder coat finish on the exterior with a white polyester powder coat finish on the interior.

G. Accessories:

1. Provide data pocket mounted on the interior of the panel for storage of wiring diagrams.

2. Provide a door stop kit designed to secure the door in the 90 degree open position.

H. Shall comply with UL 50, UL 508A, and NEMA ICS 6 standards.

2.03 Thermal Management:

A. Electric Heaters:

1. Provide a forced air panel heater for each exterior mounted control panel.

2. Heater shall be sized to maintain an interior panel temperature of 40°F.

3. Integral thermostat adjustable from 0°F to 100°F.

4. Rigid metal housing.

5. Motor shall be thermally protected.

6. Ball bearing fan shall run continuously to distribute heat throughout panel.

7. Powered from 120Vac.

8. Provide all required mounting brackets for complete installation in the panel.

B. Ventilation Fans:

1. Provide as required to maintain panel temperature below component ratings.

2. Provide for the following panels:

    a. NEMA 12 panels with PLCs installed.

3. Provide a compact 6-inch fan with rigid metal housing with finger guard. Motor shall be thermally protected and bearings shall be permanently lubricated ball bearings and design for a minimum of 50,000 hours of continuous operation. Impeller shall be polycarbonate. Powered from 120Vac.

4. Provide 14-gage steel louver for the intake and exhaust openings. Louver finish shall match the finish on the panel. Provide an aluminum filter and gasket for each louver.

5. Provide all required mounting brackets for complete installation in the panel.

6. Temperature Control Switches:

a. Provide two temperature control switches for each panel, one for control of the exhaust fan, and one for the high temperature alarm as indicated.

b. The temperature control switches shall have an adjustable range of 30°F to 140°F.

c. The temperature switch contact shall close on temperature rise and be rated 15A at 120Vac.

d. Designed for DIN rail mounting.

e. The high temperature alarm switch shall be set at 100°F and the fan switch shall be set at 80°F.

2.04 Nameplates:

A. Fabricate from laminated phenolic sheeting with black core and satin finish melamine overlay.

B. Colors shall white with black letters.

C. Thickness: 1/16 inch nominal.

D. Bevel edges to expose black core on perimeter.

E. Engraved legend through overlay to expose core.

F. Attach to panels with industrial grade double-faced tape.

G. Refer to Section 26 05 53 – Identifications for Electrical Systems for additional labeling requirements.

2.05 Motor Starters and Circuit Breakers:

A. Motor starters:

1. Shall be NEMA style, full-voltage, minimum NEMA size 1, and provided with motor circuit breaker type disconnect.
2. Provide with solid-state, self-powered overload relay sized for and adjusted to full load current of motor being protected.

B. 480Vac Circuit Breakers:

1. Protective devices shall be molded case circuit breakers with thermal-magnetic trip units and inverse time and instantaneous tripping characteristics.

2. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position.

3. Circuit breakers shall have a minimum symmetrical interrupting capacity of 18,000 AIC.

4. Main circuit breakers shall be provided with a door interlocked remote operator kit suitable for installation in provided enclosure. The main disconnect shall be lockable in the off position.

5. Number of poles and ampere rating as required.

C. 120/240Vac and 24Vdc Circuit Breakers:

1. Provide for main disconnecting means for panel and for power distribution within the panel as indicated.

2. Rated for 120/240Vac and 24Vdc as indicated.

3. Thermal-magnetic trip units.

4. Trip rating and curve as recommended by manufacturer of equipment being protected.

5. DIN rail mounted on the inside of the control panel in a readily accessible location.

6. Toggle-type handle with a quick-make, quick-break over-center switching mechanism that is mechanically trip-free.

7. Minimum symmetrical interrupting capacity of 10,000 AIC.

D. All circuit breakers must be UL 489 listed.

2.06 Surge Protective Devices:

A. 120/240V Surge Suppressors:

1. Provide for 120V/240Vac distribution system within panel to protect electronic components from transient voltage surges.

2. UL 1449 (3rd Edition) listed.

3. Shall meet Type 2 SPD criteria with the following minimum protection characteristics:

a. I_n: 20kA (per mode)

b. SCCR: 100kAIC (minimum)

c. MCOV: 150V (L-G), 270 (L-L).

d. UL Voltage Protection Rating:

i. L-L: 1000V

        ii. L-N, L-G, N-G: 600V

    4. Designed for 120/240Vac, single-phase operation.

    5. EMI/RFI filtering.

    6. Peak clamping voltage of 320 volts line to neutral and 350 volts line to ground with Category B waveform.

    7. Minimum surge current capacity of 10 kA per mode (8/20µs).

    8. Response time of less than 25 nanoseconds.

    9. Equipped with an LED status indicator for verification that unit is functioning.

    10. NEMA 1 enclosure designed for back panel or DIN rail mounting within a control panel.

    11. Minimum five year warranty.

B. Panel I/O Surge Suppressors:

    1. Provide DIN rail mounted terminal block type transient voltage surge suppressors for all inputs and outputs that are wired to devices located outside of the building envelope.

    2. Finger safe screw type terminals.

    3. Replaceable surge modules.

    4. Three-stage surge protection.

    5. Provisions for labeling terminal block numbers.

    6. Minimum five year warranty.

    7. Analog and 24Vdc Signal Surge Protection:

        a. Series surge suppressor.

        b. Minimum surge current capacity of 10 kA per mode (8/20µs).

        c. Minimum lightning surge current capacity of 500A per path (10/350µs).

        d. Maximum let thru voltage line to ground of 45 Vdc.

        e. Maximum let thru voltage line to line of 90 Vdc.

        f. Response time of less than 5 nanoseconds.

        g. Maximum series resistance of 10 ohms.

    h. Minimum continuous current rating of 300 mA.

8. 120Vac Discrete Signal Surge Protection:
    a. Series surge suppressor.
    b. Minimum surge current capacity of 4 kA per mode (8/20µs).
    c. Minimum lightning surge current capacity of 2.5 kA per path (10/350µs).
    d. Maximum let thru voltage line to ground 380 Vac.
    e. Maximum let thru voltage line to line of 600 Vac.
9. Minimum continuous current rating of 15A.
10. Response time of less than 25 nanoseconds.

C. Shall be designed to pass the appropriate IEEE testing standards included below:
    1. IEEE C62.11.
    2. IEEE C62.33.
    3. IEEE C62.36.
    4. IEEE C62.45.
    5. IEEE C62.62.

2.07 Terminal Blocks:

A. 600V, sectional type polyamide blocks.

B. Rated a minimum of 30A. Provide higher Amp rated blocks as required.

C. Screw connection type.

D. Finger safe.

E. Slide in vinyl marking strip for terminal identification.

F. DIN rail mounted.

G. Terminal blocks shall comply with NEMA ICS 4.

2.08 Switch Action Fuse Blocks:

A. Rated 600V.

B. Screw connection type.

C. Finger safe.

D. DIN Rail mounted.

2.09 Push Buttons and Selector Switches:

A. Heavy duty, 30 mm units with contacts rated 10A continuous at 120Vac.

B. NEMA 4X rated when installed in NEMA 12 or 4X enclosures.

C. Provide the number of contacts and contact development as indicated.

D. Operator colors shall comply with UL 508A and NFPA 79.

1. Start or On push buttons shall have green operators.

2. Stop or Off push buttons shall have red operators.

E. Emergency Stop push buttons shall have red mushroom head operators with a yellow base.

F. Push Buttons and Selector Switches shall conform to NEMA ICS 5.

2.10 Pilot Lights:

A. Heavy duty, 30 mm units.

B. NEMA 4X rated when installed in NEMA 12 or 4X enclosures.

C. 120Vac or 24Vdc cluster LED type.

D. Green lights shall indicate “Equipment On” or “Running”.

E. Red lights shall indicate “Equipment Off” or “Stopped”.

F. Amber lights shall indicate “Equipment Failure” or “Alarm”.

G. Push-to-test type.

H. Pilot lights shall conform to NEMA ICS 5.

2.11 Control Relays:

A. Plug-in type relay with neon coil energization indicator.

B. Coil voltage: 120Vac or 24Vdc as required.

C. Contacts rated 10 Amps at 120Vac.

D. Number of contacts as required.

1. Provide one spare N.O. and one spare N.C. contact (minimum).

E. Provide DIN rail mounted relay socket with screw type terminations.

F. Control relays shall conform to NEMA ICS 5.

2.12 Intrinsically Safe Barriers:

A. Intrinsically Safe Barrier Relays:

1. Supply voltage 120Vac.

2. Approved intrinsically safe for Class 1, Division 1, Group D areas.

3. Accept a dry contact input.

4. Two SPDT relay outputs rated 5A at 120Vac.

5. LED indication of relay state.

B. Intrinsically Safe Barrier Transmitters:

1. 24Vdc regulated power supply input.

2. 2 wire, 4-20mA transmitter type.

3. 4-20mA safe area output.

4. Approved intrinsically safe for Class 1, Division 1, Group D areas.

2.13 DC Power Supplies:

A. Provide industrial rated primary switched 24Vdc power supplies as specified and indicated.

B. Enclosed design with finger safe input and output terminal blocks.

C. Designed for DIN rail or back panel mounting.

D. DC power supply rated as follows:

1. Input voltage: 95 to 130Vac.

2. Output voltage: 24Vdc ±1%.

3. Output current: As required with a minimum 25% spare capacity.

4. Line regulation: ±0.2% maximum.

5. Load regulation: ±1.5% maximum.

6. Ripple: <50 mV pk-pk.

7. No overshoot for turn on, turn off, or power failure.

8. Operating temperature: -25°C to +60°C.

9. Overload and short circuit protection.

10. Indicating lights for status.

2.14 UPS (Line Interactive)

A. Network grade, line interactive, uninterruptible power system completely self-contained module with an inverter, batteries and control system.

B. Shall be provided for PLC Cabinets.

C. Electrical Capacity: As required.

D. The inverter shall be connected to the output at all times and provide continuous voltage regulation to protect against swells, sags, and brownouts.

E. When input voltage drops below the UPS tolerances for automatic voltage regulation or fails the batteries and inverter shall maintain continuity of power to the load and disconnect from the utility supply.

F. The UPS output waveform shall be a sinewave. A stepped sinewave output shall not be allowed.

G. Input Voltage: 120Vac ±10%, 60 hertz, single phase.

H. The unit shall automatically switch to battery inverter backup upon loss of power and retransfer on return of normal power. These transfers shall have no effect on the output waveform and shall be transparent to the connected load.

I. UPS Output Voltage:

  1. The output voltage shall be 120Vac nominal regulated to ±10% to unit-mounted receptacles when in normal or voltage regulation mode.

  2. Output voltage in battery mode shall be 120Vac ±5% and the frequency shall be 60 hertz ±5%.

J. Minimum of four (4) output receptacles.

K. Surge withstand shall exceed C62.41.1 and C62.41.2.

L. Provide continuous EMI/RFI filtering.

M. Shall provide continuous surge protection against voltage spikes on the incoming power in accordance with UL 1449.

N. The batteries shall be valve regulated or sealed maintenance-free type. Capable of changing batteries without powering down (hot swap).

O. The battery charger shall be fully automatic capable of recharging the batteries within 6 hours.

P. The unit shall automatically disconnect from the batteries and shutdown, preventing damage to the batteries due to a deep discharge.

Q. The battery capacity shall be such to be able to sustain a power outage of 8 minutes at 100% rated wattage output, and to maintain 50% of rated wattage output for a period of 20 minutes.

R. Ambient Environment: 0°C to 40°C at 95% relative humidity.

S. Unit shall periodically test the battery system to verify proper operation. Unit shall alarm if battery degradation is detected.

T. Status indicators shall indicate normal, transfer to inverter, battery charging and overload, or failure alarm. An audible alarm shall be available.

U. For units servicing control cabinets provide dry contact outputs for power failure and low battery indication. Contacts shall be rated for 24Vdc.

V. AC Input Service: Shall include 6-foot line cord with NEMA 5-15P plug.

W. Shall be designed for floor mounting as indicated. Provide all required mounting hardware.

X. The UPS shall conform to UL 1778. When the UPS is installed within UL508A listed control panels the control panel environment shall be maintained to UL 1778 requirements.

2.15 Convenience Receptacles:

A. Interior Mounted Receptacle:

1. DIN rail mounted, 15-A duplex three-wire grounding GFCI type receptacle with enclosure.

2. Equipped with terminal blocks for power connection.

3. Outlet shall be protected with a 5 Amp circuit breaker.

4. One mounted inside control panel for use in powering laptops and test equipment for service of the panel.

2.16 UPS Receptacle:

A. DIN rail mounted, 15-A duplex three-wire grounding type outlet with enclosure.

B. Equipped with terminal blocks for power connection.

C. Outlet shall be protected with a 15 Amp circuit breaker.

D. One mounted inside each control panel for use in powering the UPS.

2.17 Interior Illumination:

A. Provide LED type panel lights.

B. Minimum 50,000 hour life.

C. Provide a minimum 50 foot-candles at the base of the panel

D. Powered from 120Vac. Provide required power supply.

E. Door interlocked switch.

2.18 Panel Mount Unmanaged Ethernet Switches:

A. Panel mounted unmanaged Ethernet switches shall be 10/100 Mbps autosensing and operate using the Store and Forward Method.

B. Compact Industrial DIN rail mounted design.

C. Convection cooled with no fans and designed for an industrial environment.

D. Operating temperature 0°C to 60°C minimum.

E. Shall provide half and full duplex operation.

F. Provide with a minimum of 8 10/100 Base-TX RJ-45 ports.

G. Input power 24Vdc with terminal blocks for connection.

H. LED indicators for system status, each power supply status, fault.

I. LED indicators for each port indicating link, activity, full/half duplex mode and speed.

J. Comply with IEEE 802.3 and 802.3U.

K. Shall be UL listed and FCC approved. Unit shall be rated for continuous operation under the environmental temperature, humidity, and vibrating conditions encountered at the installed location.

2.19 Programmable Logic Controllers (PLC):

A. Provide GE PLC hardware as specified and indicated for PLC Cabinet.

  1. General:

a. The programmable controller shall receive status intelligence, perform logic functions, issue control commands, and provide alarms and status information for the systems described in these Specifications.

b. The PLC shall support the following programming languages:

   i. Relay ladder

   ii. Structured text

   iii. Function block

c. The programmable controller Equipment shall consist of a solid-state control system which has user programmable memory for storage of instructions to implement specific functions.

d. The PLC Equipment shall be purposely designed as an industrial control system which can perform functions equivalent to a relay panel or a wired solid-state logic system.

e. All PLC Equipment provided shall be capable of operation in ambient temperatures of 0°C to 60°C, and 5 to 95% relative humidity (non-condensing), without fans or other cooling equipment.

f. All external connection points shall be capable withstanding the IEEE surge withstand capability (SWC) test as defined in IEEE C37.90.1.

2. Chassis:

   a. Provide PLC chassis as required to accommodate the I/O and communications modules required and indicated.

   b. Provide slot fillers for all unused chassis spaces.

3. Power Supplies:

   a. Provide power supplies for the processor chassis and expansion chassis as required.

   b. Power supply shall be sized to supply required power for all installed modules and any spare spaces within the chassis.

   c. Input voltage shall be 120Vac as indicated.

4. Processor:

   a. Provide PACSystems RX3i Controller by GE Automation.

   b. The processor shall be of solid-state design on modular printed circuit boards.

c. The processor shall be equipped with a USB 2.0 communications port for programming.

d. The processor shall have user-programmable memory with provisions to prevent unauthorized changes.

e. The processor shall be equipped with a minimum of 8 Mbytes of user memory.

    i. The complete memory capacity specified shall be available for use by the user.

    ii. Memory shall be SRAM, flash.

f. The processor shall continuously perform diagnostics analysis with a predetermined failure mode in the event of a fault.

g. The ladder diagram logic shall be scanned and solved at a rate not to exceed 1 milliseconds per kiloword of logic.

h. All I/O including analog shall be scanned and updated at a rate not to exceed 0.3 milliseconds for all I/O.

i. The ladder logic programming shall include support for subroutines.

j. The processor shall include a real time clock and calendar accessible for use by the user program.

k. The processor shall have at least two (2) operating modes: Run and Program. These operating modes shall be user changeable via front panel switches and over the PLC communications network.

l. The processor shall allow the logic to be modified, in ladder logic format, while the processor is in the Run mode without affecting the operation of those portions of the logic not being modified.

m. The processor shall allow disabling and forcing on and off of individual input and output when the processor is in the Run mode.

n. The processor shall provide selectable timed interrupt capabilities for the user to incorporate into the ladder logic.

o. The processor shall provide user defined fault routine capabilities.

p. The processor shall automatically clear all output and update all input on power-up and prior to scanning and solving any logic.

q. The processor shall provide the user with a status bit for use in the ladder logic for initialization purposes. This status bit shall be set/reset based on the indicating the first ladder logic scan.

r. The processor shall provide a comprehensive instruction set including:

- i. Relay Contact Input:
  - (a) Normally open.
  - (b) Normally closed.
  - (c) Transitional.
- ii. Relay Coil Output:
  - (a) Standard.
  - (b) Retentive.
- iii. Timers:
  - (a) On delay.
  - (b) Off delay.
  - (c) Duration.
  - (d) Retentive
  - (e) Time bases of 1.0 sec, 0.1 sec, and 0.01 sec.
- iv. Counters:
  - (a) Count up.
  - (b) Count down.
- v. Arithmetic:
  - (a) Single-precision.
  - (b) Double-precision.
  - (c) Integer.
  - (d) Add.
  - (e) Subtract.
  - (f) Multiply.
  - (g) Divide.
  - (h) Square root.
  - (i) Less than.

(j) Greater than.

(k) Equal.

vi. Logical:

(a) And.

(b) Or.

(c) Exclusive or.

(d) Compare.

vii. PID.

5. Communications Hardware:

a. Provide Ethernet/IP communication modules as indicated for communications via an Ethernet PLC communications network.

i. All data within a PLC shall be accessible to any operator station or PLC.

(a) Programming functions shall be possible over the Ethernet communications network.

(b) Unloading and downloading of programs shall be possible over the Ethernet communications network.

(c) The operating mode of the PLC shall be changeable via the Ethernet communications network.

b. Provide all required communication cables, connectors, and terminating resistors.

6. PLC Input and Output Modules:

a. Digital Input Modules: Module IC694MDL250 or approved by Owner

i. 120Vac nominal input voltage with an on state voltage of 74 to 132Vac and an off state voltage less than 20Vac.

ii. Shall have a maximum of 16 inputs per module.

iii. Maximum hardware input delay time of 10 ms.

iv. Maximum inrush current of 0.25 Amps.

v. Operating temperature of 0 to 60°C at 5 to 95% non-condensing relative humidity.

b. Relay Output Modules: Module IC694MDL930 or approved by Owner

    i. Rated 2.0 Amps nominal at 120Vac.

    ii. Shall have a maximum of 8 individually isolated relay outputs per module.

    iii. Maximum output delay time of 15 ms.

    iv. Make rating of 15 Amps and a break rating of 1.5 Amps at 120Vac.

    v. Operating temperature of 0 to 60°C at 5 to 95% non-condensing relative humidity.

    vi. Provide individual surge suppressors for each output to protect module from surges caused by inductive load switching.

a. Digital Output Modules: Module IC694MDL340 or approved by Owner

    i. Rated 0.5A per point (4.0A per module) nominal at 120Vac.

    ii. Shall have a maximum of 16 outputs per module.

    iii. Maximum output delay time of 10 ms.

    iv. Operating temperature of 0 to 60°C at 5 to 95% non-condensing relative humidity.

b. Analog Input Modules: Module IC695ALG106 or approved by Owner

    i. Shall have maximum of 8 differential type, 4-20 mA current inputs.

    ii. Each input shall have a minimum 16-bit resolution.

    iii. Provide channel to channel and channel to backplane isolation.

    iv. Programmable input filter.

    v. Operating temperature of 0 to 60°C at 5 to 95% non-condensing relative humidity.

c. Analog Output Modules: Module IC695ALG808 or approved by Owner

    i. Eight individually isolated, 4-20 mA current outputs.

    ii. Each output shall have a minimum 16-bit current resolution.

    iii. Provide 1500VAC channel to channel isolation and channel to backplane isolation.

    iv. Maximum scan time of 25 ms for all channels.

v. Operating temperature of 0 to 60°C at 5 to 95% non-condensing relative humidity.

d. Provide screw clamp removable terminal block connectors for each module.

2.20 OPERATOR INTERFACE TERMINAL (OIT):

A. Provide for PLC cabinets and manufacturer supplied control panels where indicated and specified.

B. Provide a 15" flat panel color TFT display (18-bit color, minimum) for EBPS PLC panel and minimum 10” display for vendor equipment control panels for Grinder system. Resolution shall be 800x600 minimum.

C. Luminance shall be a minimum of 300 cd/m2 (Nits) with a field replaceable backlight.

D. Operating systems shall be Microsoft Windows EC7 or newer.

E. CPU shall be an x86 with 1.0 GHz clock speed minimum.

F. Display unit shall have a minimum of 512MB or DDR2-533Mhz RAM.

G. Environmental operating temperature range shall be 0 to 55°C, at 5 to 95% non-condensing relative humidity.

H. Shall be panel mounted with a NEMA rating to match the associated enclosure rating.

I. Provide the following external ports and interfaces as minimum:

1. One SD Card (SDHC).

2. Two USB-2.0 host ports for peripheral connections.

3. One USB device port for connection of host computer.

J. Communication interfaces shall include the following:

1. One RJ-45 Ethernet (10/100 Mb Autosensing).

2. One RS232 Serial Port (DB9).

K. Shall accept input power from 24VDC or 120Vac, 60Hz.

L. Software shall include FactoryTalk ME, PDF viewer, ActiveX controls, and other software required for specific installation.

M. Shall be capable of communicating over the Ethernet/IP network as indicated.

N. Provide GE QuickPanel+.

2.21 PLC I/O:

A. Refer to the I/O Lists at the end of Section 40 61 96 – Process Control Software Programming and Reports for a list of I/O required to be provided for the plant control system.

2.22 Electrical System:

A. Wiring:

1. UL style 1015, machine tool wire (MTW), 600V, 90°C.

2. No. 14 AWG (minimum), 19 strand, for all control wiring.

3. No. 18 AWG (minimum), shielded twisted pairs and triads as applicable for all instrumentation wiring.

    a. Color code shall be black/red pair (black/red/white triad) with black [or blue] PVC jacket.

4. Wire Colors (UL508A):

    a. Black: 240V or 480V AC wiring.

    b. Red: 120V AC wiring.

    c. White: AC neutral.

    d. Green: Ground.

    e. Blue: DC(+).

    f. White w/ Blue Tracer: DC(-) grounded.

    g. From alternate power source that remains energized when main disconnect is open:

        i. Yellow: Un-switched power.

        ii. White w/Yellow Tracer: Un-switched neutral.

B. Wire Markers:

1. Heat shrinkable, tube-type sleeve markers, constructed of polyolefin material.

2. White sleeves with black thermal printed text.

3. Identify both ends of wire with the same unique wire number.

4. Assign wire numbers where specific designations are not indicated.

5. Markers sized for snug fit for wire size.

C. Wiring Duct:

1. Provide wide slot wiring duct in panel for routing of panel wiring. Slots shall be a minimum of 0.25-inches.

2. Provide with dual hinge, push-on cover that opens a minimum of 100 degrees to either side.

3. Wiring ducts shall be sized to accommodate all installed wire plus a minimum of 25% spare capacity.

D. Ground Bus:

1. Provide copper ground bus for power circuits.

2. Provide isolated copper ground bus for instrument shields.

2.23 ARC Flash Label:

A. Provide a 6 x 4 inch (minimum), plastic arc flash label for each control panel.

B. Label shall be orange and white.

C. Label shall read as follows: WARNING – Arc Flash and Shock Hazard. Appropriate PPE and Tools Required When Working on this Equipment.

Part 3 Execution

3.01 Examination:

A. Verify site conditions are suitable for installation of equipment.

B. For indoor control panels final or temporary HVAC systems shall be in place and operational to maintain the ambient temperatures and humidity conditions at occupancy levels prior to energizing panel and shall be maintained for the remainder of the construction period.

3.02 Panel Fabrication:

A. Install all components in the panel as required and recommended by the manufacturer.

B. Provide master nameplate and nameplates for all operator interfaces. Interior nameplates shall be provided for individual component identification including, but not limited to, power supplies, PLCs, control relays, terminal blocks, Ethernet switches, circuit breakers, etc.

C. Provide interior illumination for all panels equipped with a PLC and/or network equipment.

D. Power Distribution:

1. Provide circuit breakers for protection of equipment in the panel and distribution of power to equipment powered from the control panel.

2. Provide main power disconnect operable from the exterior of the panel for all panels supplied with 480-volts. For panel supplied with 480-volt power provide properly sized control power transformer and required circuit breakers for distribution of power within the panel. Provide dedicated circuit breakers for all 480-volt equipment powered from the panel.

3. Provide 120Vac circuit breakers to distribute power within the control panel. Circuit breakers shall be sized based upon connected load. As a minimum, dedicated circuit breakers shall be provided for the following:

    a. Incoming power sources.

    b. Each device such as lights, fans, heaters, receptacles installed within the panel.

    c. PLC power supplies (120Vac).

    d. 24Vdc power supplies.

    e. Each 120Vac digital input or output module.

    f. Each 120Vac instrument or device powered from the panel.

4. Provide 24Vdc circuit breakers to distribute power within the control panel. Circuit breakers shall be sized based upon connected load. As a minimum dedicated circuit breakers shall be provided for the following:

    a. Output of 24Vdc power supply.

    b. PLC power supply (24Vdc).

    c. Each 24Vdc digital input or output module.

    d. Each loop powered instrument.

    e. Each analog input module, if required.

    f. Each analog output module, if required.

    g. Each 24Vdc instrument or device powered from the panel.

5. Provide signage on panel to clearly indicate that the panel is powered from multiple sources if applicable.

E. Surge Protection:

1. Provide surge protection on the incoming 480Vac supply and 120Vac distribution systems within the panel to protect electronic components from transient voltage surges.

2. Provide surge protection on all power circuits to instruments installed outside of the building envelope in which the control panel is installed. The terminal block type surge suppressor shall be the termination point for the field cabling.

3. Provide surge protection on all inputs and outputs that are connected to equipment outside of the building envelope in which the control panel is installed. The terminal block type surge suppressor shall be the termination point for the field cabling.

F. Component Mounting:

1. Operator interfaces and indicating lights shall be installed in the door of the panel at a convenient height for operator interaction.

2. Components shall be mounted to provide complete accessibility to all terminals, relay sockets, and other devices without dismantling of panel equipment.

3. Provide sufficient space around and layout components to allow for proper heat dissipation.

4. Provide sufficient space at the top of the panel for conduits and cable entry. Conduit entry locations shall be coordinated with the installing Contractor.

G. PLC I/O:

1. Wire all inputs and outputs from the PLC to terminal blocks.

H. Wiring Methods:

1. Route main groups of wires in plastic nonflammable wiring duct.

2. Smaller groups of wire shall be cabled and secured with nylon cable clamps and ties or plastic spiral wraps.

3. Maintain physical separation of power, control and instrumentation cables within the panel.

4. Provide dedicated wiring ducts for management of field cables within the panel. Wiring ducts shall be sized to accommodate multi-conductor control cables. Assume a minimum of 25% spare conductors and provide a minimum of 25% spare capacity when sizing wiring ducts.

I. Terminal Blocks and Connections:

1. Provide terminal blocks for all external connections.

2. Make all connections on terminal blocks.

3. Follow manufacturer’s recommendations for terminal block installation.

4. Connect terminal blocks for instrumentation cable shields to isolated ground bus.

5. Provide required grounding type terminal blocks.

J. Spare Capacity:

1. Provide a minimum of 40 percent or 4 circuit breakers, whichever is greater, for each power source (Vac and Vdc) present within the panel. All spare circuit breakers shall be mounted, wired, and include provisions to terminate associated neutral or negative conductors.

2. Provide a minimum of 4 spare slots in each PLC chassis. Provide blank filler modules for all empty slots.

3. Provide a minimum of 20 percent or 4 points, whichever is greater, spare PLC inputs and outputs for each type in each panel. All spare points shall be wired to field terminal blocks. Fifty percent of spare analog inputs shall be configured to provide loop power.

4. Provide a minimum of 20 percent spare terminal blocks of each type mounted in the panel.

5. Provide spare DIN rail space for the installation of terminal blocks for all spare slots in the PLC chassis.

K. Provide labeling on all terminal blocks, wiring and relays to match panel drawings.

3.03 Uninterruptable Power Supply Installation:

A. Install UPS systems in control panel as specified.

B. Startup and initial charging shall be as required by the UPS manufacturer.

3.04 Ethernet Switch Installation:

A. Install Ethernet switches in control panels and make connections as indicated.

B. Arrange with proper clearances from other equipment and material to obtain accessibility for operation and maintenance.

C. Shall provide adequate ports for connection to the plant control system, PLC, OIT, and provide a minimum of one spare programming port.

3.05 PLC Programming:

A. Refer to Section 40 61 96 – Process Control Software Programming and Reports for PLC programming requirements.

B. The PLC shall be programmed to perform the required logic for proper operation of the equipment.

C. The PLC program shall be thoroughly documented with explanations in the program of the operation performed in each program line or rung.

D. The PLC shall monitor power status to the control panel. Logic shall be implemented that shall clear run contacts when power is lost and perform routine startup of equipment after a power restoration.

E. Control and status points specified to be communicated with the plant control system shall be tagged as specified and indicated and shall be organized to provide efficient communication with the plant control system.

F. Shall be programmed utilizing the latest version of GE PAC programming software.

G. Soft copy of the program shall be provided to the Owner.

3.06 OIT Programming:

A. The OIT shall be programmed to provide required operator interfaces with the equipment.

B. Shall be programmed utilizing the latest version of Windows based programming software from the manufacturer.

C. Screens shall be laid out in a logical order with a main overview screen and links from each screen back to the main overview screen. The graphic displays shall be developed using design elements and concepts intended to enhance the operator’s “Situational Awareness”. The development, design, and implementation of the system displays shall comply with ISA 101.01 – Human Machine Interfaces for Process Automation Systems.

D. The color scheme shall utilize a grey scale color palette for equipment and backgrounds with colors only being utilized for operator setpoints, variables, warnings, and alarm conditions.

  1. The color dark gray shall indicate “Equipment On” or “Valve Open” and the color white shall indicate “Equipment Off” or “Valve Closed”.

E. Operator adjustable set points shall be password protected.

F. A Soft copy of the program shall be provided to the Owner.

3.07 Installation:

A. Control Panels:

  1. Conform to manufacturer’s written instructions.

2. Surface-mount wall mount enclosures on structural supports or wall approximately 4 feet to center line above the floor when possible.
3. Install floor mounted enclosures where indicated and bolt to floor using expansion type concrete anchors.
4. Install all necessary openings in panels.
5. Arrange with proper clearances from other equipment and material to obtain accessibility for operation and maintenance.
6. Mount plumb and level.

B. Electrical Connections:

1. Install wire and cable as specified in Division 26.
2. Conform to manufacturer's wiring diagrams.
3. Install circuits to field-mounted equipment as indicated and required.
4. Installation shall conform to NFPA 70 (NEC).

C. Place arc flash label on equipment.

3.08 Field Quality Control:

A. Manufacturer's Field Services:

1. The panel supplier shall provide the field services of a trained technician for the amount of time required to commission, test and start-up all equipment provided.
2. All travel and living expenses shall be included for all trips to the site. All equipment required for testing, start-up and performance verification shall be provided by the start-up technician.

B. Check all internal and external connections and tighten as required.

C. Perform I/O checkout on all points and verify proper operation.

D. Verify proper connection of communication cabling and proper communication system configuration.

E. Field verify proper operation of all inputs and outputs.

F. Record results of I/O checkout and submit test reports as specified in Division 01.

3.09 Finishes:

A. Control panel coatings shall be free from scratches, rust, or other defects.

B. All damaged or defective coatings shall be repaired prior to final acceptance.

C. Field Painting:

1. Touch Up:

   a. Contractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.

   b. Field painting shall be performed based on manufacturer's recommended procedures.

   c. Contractor shall provide the necessary quantity of Manufacturer's touch-up paint to match the factory applied finish.

3.10 Adjusting and Cleaning:

A. After field installation and final wiring terminations are completed the control panel wiring and cables shall be adjusted and neatly secured with tie wraps, hook-and-loop straps, or the like.

B. Wiring duct covers shall be replaced and secured as required.

C. Prior to final acceptance control panel interior and exterior shall be wiped clean and free from dust and debris.

3.11 Training:

A. Provide a minimum of 4 hours of training for each panel provided at the customer's facility for operations, maintenance and service personnel.

1. The training session shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment.

2. Topics covered shall include safety, hardware layout and functions, power and control wiring, diagnostic indicators, keypad/display interface, faults, diagnostic tools, troubleshooting, and preventive maintenance.

3. Hands-on training shall be provided on equipment.

4. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.

B. The Owner at their option shall be allowed to video record all training sessions for future reference.

END OF SECTION

Part 1 General

1.01 Related Documents:

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

1.02 Summary:

A. This Section includes the requirements for measuring and controlling instruments.

1.03 Related Requirements:

A. Section 40 67 00 – Process Control Panels and Hardware.

1.04 Reference Standards:

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

B. American Society of Mechanical Engineers (ASME):

1. ASME B16.5 – Pipe Flanges and Flanged Fittings.

C. International Society of Automation (ISA).

1. ISA S20 – Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.

D. National Electrical Manufacturers Association (NEMA).

1.05 Submittals:

A. Submit as specified in Division 01.

B. Manufacturer with prime responsibility shall assume responsibility for all Compliance Submittals.

C. Product Data: Submit for each type of product specified and included the following as minimum:

1. Individual specifications and technical data for instruments and similar major system components to conform to ISA S20.

2. Electrical and mechanical connection diagrams for all instruments.

3. Physical dimensions for each instrument.

D. Special Procedure Submittals:

1. Test Plan:

a. Provide a complete and detailed calibration and test plan for the supplied instrumentation.

b. Include procedures for certification, validation, and testing.

2. Syllabus for Owner training.

E. Test and Evaluation Reports:

1. Factory test and calibration reports.

2. Field test and calibration reports.

F. Closeout Submittals: Final documentation shall include the following as minimum:

1. Operation and Maintenance Manuals including the following:

a. Operation and maintenance manuals for all instruments furnished.

b. Copies of all approved Product Data.

c. Copies of all approved Test and Calibration Reports.

d. Spare parts and supply list.

e. Warranty Information.

f. Contractor Information.

G. Maintenance Material Submittals:

1. Spare Parts:

a. Provide five (5) spare fuses of each type used.

2. Software:

a. Manufacturer supplied software required for setup and calibration of instrumentation shall be provided.

b. Assemble and submit all device type manager (DTM) software modules required for HART enabled instrumentation.

c. Organize and submit all software copies in a 3-ring binder.

1.06 Quality Assurance:

A. Factory Tests:

   1. As a minimum, the manufacturer's standard tests and calibration procedures shall be conducted on all instruments.

1.07 Delivery, Storage, and Handling:

A. Instrumentation and associated equipment shall be packaged and shipped to the project site to avoid damage.

B. All instrumentation shall be stored according to the manufacturer’s instructions.

1.08 Warranty:

A. Instruments shall be provided with a minimum 1-year manufacturer’s warranty from the date of Equipment start-up or as specified in Section 01 43 33.

B. In the event a component or instrument fails to perform as specified or is proven defective during the warranty period, the manufacturer shall promptly repair or replace the defective part at no cost to the Owner.

Part 2 Products

2.01 Manufacturers:

A. Guided Wave Radar Level Transmitters:

   1. Rosemount, Emerson Electric Co.

B. Float Switches:

   1. Anchor Scientific, Inc.

   2. Siemens.

C. Gas Detection Equipment:

   1. MSA.

D. Pressure Transmitters:

   1. ABB.

   2. Endress+Hauser, Inc.

   3. Foxboro, Schneider Electric.

   4. Krohne, Inc.

5. Rosemount, Emerson Electric Co.

6. Siemens.

E. Limit Switches:

1. ABB.

2. Allen-Bradley, Rockwell Automation, Inc.

3. Honeywell International, Inc.

4. Square D, Schneider Electric.

2.02 Instruments:

A. Refer to the instrument list at the end of this Section for a list of instruments specified to be provided by this Division.

B. Refer to Division 46 for instruments to be provided with packaged equipment.

2.03 General:

A. Transmitters shall have an output signal of 4 to 20 mA dc into a minimum load range of 0-600 ohms at 24Vdc.

B. All analog indicating and recording receivers shall have evenly graduated scales.

C. Provide all mounting brackets, pipe stands and accessories required to install all field mounted instruments. All mounting brackets and hardware for instruments installed in exterior locations or within process areas shall be stainless steel.

D. Furnish and install all accessories required for complete and working systems as specified and indicated.

E. Provide sun shades for all exterior mounted transmitters.

F. All flanged instruments shall comply with ASME B16.5.

2.04 Guided Wave Radar Level Transmitters:

A. Provide loop powered radar level transmitter for continuous level detection of liquids.

B. Provide guided wave type. Wave guide shall be stainless steel.

C. Process connection shall be 4 inch, 150lb flange unless required or indicated otherwise.

D. NEMA 4X aluminum housing with LCD display.

E. Provide 4-20mA analog signal proportional to level.

F. System accuracy shall be within ±0.25-inch.

G. Unit shall be capable of mapping out unwanted obstructions via user friendly interface software. Provide required software and cable to connect to the unit.

H. Provide waveguide extension for proper mounting as required.

I. Provide sunshield for outdoor mounted units.

J. Provide Rosemount 3300 series guided wave radar.

2.05 Float Switches:

A. Rigid, Teflon coated float switch.

B. One N.O. contact rated 1.0 Amps, 120Vac minimum.

C. Furnished with necessary length of cable for cable suspension.

D. Float switches shall be mercury free.

E. Provide intrinsically safe barrier relay for use in hazardous locations. Intrinsically safe barriers shall be as specified in Section 40 67 00 – Process Control Panels and Hardware.

2.06 Gas Detection Equipment:

A. Gas Monitoring Units:

1. Provide standalone gas detection monitors for toxic and combustible gas monitoring as indicated.
2. Gas monitors shall be capable of supporting up to three remote mounted sensors.
3. User adjustable "calibration reminder" message.
4. LCD display with backlight for local indication.
5. Provide LED indication and alarm relays for high gas level.
6. Provide with integral battery back-up that provides a minimum of 1,200 mAh.
7. Provide normally-closed contact that opens upon fault or failure of the gas monitoring system.
8. Monitors shall operate from 120 VAC source.
9. Remote mounted sensor shall be connected by manufacturer’s factory assembled cable for signal and power, and up to 100 ft away. Coordinate cable length for each sensor provided.

10. Housed in NEMA 4X polycarbonate enclosure.

11. Gas types monitored shall be Hydrogen Sulfide and Combustible Gas. Sensors shall be suitable for locations indicated, including both Class I/Division 2 and unclassified areas.

12. Provide MSA TRIGARD Gas Monitor with Ultima X-series sensors.

B. Calibration Kit:

1. Provide one calibration kit for each type of Gas Detection sensor provided.

2. Calibration kits shall be as recommended by the manufacturer for each type of detector used.

2.07 Differential and Gauge Pressure Transmitters:

A. Electronic, two-wire type with a 4-20mA output and integral LCD display.

B. Aluminum body with stainless steel wetted parts.

C. Sensor fill fluid shall be silicone oil.

D. Measuring element shall be a resonant wire or strain gauge type. Force balance mechanisms are not acceptable.

E. Process connections shall be 1/2 -inch NPT unless specified otherwise.

F. Accuracy including hysteresis, linearity, and repeatability shall be within ±0.20% of calibrated span.

G. Provide zero, span, and damping adjustments. Zero adjustment shall be external.

H. Zero suppression or elevation shall be adjustable to a minimum of 100% of calibrated span.

I. Enclosure shall be NEMA 4X epoxy coated aluminum.

J. Designed for wall or pipe stand mounting.

K. Accessories:

1. Stainless steel three-valve manifold for all differential pressure transmitters.

2. Stainless steel two-valve block and bleed manifold for all pressure transmitters.

3. Provide stainless steel mounting bracket for units indicated to be wall mounted.

4. Provide with remote atmospheric pressure compensation tube, length as required.

2.08 Limit Switches:

A. SPDT contacts rated 5 amps at 120Vac minimum.

B. Snap action type switch in a NEMA 4X enclosure.

C. Enclosure shall be rated for use in a Class 1 Division 2 enviroment.

D. Operator type as required for the function specified or indicated.

Part 3 Execution

3.01 Examination:

A. Verify site conditions are suitable for installation of instrumentation and associated equipment.

3.02 Installation:

A. Panel Mounted Devices: As specified in Section 40 67 00 – Process Control Panels and Hardware.

B. Field Mounted Devices:

1. Install as follows:
    a. Mount on floor or wall as required.
    b. Mount plumb and level.
    c. Mount on walls with bottom of box or instrument four feet above floor unless indicated otherwise and instrument case spaced at least 1/2-inch away from wall.
    d. Install supports as specified this Division.
    e. Install floor-mounted instruments on pipe stands.
    f. Install measuring and controlling instruments in accordance with manufacturer’s written instructions.
    g. Install identification tags on all instruments.
    h. Coordinate with Owner for alarm horn tone selection and adjust volume and horn direction for proper plant coverage.
2. Connect inputs and outputs as indicated on the manufacturer's shop drawings and as follows:
    a. Transmitters requiring electric power shall be supplied from their associated control panels.

3.03 Field Quality Control:

A. Manufacturer’s field services:

1. Manufacturer’s field services shall be provided as specified in this Section and in Section 40 60 00 and in Division 01.

2. Provide a minimum of 2 hours for each instrument to supervise/inspect installation, commission, test and start-up all equipment provided.

3. All equipment required for testing, start-up and performance verification shall be provided by the start-up technician.

4. All travel and living expenses shall be included.

B. Field Testing:

1. Test and start-up supervision shall continue until the system is in proper operating condition as determined by Engineer.

2. Provide manufacturer's supervision during Work to correct deficiencies in Equipment manufactured by them and to correct deficiencies in the installation and wiring of Equipment. Corrections shall be at no increase in the Contract Price.

3. Functional Testing of Controls:

   a. Perform before equipment is placed in service.

   b. Include operating control system from each control point.

   c. Completely check each annunciator point and equipment alarm.

   d. Operate by hand all relays, pressure switches, limit switches and other system components that cannot be operated in normal manner with plant not in service.

   e. Repeat with plant in operation.

4. Instrument Tests and Adjustments:

   a. Calibrate and startup measuring and controlling instruments in accordance with manufacturers recommendations.

   b. With each system variable transmitter disconnected from its normal source of input signal, apply an input with manometer, instrument potentiometer, or other device and adjust span and zero on all instruments transmitting, receiving, or retransmitting the resulting variable current, voltage, time duration or pneumatic signal and on all final control devices. Check instruments and final control devices at several points over the instrument measuring or control device span.

c. Apply manually adjustable time duration or current signals directly to receivers where required to adjust zero and span and to check operation of the instrument over the measuring span.

d. Accurately measure variable current, voltage, time duration and pneumatic signals as required to adjust all receivers, transmitters, transducers, and final control devices.

e. Check operation of controller with various set points and system variable inputs; adjust controller proportional band, reset, and rate to conform to instructions from manufacturer's representative and Engineer.

f. Check operation of each instrument with system in actual operation.

g. Readjust controller settings as required to obtain desired control of the associated system variables.

3.04 Training:

A. Provide a minimum of 4 hours of training at the customer's facility for operations, maintenance and service personnel for each type of instrument provided.

1. The training session shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment.

2. Topics covered shall include safety, hardware layout and functions, power and control wiring, diagnostic indicators, keypad/display interface, faults, diagnostic tools, troubleshooting, and preventive maintenance.

3. Hands-on training shall be provided on equipment.

4. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.

B. The Owner at their option shall be allowed to video record all training sessions for future reference.

END OF SECTION

CITY OF CHATTANOOGA, TN
CITICO EMERGENCY PUMP STATION
INSTRUMENT LIST

A	B	C	D	E	F	G	H	I	J	K	L	M	N
INSTRUMENT TAG NUMBER		**TYPE**	**DESCRIPTION**	**FUNCTION**	**PROCESS CONNECTION(S)**	**MOUNTING**		**OUTPUT**	**RANGE/ SET POINT**	**ENGINEERING UNIT**	**XMTR TYPE**	**POWER**	**SPECIAL NOTES**
TRANSMITTER OR CONTROLLER	**ELEMENT**					**TRANSMITTER**	**ELEMENT**						
EBPS-LSH-101	N/A	FLOAT SWITCH	EBPS WIER DOWNSTREAM HIGH LEVEL BACKUP	LEVEL	IMMERSION	SUSPENDED	N/A	N.O. CONTACT	N/A	N/A	2-WIRE	LOOP	
EBPS-LSH-111	N/A	FLOAT SWITCH	EBPS WET WELL HIGH LEVEL ALARM	LEVEL	IMMERSION	SUSPENDED	N/A	N.O. CONTACT	N/A	N/A	2-WIRE	LOOP	
EBPS-LSL-112	N/A	FLOAT SWITCH	EBPS WET WELL LOW LEVEL ALARM	LEVEL	IMMERSION	SUSPENDED	N/A	N.O. CONTACT	N/A	N/A	2-WIRE	LOOP	
EBPS-LIT-101	N/A	FLEXIBLE LEAD GUIDED WAVE RADAR LEVEL TRANSMITTER	EBPS DIVERSION CHAMBER LEVEL	LEVEL	PROBE	FLANGE	FLEXIBLE LEAD	4-20mA	0 - 40	FEET	2-WIRE	LOOP	2
EBPS-LIT-102	N/A	RIGID LEAD GUIDED WAVE RADAR LEVEL TRANSMITTER	EBPS WIER DOWNSTREAM LEVEL	LEVEL	PROBE	FLANGE	RIGID LEAD	4-20mA	0 - 30	FEET	2-WIRE	LOOP	2
EBPS-LIT-111	N/A	FLEXIBLE LEAD GUIDED WAVE RADAR LEVEL TRANSMITTER	EBPS WET WELL LEVEL	LEVEL	PROBE	FLANGE	FLEXIBLE LEAD	4-20mA	0 - 40	FEET	2-WIRE	LOOP	2
PS-AIC-001	PS-AE-1	GAS DETECTION TRANSMITTER	PUMP STATION UPPER LEVEL SCREEN ROOM H2S	GAS DETECTION	N/A	WALL	REMOTE	AS INDICATED	10	PPM	5-WIRE	120 VAC	3,4
	PS-AE-2		PUMP STATION LOWER LEVEL SCREEN ROOM H2S	GAS DETECTION	N/A		REMOTE	AS INDICATED	10	PPM	5-WIRE		3,4
PS-AIC-002	PS-AE-3	GAS DETECTION TRANSMITTER	PUMP STATION DRYWELL H2S	GAS DETECTION	N/A	WALL	REMOTE	AS INDICATED	10	PPM	5-WIRE	120VAC	4
	PS-AE-4		PUMP STATION ELECTRICAL ROOM H2S	GAS DETECTION	N/A		REMOTE	AS INDICATED	10	PPM	5-WIRE		4
	PS-AE-5		PUMP STATION EQUIPMENT ROOM H2S	GAS DETECTION	N/A		REMOTE	AS INDICATED	10	PPM	5-WIRE		4
PS-AIC-003	PS-AE-6	GAS DETECTION TRANSMITTER	PUMP STATION LOWER LEVEL SCREEN ROOM COMBUSTIBLE GAS	GAS DETECTION	N/A	WALL	REMOTE	AS INDICATED	TBD	LEL	5-WIRE	120 VAC	3,4
	EBPS-AE-1		EBPS WETWELL COMBUSTIBLE GAS	GAS DETECTION	N/A		REMOTE	AS INDICATED	TBD	LEL	5-WIRE		3,4

NOTES:

1. 120VAC POWER SOURCE FOR INSTRUMENT TRANSMITTER SHALL BE SUPPLIED FROM WITHIN THE ASSOCIATED RTU CABINET.

2. PROVIDE TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS) FOR INSTRUMENT.

3. SHALL BE SUITABLE FOR INSTALLATION IN A CLASS I , DIVISION 2 LOCATION

4. SENSOR CONNECTION VIA MANUFACTURER'S CABLE

PART 1 - General

1.01 Summary

A. This Section includes the following types of Equipment:

1. Bridge crane.
2. Trolley hoist.
3. Crane rails.
4. Runway festoon cable.

B. General requirements for crane and hoist required are defined in this Specification.

C. Related Work Specified Elsewhere:

1. DIVISION 26 - ELECTRICAL.

1.02 References

A. Applicable Standards:

1. American Institute of Steel Construction (AISC):
    a. Code of Standard Practice for Steel Buildings and Bridges.
2. American National Standards Institute (ANSI/ASME):
    a. B30.2 - Overhead and Gantry Cranes (Top Running Bridge, Single or Multipole Girder, Top Running Trolley Hoist).
    b. B30.11 - Monorail and Underhung Cranes.
    c. B30.16 - Overhead Hoists (Underhung).
3. American Society for Testing and Materials (ASTM):
    a. A36 - Structural Steel.
    b. A48 - Gray-Iron Castings.
    c. A148 - Steel Castings, High-Strength, for Structural Purposes.
    d. A536 - Ductile-Iron Castings.
    e. A668 - Steel Forgings, Carbon and Alloy, for General Industrial Use.

      f. B766 - Electrodeposited Coatings of Cadmium.

4. Crane Manufacturers Association of America (CMAA):
    a. No. 70 - Specifications for Electric Overhead Traveling Cranes.
    b. No. 74 - Specification for Top-Running and Under-Running Single- Girder Electric Overhead Traveling Cranes.
5. Hoist Manufacturers Institute (HMI):
    a. HMI 100 - Standard Specifications for Electric Wire Rope Hoists.
6. Federal Specification (FS):
    a. RR-W-410 - Wire Rope.
7. Forging Industry Association Handbook.
8. Institute of Electrical and Electronics Engineers (IEEE).
9. Master Car Builder (MCB).
10. National Electrical Code (NEC), Article 610.
11. National Electrical Manufacturers Association (NEMA).
12. Society of Automotive Engineers (SAE).

1.03 Submittals

A. Submit as specified in DIVISION 01.

B. Include, but not limited to, the following:

1. Product Data:
    a. Specifications and manufacturer's data.
    b. Catalog cuts.
    c. Fabrication and erection Drawings, and details.
    d. Operation and maintenance manuals.

1.04 Quality Assurance

A. Provide the services of a factory representative to place cranes and hoists in service in the event it does not function in an acceptable manner, or in the event of erection difficulties requiring expert advice from the manufacturer.

1.05 Delivery, Storage, and Handling

A. Store and handle crane(s) to prevent warping or racking of members.

B. Protect all components from damage by weather and operations on the Site.

1.06 Data Sheets

A. For design criteria of trolley and hoist, see Data Sheets at end of this Section.

PART 2 - Products

2.01 Acceptable Manufacturers

A. Subject to compliance with requirements specified, provide products of one of the following:

1. Bridge Crane and Trolley Hoists:

    a. ACCO Material Handling Solutions.

    b. Shaw-Box.

    c. Detroit Hoist and Crane Company.

    d. Yale Hoists.

    e. Engineer-approved equal.

2.02 Single Girder Top Running Bridge Crane

A. General Requirements:

1. Conform to CMAA No. 74, ANSI B30.11, OSHA and as otherwise indicated.

2. Trolley hoists for use with these cranes shall be provided as indicated on Data Sheets and conform to Specifications for "Trolley Hoists," this Section.

B. Structural Design:

1. Conform to requirements for individual cranes as indicated on Data Sheets.

2. Steel shall conform to ASTM A36, ASTM A572 Grade 50, or ASTM A992 for all structural members. Welding shall conform to AWS D14.1.

3. Bridge shall consist of single main girder mounted on end trucks with all structure connections welded. Bridge girder shall have safety stops on each end to prevent over travel of trolley hoist. Bridge girders shall be welded steel box shape, standard wide flange or S shape beam. Camber and sweep shall be measured by the manufacturer prior to shipment.

4. End trucks shall be open channel-box/structural tube construction welded to form rigid member.

5. Bumper and Stops:

    a. Bumpers shall conform to CMAA-74, ASME 30-11, and OSHA.

    b. Bumpers shall be rigidly mounted and shall be designed and installed to prevent parts falling from the crane in the event of breakage.

    c. Trolley stops conforming to CMAA-74, ASME 30-11, and OSHA and shall be designed and provided by the crane supplier.

6. Crane shall be top running and hoist is underhung as indicated on Data Sheets.

7. Crane shall include bridge rail sweeps in accordance with CMAA-74.

8. Deflection requirements shall be in accordance with CMAA-74.

C. Mechanical Design:

1. Cranes shall be designed so that it is readily accessible for maintenance lubrication and inspection. Provide with all necessary lubrication fittings. Lubricate all bearings, gears, and other items requiring lubrication before placing crane in operation.

2. Wheels:

    a. Shall be design and supplied by the crane supplier in accordance with CMAA- 74 and as indicated below.

    b. Shall be forged steel and be single flanged for underhung hoist and double flanged for top-running cranes. Wheel axles shall be fixed or rotating axle type of forged steel or alloy steel.

    c. Wheels for trolleys capable of running on tapered or flat flange beams.

    d. Wheels shall turn on permanently-lubricated anti-friction spherical roller bearings, with minimum AFBMA L10 bearing life equal to the crane duty classification, but not less than 10,000 hours for electric drive cranes. Bearing enclosures shall exclude dirt and prevent leakage of oil and grease.

    e. Drive wheels shall be matched machine pairs.

    f. At least one wheel on each end truck shall be driven.

    g. Design shall prevent skewing and flange wear.

3. Crane drive:

    a. Crane shall be dual driven.

    b. Bridge drive motors shall be provided with brakes.

4. Pinions and gears shall be forged steel and designed in accordance with CMAA-74 and the American Gear Manufacture's Association quality class 5 or better. No underhung or worm gears shall be permitted for the bridge crane. Electric bridge drive shall use spur and helical gearing.

5. Bridge End Truck: Shall conform to CMAA-74 and the following;

    a. Bridge shall be supported by steel end trucks.

    b. Equalizer bridge trucks shall be used.

6. Couplings:

    a. Cross shaft couplings shall be steel.

    b. Coupling shall be flange type.

7. Bridge Drive:

    a. Electric drive where specified on Data Sheets.

        (1) Bridge travel shall be two-speed drive as specified on the crane data sheets with a maximum high speed of 80 ft./min.

        (2) Bridge crane shall be VFD controlled and set for two speed operation.

        (3) Bridge drive shall consist of motor driving through a reduction unit or units to wheels located on each end of the bridge. All bearings shall be provided with proper lubrication. Bearing enclosures to exclude dirt and prevent leakage of oil or grease.

        (4) Provide soft-start controllers for smooth start of bridge.

8. Bridge Brakes for Electric Drives:

    a. Conform to CMAA-74, OSHA, ANSI B30.11 and as specified.

    b. Magnetic ac or dc disc brake applied directly to the shaft of the bridge drive motor.

c. Shall stop the motion of the bridge within a distance in feet equal to 10% of the full-load speed in feet per minute when traveling at full speed with full load.

d. Bridge brakes shall have a minimum torque rating of 50% of the rated motor torque for indoor cranes and 100% of the rated motor torque for outdoor cranes.

e. The brake shall operate upon release of bridge travel from the controller or loss of current to bridge drive motor.

f. The brakes shall have removable discs for ac or dc disc brakes.

D. Electrical Design for Cranes with Electric Drives or Hoist Operation:

1. Electric Power:

a. 3 phase, 60 Hz, 460V.

b. Bridge drive motor shall be totally enclosed, nonventilated, squirrel cage "Class B" insulation rated 60 min., 80ºC temperature rise.

2. Controllers:

a. Type: Control systems may be magnetic, static, inverter (variable frequency) or variable voltage DC, as specified and in accordance with CMAA-70.

(1) Hoists shall be furnished with a control braking means, either mechanical or power.

(2) Mechanical type control shall be mechanical load brakes.

(3) Power type control shall be dynamic lowering, eddy-current braking, or regenerative braking.

b. Construction: Heavy and rugged, enclosed, with ventilated renewable contacts. Conform to appropriate NEMA standards.

c. Markings: Each controller shall be legibly marked with the crane component it controls, and indicator direction of motion.

d. Resistor shall be NEMA Class 160 minimum. Resistors shall provide the proper speed and torque as required by the control system used. Resistors shall be installed with adequate ventilation and with proper supports to withstand vibration and to prevent broken parts.

3. Control panels and junction boxes shall be enclosed in nonventilated enclosures conforming to NEMA Publication ICS 1 110 Type 3S for outdoor service

4. Trolley Hoist and Runway Electrification and Supports for Electric Cranes:

a. Type: Bridge crane electrical system for powering the hoist and trolley shall be Rigid "C" track festoon system with flat wire cross conductors for power and controls.

(1) "C" track to be minimum of 14-gauge galvanized steel.

b. Capacity: Sufficient to provide proper voltage from the point of electrical feed to crane operated at the far end of the runway which will be approximately indicated on Data Sheets.

c. Mounting: Mount on runway beams on building steel.

E. Operation and Control for Electric Cranes:

1. Operation by pendant.

a. Pendant cord and push button station shall be festooned from an adequate number of wheeled trolleys operating pendent support system.

b. Flexible festoon cable shall be Type SO or W suitable for 0ºF to 110ºF temperature range with oil-resistant outer jacket.

c. Arrange control for operation with top of Station 4 ft.-6 inches above floor line.

d. Provide individual push buttons to control crane bridge, main hoist, and trolley. Pendant shall also have "start-stop" button to actuate the main line contactor with torque reel.

e. Pendant shall be of nonconductive material.

f. Control voltage shall be 24V ac.

F. Paint System:

1. Paint system is specified in specification 099000 for outdoor and corrosive environment. Color shall be safety yellow or safety orange as specified.

a. Abbreviated coating systems placed here for your convenience:

(1) Surface preparation: SSPC-SP6 and profile depth 1.5-2.0 mils.

(2) 1st coat: Tnemec Epoxoline Series 66HS at 5.0-8.0 mils dry film thickness.

(3) 2nd coat: Endura-Shield II, Series 1074 at 2.0 mils dry film thickness.

2. Crane manufacturer shall submit to Engineer for approval the coating manufacturer’s product description, and application recommendations, and color samples. Submit to Engineer for information the Material Data Sheets, and coating application reports.

3. Furnish two gallons of finish paint for touch up by others after crane installation.

G. Accessories:

1. Placards: Rated capacity of bridge crane shall be indicated by placards on both sides of crane and in a position clearly visible from floor of operation.

2.03 Hoist with Electrified Trolley Drive

A. General Requirements:

1. Conform to ANSI/ASME B30.16 except as otherwise indicated.

2. Conform to requirements for individual cranes and trolley hoists as indicated on Drawings and Specifications.

3. Rated capacity shall be permanently marked one each side of unit.

B. Electric-Motor Operated Trolley Hoist:

1. Type:

    a. HMI Duty Class: H1.

    b. Electric, heavy-duty, lug-mount hoist.

    c. Standard or low headroom.

    d. Double-reeved, wire rope.

    e. Single-speed lift. 15 fpm.

    f. Trolley to be motorized type. Single-speed: 50 fpm.

    g. Manufacturer's models shall be as follows:

        (1) ACCO - Work Rated.

        (2) Coffing - Model WDT, WDGT, or WDMT.

        (3) Lift-Tech International, Inc. - Shaw-Box Series 700.

        (4) Yale - Cable King.

2. General Construction:

    a. Conform to HMI Standards.

    b. Unit shall have automatic weston mechanical load brake, automatic upper-limit switch, geared upper and lower hook travel limit switch, overload device, and safety hook latch.

c. Motor shall be fully enclosed, heavy-duty, with high starting torque.

d. Trolley shall be provided with electronic soft-start controllers for smooth starting.

e. Units shall be suitable for use on a bridge beam.

PART 3 - Execution

3.01 Preparation

A. Inspect all areas and surfaces for conditions detrimental to proper installation. Do not proceed with installation until conditions are satisfactory.

3.02 Installation

A. Provide a complete installation including all Materials and Equipment necessary for operation of the Equipment. Place all specified Equipment into operation, including machinery lubrication.

B. Install bridge crane, runway beams, crane rail, hoist and trolley level and in alignment.

C. Adjust Equipment to operate properly, including adjustment of stops to prevent overtravel, and tension to prevent travel when not in use.

D. Touch-up damaged paint surfaces with matching paint system same as used in the shop.

E. Lubricate all bearings, gears, and other items requiring lubrication before placing crane in operation.

3.03 Testing

A. Prior to initial use and at other intervals until date of acceptance, test operate and load test crane as required by Occupational Safety and Health Administration Part 1910.179.

B. Send copies of test report to Engineer and Owner and place on file at Project Site.

1. Testing shall be performed by Contractor or under direction of authorized persons.

END OF SECTION

TROLLEY HOIST ON MONORAIL BEAM - DATA SHEET

1. Quantity: 1
2. Locations: As indicated on Drawings.
3. Capacity: 5 ton
4. Required Hook Lift from Operating Floor: As indicated on Drawings.
5. Distance from Operating Floor to Underside of Monorail Beam: As indicated on Drawings.
6. Type and Size of Monorail Beam: As indicated on Drawings.
7. Operation: ☐ Indoors ☒ Outdoors ☐ Both
8. Trolley Drive: ☐ Push ☐ Hand chain ☒ Electric
9. Hoist:

   ☐ Hand chain ☒ Standard headroom ☐ Single reeved

   ☒ Electric ☐ Low headroom ☒ Double reeved

10. Trolley - Hoist Electrification:

    ☐ Cable reel ☐ Not required

    ☐ Insulated bar conductors ☒ Flexible conductors cable with cable trolleys

11. Connect to point of electrical feed as described below:

    A disconnect below the hoist location.

PART 1 - General

1.01 Related Documents

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

1.02 Summary

A. This Section includes the following:

1. Motors and accessories for process and other equipment.

2. Unless specified or indicated otherwise, motors 1/2-horsepower or smaller shall be single phase and motors 3/4 horsepower or larger shall be polyphase.

1.03 Related Requirements

A. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

1.04 Reference Standards

A. Applicable Standards:

1. American National Standards Institute (ANSI).

    a. ANSI B11.19 – Performance Criteria for Safeguarding.

2. American Bearing Manufacturers Association (ABMA).

    a. ABMA 9 – Load Ratings and Fatigue Life for Ball Bearings.

3. Institute of Electrical and Electronic Engineers (IEEE).

    a. IEEE 112 – Test Procedure for Polyphase Induction Motors and Generators.

4. National Electrical Manufacturers Association (NEMA):

    a. NEMA MG 1 – Motors and Generators.

1.05 Submittals

A. Submit as specified in Division 01.

B. Product Data: Submit the following as minimum:

1. Nameplate information consisting of the following:

        a. Manufacturer's name and serial number.
        b. Horsepower output.
        c. Temperature rise and method indicated.
        d. Maximum ambient temperature.
        e. Insulation class.
        f. Rpm at rated load.
        g. Frequency.
        h. Number of phases.
        i. Voltage.
        j. Rated load amperes.
        k. Locked rotor amperes or code letter.
        l. Service factor.
        m. Maximum noise level of pump/motor unit (dBA).
        n. Efficiency, determined in accordance with IEEE 112, Method B.
    2. Dimensions for enclosure and shafts.
    3. Weight.
    4. Bearing information.
    5. Schematic diagrams for motor and specified motor accessories.
    6. Certification from motor manufacturer for motors controlled by variable frequency drives that the motor is "Inverter Duty" complies with NEMA MG 1 - Part 31 for all operational load and speed conditions specified and required.

C. Test and Evaluation Reports:

    1. Factory test reports.
    2. Field test reports.

D. Closeout Submittals: Final documentation shall include the following as minimum:

    1. Operation and Maintenance Manuals including the following:
        a. Operation and maintenance manuals for all components furnished.

   b. Copies of all approved Product Data.

   c. Copies of all approved Test Reports.

   d. Warranty Information.

   e. Contractor Information.

1.06 Delivery, Storage, and Handling

A. Motors shall be packaged, skidded and shipped to prevent damage during shipment.

B. Stored motors shall be environmentally protected and maintained according to manufacturer’s recommendations.

C. If supplied, energize space heaters to prevent condensation within the motor enclosure.

PART 2 - Products

2.01 Submersible Motors

A. Vertical squirrel-cage induction type.

B. NEMA Design B, Class F insulation. Class H insulation shall be provided when recommended by manufacturer for the application.

C. Rated 460 volts, 3 phase, 60 hertz.

D. Variable frequency drive starting as indicated.

E. Motor shall be Inverter Duty rated for use with a variable frequency drive conforming to NEMA MG 1 Part 31.

F. Provide insulated motor bearings.

G. Totally enclosed construction suitable for submerged service.

H. When installed within hazardous areas motors shall be suitable for operation in Class I, Division 1 locations.

I. Rating:

   1. Ambient temperature: 40°C.

   2. Service factor: 1.15.

   3. Speed as specified or indicated for each piece of equipment driven.

   4. Adequate to drive equipment without using service factor except in emergency conditions.

5. Rated for continuous duty, capable of withstanding a minimum of 15 starts per hour.

J. Provide with water jacket cooling system, and include three disc-type temperature switches imbedded in the stator windings (one per phase) to stop motor on high-temperature conditions. Wiring included in the manufacturers provided pump cables.

   1. Motor supplier shall provide thermal sensing relay for integration into motor controls.

K. Provide water seal leak detectors between first and second mechanical seals with wiring included in the manufacturers provided pump cables.

   1. Motor supplier shall provide moisture sensing relay for integration into motor controls.

L. Motor shall be fitted with a PT100 sensor for continuous bearing temperature monitoring and over-temperature protection.

   1. Provide with temperature monitoring relay compatible with sensor provided for remote mounting and integration into the indicated motor controls.

      a. Motor manufacturer shall provide the required temperature setpoints for proper protection of motor supplied.

   2. Relay shall be designed for DIN-rail mounting.

   3. Provide sensor with sufficient length of cable to allow termination at the remote mounted temperature monitoring relay in the motor cable junction enclosure.

M. Supply cables for each pump of adequate length and a minimum of 75 feet to reach from the motor to the indicated motor terminating junction box when the motor is in operating position. Contractor shall coordinate required length with motor manufacturer.

N. Cable shall be coated with Hypalon or approved equal.

O. Provide stainless steel cable grips for each pump cable to relieve strain from cable exiting the junction box.

P. Manufacturer shall prepare surfaces, prime, and finish paint all surfaces with manufacturer's standard coating system. Coating system and color shall be suitable for intended services.

Q. Stainless steel data nameplate with all lubrication and electrical data located at each motor.

PART 3 - Execution

3.01 Installation

A. Install to conform to manufacturer's instruction.

B. Lubricate all bearings, gears and items requiring lubrication before placing equipment in operation.

3.02 Field Quality Control

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust motors, assemblies, and associated equipment installations, including connections.

B. Field Testing:

1. Provide manufacturer recommended testing prior to startup of motors.

2. Testing shall be performed in accordance with IEEE 112.

3. Check equipment ground to assure continuity of connections as specified in Division 26.

4. Measure the insulation resistance of the stator winding before applying voltage. Compare this measured value against the manufacturer's value. If there is no insulation resistance value furnished by manufacturer, use the following:

Motor Voltage	Insulation Resistance
600 volts and below	5 megohms

a. If measured resistance values are lower than above, record room temperature and humidity and submit readings to Engineer before energizing. Dry out motors as required by accepted method of application of external heat, and do not apply voltage to motor until substandard resistance condition is corrected. Megger readings are to be one-minute duration, using a 500V megger for all motors 600V and below.

5. After the motor is placed in operation, observe the motor for heating at the bearings or windings. If the motor appears to be running hot, notify Engineer.

6. Take motor full load amps readings on all phases.

7. Prepare all results and submit field testing and startup report to Engineer.

3.03 Finishes

A. Equipment coatings shall be free from scratches, rust, or other defects.

B. All damaged or defective coatings shall be repaired prior to final acceptance.

C. Field Painting:

1. Touch Up:
    a. Contractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.
    b. Field painting shall be performed based on manufacturer’s recommended procedures.
    c. Motor manufacturer shall furnish Contractor with an adequate quantity of touch-up paint to match the factory applied finish.

END OF SECTION

APPENDIX A -CONTRACTOR PERMIT APPLICATIONS

City of Chattanooga, TN
Land Development Office
Plans Review Services
1250 Market Street ● Suite 1000 ● Chattanooga, TN 37402
Phone: (423) 643-5800 Fax: (423) 643-5848

LAND DISTURBING PERMIT APPLICATION

Not Refundable

Permit No. ____________

Permit Fee ($30/acre - $100 minimum) $ 100
Double Fee, if applicable $____________
Residential Fill Fee $25.00 (if applicable) $____________
Technology Fee $ 10.00
Admin. Charge $ 5.00
Certificate of Occupancy Fee $____________
TOTAL FEE $ 115.00

Please Print Clearly or Type

Contract Value Of Work: $

Fee Adjustment: $ **Approved by**

PROPERTY ADDRESS

Number and Street Name	Suite / Unit Number	Zip Code
State Tax Map Number	Lot Number	Subdivision Name

Ownership is: ☐ Private ☐ Public (Government)

	Name		Mailing Address – Number, Street, City, ST & Zip Code	Telephone Number
Owner	First	Last		
	Company			E-mail Address:
Contractor	First	Last		
	Company		State Lic. # County Lic. # City Business Lic.#	Worker's Comp? Yes☐ Exempt ☐
Engineer	First	Last		
	Company		State Lic. # County Lic. # City Business Lic.#	E-mail Address:
Applicant / Agent	First	Last		
	Company or Relationship to Appl.			E-mail Address:

TYPE OF WORK
- ☐ New Construction
- ☐ Addition
- ☐ Alteration
- ☐ Clearing Only
- ☐ Excavation
- ☐ Grading Only
- ☐ Demolition Only
- ☐ Repair / Replace

PROPERTY OCCUPIED/USED AS ZONED
- ☐ Institutional
- ☐ Industrial
- ☐ Residential
- ☐ Commercial

Disturbed Acreage: _____
For sites 1 acre and over of a larger development, a NPDES Construction Stormwater Permit must be obtained before Issuance of this permit. Please attach a copy of this permit or Copy of the completed Notice of Intent (N.O.I.) to this Application.

NOI, NPDES or NOC: ☐ No ☐ Yes

Proposed Starting Date: _____
Projected Completion Date: _____
This permit will expire on this date if an Extension is not requested in writing within 30-days of termination.

LAND DISTURBING PERMITS ISSUED FOR FILLING IN ON ADJOINING, RESIDENTIAL ZONED PROPERTIES ARE VALID FOR A PERIOD OF ONE-YEAR FROM DATE OF ISSUANCE. IN ADDITION, SPECIAL REGULATIONS APPLY. SEE CITY ORDINANCE 10708.

Preconstruction Impervious Acreage = _____
Postconstruction Impervious Acreage = _____
Change in Impervious Acreage = _____
If construction results in an increase in impervious Acreage, provide a Hydrology Report from a TN P.E. (2 copies)

Hydrology Report: ☐ No ☐ Yes

PLANS REVIEW INFORMATION (For Office Use Only)
Zoning Classification: ________
Adjacent Zoning: ________
Conditional Zoning: ☐ No ☐ Yes
Ordinance/Resolution #: ________
Flood District: ☐ No ☐ Yes
Elevation: ________ ft.
FIRM Map No.: ________
Elevation Certificate: ☐ No ☐ Yes
Historic District: ☐ No ☐ Yes
Which Historic District? ________
COA: ________
Overlay District: ☐ No ☐ Yes
Fire District: ☐ No ☐ Yes
P.U.D.: ☐ No ☐ Yes

I certify under the penalty of law that I have examined and am familiar with the information submitted and believe the submitted information to be true and accurate. THE GRANTING OF THIS PERMIT DOES NOT AFFECT ANY RIGHTS THIRD PARTIES MAY HAVE PURSUANT TO DEED RESTRICTIONS, COVENANTS RUNNING WITH THE LAND, OR OTHER PRIVATE ARRANGEMENTS. Persons performing construction work under this permit must observe Tenn. Law. (Pub. Chap. 289 Acts of 1955) providing for precautions to be taken in vicinity of high voltage wires.

____
Property Owner or General Contractor (Print)

____
Company Name

Signature ______________________ Date ______________

This document becomes the Land Disturbing Activity Permit when signed for or by the Land Development Official and purchase receipt is attached.

By ________________________________.
Land Development Official

City of Chattanooga
Economic and Community Development
Land Development Office
1250 Market Street, Suite 1000
Chattanooga TN 37402
(423) 643-5800

Checklist for Simple Residential Land Disturbing Permit Application (1-2 lots or homes)

Site Address: __’____

APPLICANT INFORMATION	
Applicant name:	
Applicant Address:	,
Telephone number:	
Email Address:	
Date:	
Signature:	

CHECKLIST: PLEASE ANSWER ALL THE FOLLOWING ITEMS TO HELP SPEED YOUR REVIEW		
☐	Will there be any filling operations performed at this site?	
☐	Will there be any cutting of slopes or other excavation operations other than those minor excavations needed for footers & foundations performed at this site?	
☐	Will there be any retaining walls of four (4) feet or greater in height constructed at this site?	
☐	Will any slopes greater than 3:1 be disturbed at this site?	
☐	Will any slopes greater than 3:1 be created at this site?	
☐	Will the existing drainage be altered at this site?	
☐	Is this site adjacent to any Streams, Wetlands or other critical water resources?	
☐	Are you aware of any existing drainage problems/ issues at this site?	
☐	Will the scope of work at this site exceed the excavation of trenches for the foundation, basements, service and sewer connections, and minor grading for driveways, yard areas and sidewalks?	
☐	Will clearing of greater than 5,000 ft^2 of tree canopy be performed at this site?	
☐	Will the TOTAL disturbed acreage under this permit/ at this site be greater than one (1) acre?	
☐	Will this permit cover more than 2 lots/ home sites?	

CITY OF CHATTANOOGA

APPLICATION FOR TREE ORDINANCE PERMIT

Date: May 8, 2017

Tree Permit Fee	$50.00
Double Fee (if applicable) **	$ n/a
Technical Fee	$10.00
Administration Fee	$5.00
Total Fee	$65.00

TREE(S) LOCATION

*Address 929 Riverside Drive, Chattanooga, TN

Map ______ Group ______ Parcel ______

APPLICANT INFORMATION

*Applicant's Name Spencer Adams

Company: Burns & McDonnell Engineering Company as agent for the City of Chattanooga Public Works Dept.

Business License #________________

*Address: 3650 Mansell Road, Suite 300

City, State, Zip: Alpharetta, GA 30022

*Phone No.: 770-510-4562

Fax No.________________

*Email: sdadams2@burnsmcd.com

PERMIT DATES

Application Date: May 8, 2017
Start Date: August 1, 2017

Completion Date: August 1, 2018

This permit will expire on this date. Notice of Completion is required within five (5) days to allow for inspection by Urban Forestry Official.

TYPE OF CITY PROPERTY

1_____Street
2_____Alley
2_____Park
4__X_Other

TREE ORDINANCE PERMITS ARE VALID UNTIL COMPLETION DATE GIVEN ABOVE

This document becomes the tree ordinance permit when signed by the city forester and paid for at the Land Development Office. No debris will be permitted on adjacent properties or right-of-way.

Permit No. 17-40235

URBAN FORESTRY DIVISION
OFFICE OF CITY FORESTER

TYPE OF WORK

______1___ Approximate Number of Trees

1. __X__ Removal. Stump below surface of ground.
2. _____ Excavation or trenching within 10' radius.
3. _____ Prune.
4. _____ Disturb.
5. _____ Ground Disturbance within Drip Line.
6. _____ Spray. State Composition of spray material
7. _____ Fertilize. State composition of fertilizer.
8. _____ Plan. State location species, cultivar & planting method.

8 - NELLIE STEVENS HOLLY

ATTACH SITE PLAN

TREE PROTECTION MEASURES***

1. __X__ Protect designated trees with fence or frame.
2. _____ Install shield to protect tree trunk.
3. _____ Pruning. Comply with instructions of City Forestry Official. Clean-up site. Use No spikes.
4. _____ Protect Tree pits with intact straw bales.
5. _____ Prune damaged roots within 24 hours.
6. _____ Water the designated trees.
7. _____ Damaged trees must be repaired.
8. _____ Tree Replacements are required.

Specific Instructions: ________________

The Permittee shall perform all work in accordance with City Code Sec. 32-300 through 32-319 and all other applicable ordinances.

I certify under the penalty of law that I have examined and am familiar with the information submitted and believe the information to be true and accurate.

By: Spencer Adams Date 5/8/17
Applicant

By: Gene Hyde Date 5-10-17
City Forester
(423) ~~757-7283~~ 643 6839

* required information
**double fee for working without a permit
***See www.urbanforestrysouth.org/resources/library/tree-protection-bmps-for-contractors-and-builders/at_download/file for Chattanooga Tree Protection BMPs.

APPENDIX B -PERMITS PROVIDED BY CITY

TDEC and TVA Permits to be
Provided by Addendum

APPENDIX C -GEOTECHNICAL REPORT

Report of Geotechnical Exploration
Citico Pump Reliability Improvements
Chattanooga, Tennessee
S&ME Project No. 1281-17-015

Prepared for:
Burns & McDonnell
3650 Mansell Road, Suite 300
Alpharetta, Georgia 30022

Prepared by:
S&ME, Inc.
4291 Highway 58
Chattanooga, Tennessee 37416

April 12, 2017

S&ME

April 12, 2017

Burns & McDonnell
3650 Mansell Road, Suite 300
Alpharetta, Georgia 30022

Attention: Mr. Matt Bracewill, PE

Reference: Report of Geotechnical Exploration
Citico Pump Reliability Improvements
Chattanooga, Tennessee
S&ME Project No. 1281-17-015

Dear Mr. Bracewill:

This report presents the results of the geotechnical exploration for the Citico Pump Station site in Chattanooga, Tennessee. Our work was performed in general accordance with S&ME Proposal No. 121700072R dated February 17, 2017 and 121700072CO1 dated April 3, 2017.

This report describes our understanding of the project, presents the results of the field exploration and laboratory testing, and discusses our conclusions and recommendations. S&ME appreciates this opportunity to be of service to you. Please call if you have questions concerning this report or any of our services.

Sincerely,

S&ME, Inc.

David Grass

David Grass, PE
Project Engineer

DAVID MICHAEL GRASS
No. 114526
4/12/17

James P. McGirl, PE
Principal Engineer

Table of Contents

Appendices

Executive Summary

This summary is presented for the convenience of the reader. The full report text should be studied and understood before preparing an estimation of quantities or preparing designs based on this report, as it contains important information and recommendations that are not included in this brief summary.

1. The geotechnical exploration included drilling and sampling of five soil test borings. The samples collected during our exploration were returned to our Chattanooga laboratory where they were further evaluated by a professional engineer.

2. Natural moisture content and Atterberg limits laboratory tests were performed on selected samples to aid our soil classification and to evaluate the on-site soil's volume change potential. Grain size testing was performed to aid soil classification. Unconfined compression testing was performed to evaluate the soil's undrained shear strength.

3. Subsurface conditions generally consisted of fill underlain by alluvial soils to boring termination or auger refusal. The fill soils were typically composed of firm to stiff sandy clays or fat silty clays with varying amounts of chert fragments to depths of approximately 12 to 32 feet below the existing ground surface. Alluvial soils were typically composed of very loose to firm silty sands transitioning to sands and gravels to auger refusal depths.

4. Auger refusal was encountered in four of the five borings at depths ranging from about 16 ½ to 66 feet below the existing ground surface. Boring B-4 appears to have encountered auger refusal within the fill. The remaining boring, B-5, was terminated at a predetermined depth of 25 feet.

5. Groundwater was encountered in boring numbers B-1 and B-2 at the time of drilling. A temporary piezometer was installed in boring B-1 to obtain long term stable groundwater measurements. Control of groundwater will be vital to the project's successful completion.

6. A temporary sheet pile bracing system will be required to support the excavation side walls in areas where there is not sufficient room to properly slope the side walls to allow safe excavation access. Temporary sheet piling will also be used to reduce water infiltration into the excavation and prevent a quick condition where the excavation extends below the groundwater level.

7. The proposed pump station structure may be supported on spread footings bearing on the alluvial silty sands. Undercutting and stabilizing loose alluvial soils at the approximate bearing depth will be required prior to foundation and slab construction.

8. Mat foundations for the proposed generator and odor control unit may be supported on firm or better consistency, properly compacted fill soils. The bearing conditions at each of the foundation excavations should be observed by the geotechnical engineer or his representative. The purpose of these observations is to evaluate whether the bearing conditions are suitable for the design bearing pressure or if remedial measures will be required.

1.0 Introduction

S&ME, Inc. has completed the geotechnical exploration at the Citico Pump Station site in Chattanooga, Tennessee. Our work was performed in general accordance with S&ME Proposal Number 121700072R dated February 17, 2017 and 121700072CO1 dated April 3, 2017. Our services were authorized by Oko Buckle of Burns & McDonnell Engineering Company, Inc. on February 23, 2017, through execution of Burns & McDonnell Professional Geotechnical Consultant Agreement, as well as Amendment No. 001 to that agreement dated April 4, 2017.

Consolidation testing was part of our proposed services. However a Shelby tube sample suitable for consolidation testing was not obtained due to rock fragments in the sample intervals.

The purpose of our work was to explore the subsurface soil conditions and groundwater level, provide feasible shallow foundation recommendations, and provide applicable earthwork recommendations. This report describes our understanding of the project, presents the results of the field exploration and laboratory testing, and discusses our conclusions and recommendations relative to the above considerations.

The scope of our geotechnical services did not include an environmental assessment for evaluating the presence or absence of wetlands, or hazardous or toxic materials. Design of excavation shoring or other retaining walls was also outside the scope of our services.

A Site Location Plan, Boring and Subsurface Profile Location Plan, Subsurface Profile, Shear Wave Velocity Test Location Plan, and Shear Wave Velocity Profile are included in Appendix I. A discussion of the field investigative procedures, a legend of soil classification and symbols, and the Test Boring Records are included in Appendix II. Appendix III contains a discussion of the laboratory testing procedures and the laboratory test results. Appendix IV contains a document titled "Important Information About Your Geotechnical Engineering Report".

2.0 Site and Project Description

Our understanding of the project is based on information provided to us by Mr. Spencer Adams of Burns and McDonnell in the form of the following items:

- Technical guidelines for this project;
- Civil Site Plan with improvements superimposed, dated January 11, 2017; and,
- Original site plan and recommended excavation method drawings, both dated March 17, 1992.
- Overall site plan, Sheet C101, and Foundation Plan and Sections, Sheet S107, dated March 24, 2017.

2.1 Site Description

The site is the existing Citico Pump Station located at 975 Riverside Drive in Chattanooga, Tennessee. A Site Location Plan, Figure 1, showing the general project site location is provided in Appendix I. The site is occupied by the pump station, CSO Treatment Facility, and maintenance building. The Chattanooga Riverwalk is located between this site and the Tennessee River to the north. The site generally slopes from Riverside Drive on the south side down to the Tennessee River. Citico Creek empties into the river upstream and east of this site.

2.2 Project Description

The project will consist of the addition of an emergency backup pump station, a generator, and an odor control unit. The proposed emergency pump station will be constructed north of the existing pump station and the generator and odor control units will be constructed to the east of the existing pump station. The pump station will consist of a cast-in-place concrete structure with approximate plan dimensions of 63 feet by 19 feet and a depth below grade of about 40 feet (about elevation 620 feet msl). The generator and odor control units will be supported on mat foundations of approximate plan dimensions of 72 feet by 24 feet and 29 feet by 24 feet, respectively. We understand maximum contact pressures of less than 3,500 pounds per square foot (psf) for the pump station and 1,500 psf or less for the equipment pads.

Once specific structural loads have been developed by the structural engineer, S&ME, Inc. should be retained to review the design loads and our recommendations. At that time, it may be necessary to modify or amend the recommendations of this report.

3.0 Regional Geology

Chattanooga, Tennessee is located in the Valley and Ridge Physiographic Province. Elongated ridges that trend in a northeast-southwest direction characterize this province. The ridges are typically formed on highly resistant sandstones and shales, while the valleys and rolling hills are formed on less resistant limestone, dolomite, and shales.

Based on our review of the Geologic Map of Tennessee, dated 1963, bedrock of the Knox Group underlies the site. The Knox Group is composed of various dolomite and siliceous limestone members. The rock is generally medium to dark gray, very hard, fine to coarsely crystalline rock. Residual soils derived from the Knox Group are typically red-brown to yellow-brown clays with locally heavy amounts of chert fragments. The strata of the Knox formations weather to form a thick cherty overburden typically in excess of 40 feet thick. Given this site’s proximity to the Tennessee River, it appears that the residual soil interval has eroded and been replaced with alluvial deposits.

Limestone, such as the strata underlying this site, is of great geologic age and has been subject to solution weathering over geologic time. Rainwater falling onto the surface and percolating downward through the soil and into cracks and fissures gradually dissolves the rock, producing insoluble impurities such as chert and clay. Since limestone varies greatly in its resistance to weathering, the soil/bedrock contact may be extremely irregular. More soluble bedrock develops a thicker soil cover and a more irregular bedrock surface with pinnacles and slots, and less soluble bedrock usually develops a thinner soil cover and a less irregular soil-bedrock surface.

These large variations in bedrock depth are greatly enhanced by the presence of fractures, bedding planes, and faults, which provide an increased opportunity for a greater influx of percolating water. The weaknesses may form clay-filled cavities or enlarge into caves and may be connected by a network of passageways. If a cave forms close to the bedrock surface, its roof may collapse and the overlying soils may erode into the cave. Once the weight of the overlying soil exceeds the soil's arching strength, the soil collapses and an open hole or depression may appear at the ground surface. Such a feature is termed a sinkhole.

There is always some risk associated with developing any site underlain by carbonate bedrock. However, the test borings drilled at this site did not encounter open voids or other signs of incipient sinkhole conditions. We have reviewed the USGS quadrangle map for this area. The map does not show a pattern of closed depressions that would indicate past sinkhole activity in near proximity to the site. We also observed successful development in the surrounding area. Therefore, we believe the risk of sinkhole development for this project is no greater than for surrounding successfully developed sites.

4.0 Subsurface Conditions

4.1 Field Exploration Procedures

The procedures used by S&ME, Inc. and it's subcontractor for field sampling and testing are in general accordance with ASTM procedures and established engineering practice in the State of Tennessee. Appendix II contains brief descriptions of the procedures used in this exploration.

S&ME, Inc. subcontracted Tri-State Drilling, LLC to perform soil test borings at the site. Five soil test borings were drilled to obtain subsurface information at the project site. Members of our engineering staff established the actual boring locations in the field by measuring distances and estimating right angles relative to the existing structures. Boring elevations were obtained by superimposing boring locations onto the provided topographic site plan and interpolating between contours. Therefore, both the boring locations shown on Figure 2 – Boring Location Plan in Appendix I, and the elevations shown on the Test Boring Records in Appendix II, should be considered approximate.

Shelby tube soil samples were collected from selected depths and locations in conjunction with the drilling for subsequent laboratory testing. Many of the Shelby tube samples were damaged due to rock fragments along with the collection of large rock fragments in the sample interval. After each boring was completed, we measured the groundwater level, if present. A temporary piezometer was installed in boring B-1 to monitor delayed groundwater levels. The remaining borings were backfilled with a bentonite/grout mixture before leaving the site.

Our field representative packaged the soil samples in sealed containers, labeled them for identification, and returned them to the Chattanooga office where a geotechnical engineer further examined them. We visually classified the soils according to the Unified Soil Classification System (ASTM D 2488). The resulting soil descriptions are shown on the Test Boring Records in Appendix II. Samples were then selected for laboratory testing.

4.2 Soil Stratification

The results of our field testing program are summarized in the following paragraphs, and are shown on the Test Boring Records in Appendix II. These records present our interpretation of the subsurface conditions at specific boring locations at the time of our exploration. The stratification lines represent the approximate boundary between soil types. The actual transitions may be more gradual than implied.

SURFACE MATERIALS

Surface material consisting of asphalt and gravel or topsoil was encountered from the ground surface to depths ranging from about 7 to 10 inches in each of the borings.

FILL

Below the ground cover, fill was encountered in each of the borings to depths ranging from about 12 to 32 feet below the existing ground surface. Fill is material that has been transported to its present location by man. The fill was generally composed of red-brown and brown lean sandy clay or fat silty clay with varying amounts of chert fragments. Standard Penetration Test (SPT) N values in the fill ranged from 2 to 17 blows per foot, indicating a soft to very stiff soil consistency, but were typically in the firm to stiff range. The penetration data indicates the fill was subjected to compactive effort when placed. However, it appears that compaction may have been inconsistent. We have not been provided with documentation regarding how the fill was placed. The fill was not penetrated in boring B-4 above an auger refusal depth of about 17 feet below the existing ground surface.

ALLUVIUM

Alluvial soils were encountered in borings B-1, B-2, B-3, and B-5 below the fill to auger refusal. Alluvial soil is soil that has been transported to its present location by flowing water. The alluvial soils encountered at the site were typically composed of gray silty sand or brown and gray sandy clay transitioning to brown and red-brown sand and gravel. SPT N values in the granular alluvium ranged from 1 to 17 blows per foot, indicating a very loose to firm relative density. SPT N values in the fine grained alluvial soil ranged from 9 to 10 blows per foot, indicating a stiff soil consistency.

AUGER REFUSAL / BORING TERMINATION

Auger refusal was encountered in each of the test borings, except B-5. The depth of auger refusal ranged from about 16 ½ to 66 feet below the existing ground surface. Boring B-5 was terminated at a predetermined depth of about 25 feet.

4.3 Water Levels

The boreholes were observed for the presence of groundwater at the termination of boring. Groundwater was encountered in test borings B-1 and B-2 at a depth of about 30 feet below the ground surface at the time of drilling. A temporary piezometer was installed in Boring B-1 to obtain delayed groundwater level measurements. Delayed groundwater measurements were taken approximately 12 and 19 days after the termination of boring and are presented in the table below. We backfilled the remaining boreholes shortly after completion due to safety concerns, and therefore delayed groundwater level measurements were not obtained at these locations. It should be noted that groundwater levels can fluctuate with seasonal, climatic, and changes in elevation of the Tennessee River. Further, groundwater may be encountered at depths different from those identified in our borings in the future.

Table 1.0 – Groundwater Depths in Boring B-1

Date	Depth to Groundwater / Elevation (feet)
3/1/17 (At Time of Drilling)	30 / 630
3/13/17	25.5 / 634.5
3/20/17	25.6 / 634.4

5.0 Laboratory Testing

Laboratory tests were performed on representative split-spoon samples obtained during the field exploration phase of this project. We conducted moisture content and Atterberg limits tests on selected samples to aid our soil classification and to evaluate the relative volume change potential of on-site soils. The resulting soil descriptions are shown on the Test Boring Records in Appendix II.

In addition to the index property testing, grain size testing was performed to aid in soil classification. Unconfined compression testing was also performed to evaluate the soil's undrained shear strength. The laboratory test results and a brief description of the laboratory test procedures are presented in Appendix III.

Lastly, consolidation testing was proposed as part of our original scope of services. Four Shelby tube samples were obtained during our drilling activities. Of these Shelby tube samples, a sample suitable for consolidation testing could not be obtained due to the large amount of chert fragments within the soil sample.

6.0 Assessment

On the basis of this geotechnical exploration, we conclude that this site is adaptable for the proposed construction. In order to develop and adapt this site, a few items should be addressed during the planning, design, and construction phases of the project.

Site preparation should include stripping topsoil and paving materials from the construction area. These material should be disposed of offsite. We understand that the pump station excavation will be a combination of sloped excavation and shoring. Based on the type of soil encountered, excavations made in which workers will be entering should have side slopes no steeper than 1.5 Horizontal to 1 Vertical (1.5H:1V). Temporary sheet piling will be required for excavation support and groundwater control.

Even with the use of sheet piling, we expect dewatering of the excavation will be required. The necessary dewatering method will likely depend on the extent and depth to which sheet piling is utilized. If sheet piling is driven to the rock surface and fully encloses the proposed excavation, we expect dewatering can be accomplished through the use of a system of pumps and a sumps. If sheet piling does not extend to rock or fully encompass the excavation, a series of perimeter well points may be required to draw the groundwater level down below the bottom of the excavation including undercutting. It will be difficult to dewater the excavation using either alternative if sheet piling is only used on three sides of the excavation.

The subsurface conditions at the probable bearing elevation for the pump station are composed of very loose to loose alluvial silty sand. Based on the depth of the pump station foundation (approximately 40 feet) and the estimated soil shear strength, these soils are suitable to support the proposed structure using spread footings. Based on our analysis, spread footings may be designed using an allowable soil contact pressure of 3,500 pounds per square foot (psf).

We expect the preparation of a working platform will be required prior to the construction of the pump station slab due to the very loose relative density of the bearing soils. Some undercutting and replacement with large rock will be required to achieve a stable working platform as recommended in Section 7.2 of this report.

Washed stone, such as No. 57 or No. 67 stone, should be used as subsurface wall backfill. Use of wash stone will reduce the amount of compaction effort necessary. This will be particularly useful in deep, confined areas where worker safety is a primary concern. Washed stone placed in approximately 12 inch loose lifts and tamped with the bucket of a hoe naturally achieves 95 percent compaction.

Prior to receiving fill and once grade is achieved in the equipment pad areas, the subgrade should be thoroughly proofrolled. Proofrolling should be performed using a fully loaded tandem axle dump truck or a similar piece of equipment. Areas deflecting under the weight of the proofroll should be undercut to suitable soil as recommended by the geotechnical engineer. Areas where undercutting is performed should be backfilled as specified in the Section 8.2 of this report.

The proposed mat foundations for the generator and odor control units may be supported on a conventional mat foundations bearing in firm or better consistency existing fill soil to be evaluated at the time of construction. Evaluations of the existing fill should include a combination of proofrolling, hand augering, and Dynamic Cone Penetrometer (DCP) testing. Shallow foundations may be proportioned for a maximum allowable contact pressures of 1,500 psf or less. Foundation excavations should be observed by the geotechnical engineer or his representative prior to placing concrete.

7.0 Design Recommendations

7.1 Limitations of Report

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The conclusions and recommendations contained in this report are based on applicable standards of our practice in this geographic area at the time this report was prepared. No other warranty, expressed or implied, is made.

The analyses and recommendations submitted herein are based, in part, on the data obtained from the subsurface exploration. The nature and the extent of variations between the widely-spaced borings will not become evident until the time of construction. If variations appear evident, then we will re-evaluate the recommendations of this report. In the event any changes in the nature, overall design, or finished floor elevations, grades, or location of the pump house, generator, or odor control unit are planned, the conclusions and recommendations contained in this report will not be considered valid unless the changes are reviewed and the conclusions verified or modified in writing.

We recommend S&ME be provided the opportunity to review the final design plans and specifications in order that earthwork and other recommendations are properly interpreted and implemented. The recommendations in this report are contingent on S&ME, Inc.'s observation and monitoring of grading and construction activities.

7.2 Foundations

PUMP STATION

The subsurface exploration revealed that the subsurface soil conditions at the probable bearing depths are generally composed of loose alluvial silty sand or sand and gravel. Based on the depth of the pump station foundation (approximately 40 feet) and the estimated soil shear strength at the foundation bearing level, these soils are suitable to support the proposed structure using a mat foundation. Based on our analysis, the spread foundation may be designed using a contact pressure of 3,500 psf.

Although the subsurface conditions at the proposed bearing elevation are suitable for shallow foundation support, we expect undercutting of loose alluvial sands will be required to stabilize and construct a suitable working platform for foundation construction. The bearing soils should be undercut to a depth of about 2 feet below the proposed mat bearing elevation. The undercut area should then be stabilized with a layer of 9 to 12 inch rip-rap type stone compacted into the subsurface soils by tamping with a hoe bucket. A mud mat constructed of lean concrete can then be placed up to the proposed bearing elevations. This will provide for a level working platform, and will also aid in sealing groundwater from the bottom of the excavation.

Although computed footing dimensions may be less, we recommend that continuous footings be a minimum of 18 inches wide and isolated spread footings be a minimum of 36 inches wide to reduce the possibility of a localized punching shear failure.

The recommendations in this report are contingent on S&ME observing and evaluating the foundation excavations prior to placing concrete. Foundation subgrade observations should be performed by the geotechnical engineer, or his qualified representative, in order to confirm the recommendations provided in this report are consistent with the site conditions encountered. A Dynamic Cone Penetrometer (DCP) should be utilized to provide information that is compared to the data obtained in the geotechnical report. If unacceptable materials are encountered, the material should be excavated to stiff or better soils or remediated as recommended by the geotechnical engineer.

GENERATOR AND ODOR CONTROL UNIT

We understand that the proposed generator and odor control unit will be supported on mat foundations. The subsurface exploration revealed that the subsurface soil conditions at the probable bearing depths are suitable to support the mat foundations. Based on our analysis, mat foundations bearing on the existing soil fill may be designed using a contact pressure of 1,500 pounds per square foot or less. The fill soils should be evaluated at the time of construction by a combination of proofrolling, hand augering, and DCP testing.

The perimeter of the mat foundation should be constructed a minimum of 30 inches below subgrade, the seasonal moisture variation depth because of the on-site soil's shrink/swell potential with soil moisture variation. Constructing the foundation perimeter at this depth also provides adequate confinement and protection against frost penetration. As an alternative to this, we recommend the perimeter of the mat foundation be undercut to a depth of 30 inches below subgrade. The undercut should be about 2 feet wide at the bottom and slope up at a 1 Horizontal to 1 Vertical slope to the mat foundation. The undercut area should then be backfilled with a dense graded aggregate. This backfill should be placed in level lifts and compacted in accordance with the recommendations of Section 8.3 of this report.

Settlement has been calculated for typical shallow foundations designed, inspected, and constructed according to the recommendations of this report. Based on our analysis, we estimate total settlement of about 1 ½ inches for mat foundations designed for a bearing pressure of 1,500 psf. Mat foundations for the generator and odor control unit may be supported on property compacted fill and can be designed using a modulus of subgrade reaction of 15 pci.

Foundation excavations should be backfilled with concrete the same day they are opened. Footings should be poured "neat" to the excavation so that water cannot collect behind forms before backfilling. If soils exposed in the foundation excavations experience moisture variations prior to concrete placement, the affected bearing materials should be undercut as recommended by our geotechnical engineer. A 2- to 3-inch thick mud-mat of lean concrete may be used to protect the exposed support materials if the opened excavations cannot be backfilled with concrete the same day.

The recommendations in this report are contingent on S&ME observing and evaluating the foundation excavations prior to placing concrete. Foundation subgrade observations should be performed by the geotechnical engineer, or his qualified representative, in order to confirm the recommendations provided in this report are consistent with the site conditions encountered. A DCP, along with hand augering, should be utilized to provide information that is compared to the data obtained in the geotechnical report. If unacceptable materials are encountered, the material should be excavated to stiff or better soils or remediated as recommended by the geotechnical engineer.

7.3 Shrink/Swell Consideration

The onsite fill soils exhibit properties that are susceptible to volume change. Unlike other areas of the country where moderately to highly plastic soils cause considerable foundation problems, the Chattanooga area does not typically endure long periods of severe drought or wet weather. However, in order to minimize the potential effects of volume change due to moisture variation in the soil, specific considerations should be incorporated into the site design. The ground surfaces adjacent to slabs/foundations should be sloped away from the pad area. Also storm water drains should constructed in a way that the water discharges away from foundations. Irrigation systems and large trees should not be placed adjacent to structures. Section 8.2 Soil Plasticity contains additional recommendations that will reduce the volume change potential of soils during construction.

7.4 Groundwater

Based on the depth of groundwater in the temporary piezometer, groundwater control will be required to construct the proposed pump station. Groundwater can fluctuate depending on the season changes and elevation of the Tennessee River. We expect the installation of sheet piling in conjunction with sumps constructed inside the excavation can be used to control groundwater. It is imperative the excavation and sheet pie design consider quick conditions should the groundwater level increase significantly from that encountered in the piezometer.

7.5 Seismic Site Classification (IBC 2012)

S&ME performed Multi-Channel Analysis of Surface Waves (MASW) and Microtremor Array Measurements (MAM) testing at the locations shown on Figure 4 in Appendix I. The MASW survey consisted of recording different frequency surface waves generated from an active energy source (sledgehammer striking a metal plate) traveling across a linear array. The MASW survey was conducted using a Geometrics ES3000 seismograph equipped with sixteen 4.5 Hz vertical geophones. Measurements were collected with geophones at a set spacing of 7 feet. The MAM survey consisted of recording different frequency surface waves generated from a passive energy source (e.g. background noise, vehicles, etc.) traveling across a linear array. The MAM survey was conducted using a Geometrics ES3000 seismograph equipped with eleven 4.5 Hz vertical geophones. Measurements were conducted along an "L" shaped array using geophones at a set spacing of 30 feet. The analysis was conducted using the OYO Corporation's SeisImager/SW^{TM} software (Pickwin^{TM} and WaveEq^{TM}).

Velocity measurements were obtained to a depth of approximately 125 feet at the test location. Based on Sections 20 and Equation 20.4.1 of ASCE 7-05 (i.e. Probabilistic Seismic Hazard Assessment), the calculated weighted average Vs100-value for SW-1 is 1,017 feet per second (ft/s). Based on these results, potential structures built on the test site can be designed using a **Seismic Site Class D.** The velocity profile showing shear wave velocity (Vs; ft/s) versus depth (ft) for the test site is presented on Figure 5 in Appendix I.

Mapped spectral accelerations for short and long periods (ie. S_S and S_1) as determined by ASCE 7-10 have also been reviewed for the project site. Based on this review and the United States Geological Survey design maps, spectral accelerations of S_S equal to 37.5 percent and S_1 equal to 12.5 percent are considered appropriate for this project site.

7.6 Excavation Shoring and Bracing

We recommend an Occupational Safety & Health Administration (OSHA) soil class of C be assigned for determining the maximum slope for subsurface excavations. According to OSHA regulation, excavations made in soil type C in which workers will be entering are required to have side slopes no steeper than 1.5 Horizontal to 1 Vertical (1.5H:1V).

We understand the southern excavation wall will be the subsurface wall of the existing pump station. We also understand that the northern excavation may be an earth slope. Site constraints on the east and west sides of the proposed pump station will prohibit sloping of the excavation side walls. Therefore, temporary bracing will be required to prevent the collapse of excavation faces and to control groundwater. We recommend temporary sheet piling be used for excavation support. We recommend the general contractor's responsibilities for the design and construction of the wall system be clearly defined prior to beginning excavation at this site. Further, we recommend the shoring system design be prepared and sealed by a Tennessee registered engineer. S&ME can provide design support, if requested. Site safety and compliance with OSHA regulation remains a responsibility of the general contractor.

7.7 Below Grade Walls

Design below-grade walls to withstand lateral earth pressures induced on them. Subsurface walls that are fixed and not allowed to deflect under lateral loads should be designed using an at-rest lateral earth pressure coefficient (Ko). Subsurface walls that are free to deflect at the top should be designed using an active lateral earth pressure coefficient (Ka). The passive earth pressure (Kp) should be used when the structure is applying force the soil. The following are the recommended earth pressure coefficients based on the retained soil shear strength.

Table 2.0 – Subsurface Wall Design Values

Earth Pressure Coefficient	Equivalent Fluid Pressure (pcf)
Ka =0.4	48
Ko = 0.6	72
Kp = 2.3	276

The recommended values above are based on the estimated shear strength of the retained soil behind the sheet piling. The wedge of material between the sheet piling and a structure wall will not be of sufficient width to develop the shear strength properties of the backfill material.

We recommend the area between the sheet pile walls and pump station wall, or similar confined areas, be backfilled with ASTM No. 57 or 67 stone. No. 57 or 67 stone are washed stones of relatively uniform size. This gradation is recommended because it can be placed in 2 foot lifts and requires minimal compaction effort.

We recommend a friction angle of 18 degrees between the concrete and soil backfill. Surcharge loads or any loads that will be placed near the top of the wall should also be considered. Surcharge loads can include, but are not limited to, vehicle traffic, sloping backfill, equipment loads, etc. Apply appropriate factors of safety to these loads before designing the wall structure.

8.0 Construction Considerations

8.1 Site Preparation

DEMOLITION

Prior to construction, abandoned utilities should be removed and replaced with compacted fill. Active utilities should be relocated outside the emergency backup pump station or equipment pad areas. If pipes are not removed from beneath the proposed construction, they may serve as conduits for subsurface erosion that could result in the formation of voids or depressions, with adverse effects on the foundations and floor slabs.

STRIPPING AND UNDERCUTTING

Topsoil and asphalt paving materials should be stripped from the construction area and disposed of off-site. The depth of the topsoil encountered in the borings ranged from about 7 to 9 inches. Asphalt and gravel was measured to be about 9 to 10 inches thick.

GENERAL

After completion of stripping in areas to receive fill, and once grade is achieved in cut areas, we recommend proofrolling the exposed surface of the subgrade soils. The purpose of proofrolling is to locate pockets of soft or unstable soils. Proofrolling should be performed using a fully loaded dump truck or other heavy equipment approved by our geotechnical engineer. The proofrolling operation should traffic the site with parallel passes of the vehicle starting at one side of the building pad and continuing to the other. Each pass should overlap the preceding pass to ensure complete coverage.

An engineer from S&ME should be present to observe the proofrolling operations and to provide recommendations should unstable soils be encountered. In general, unstable materials should be undercut until stable materials are exposed. Backfill should consist of compacted soil as described in Section 8.3 of this report. After proofrolling and prior to placing fill on the site, the upper surface soils should be scarified and properly compacted.

Subgrade repair can be expected to be more extensive if grading operations are performed during wet periods of the year. The onsite soils are moisture sensitive and will be softened by rubber-tired construction traffic when wet. Once areas that need remediation have been repaired, the site may be brought to grade with structural fill. Depending on climatic conditions and the speed of contractor activities during the grading phase of this project, proofrolling may be required on multiple occasions.

8.2 Soil Plasticity

Soils with a plasticity index (PI) of less than 30 are generally considered slightly susceptible to volume changes while soils with PI’s greater than 50 are generally considered to be highly susceptible to volume changes. Soils with PI’s between 30 and 50 are generally considered to be moderately susceptible to volume changes. The soils we tested from this site fall in the slightly to moderately susceptible range, with PIs ranging from 23 to 36.

Soil volume changes in East Tennessee are generally not as severe as in other areas because lengthy periods of continuously wet or continuously dry weather do not usually occur. However, during periods of dry weather, it is not uncommon for significant drying of soils to occur. If these soils become saturated after foundation or grade slab construction is completed, there is the possibility of structural distress associated with swelling soils. Likewise, should the foundation bearing soils dry substantially after construction, there is the possibility of structural distress associated with soil shrinkage. Therefore, the following construction precautions are recommended for sites where moderately to highly susceptible soils are found:

- Surface water should not be allowed to pond or saturate soils during or after construction;
- High plasticity clays should not be used for backfill materials;
- Foundation concrete should be poured the same day the foundation excavation is made;
- Foundation soils should be isolated from heat sources to prevent drying of the foundation soils; and,
- Plantings with high water demands should not be planted near foundations.

8.3 Fill Placement

MATERIALS

Fill soils should consist of low to moderately plastic clay or silt with a plasticity index of less than thirty (PI<30) and a standard Proctor maximum dry density greater than 95 pounds per cubic foot. The fill should contain no rock fragments larger than 4 inches in any dimension, and no organic matter.

Soil fill operations should not begin until representative samples of proposed fill soils are collected and tested. The test results will be used to assess whether the proposed fill material meets the previously discussed plasticity and density criteria, and for quality control during grading. Please allow at least 3 to 5 days for testing before the fill operations begin.

Subgrade walls should be backfilled compacted aggregate such as No. 57 or No. 67 stone. Worker safety is the primary concern to allow for rapid backfill without compaction testing. We recommend observation of compacted aggregate placement by our engineering technician to determine the maximum lift thickness and compaction method necessary to obtain suitable compaction.

COMPACTION

Fill should be placed in thin lifts with a maximum loose thickness of 8 inches, then compacted to 95 percent of the standard Proctor maximum dry density, with a moisture content within 3 percent of the optimum moisture content, depending on the shape of the Proctor curve. Wetting or drying of these soils may be required, depending on the time of year site grading is performed. We recommend the top one foot below grade supported slabs be compacted to 100 percent standard Proctor compaction. The edge of the compacted fill should extend at least 10 feet beyond the outside foundation or slab edges before sloping. A representative of S&ME should test the density and moisture content of each lift before placing additional lifts.

8.4 Drainage and Runoff Concerns

In the Tennessee Valley Region, frequent and sometimes substantial rainfalls occur from November through May. These rainy months can greatly influence the cost and schedule of construction projects, particularly earthwork and work in confined excavations. The moderate plasticity clay soils present at the site will be difficult to work in periods of wet weather. Construction traffic repeatedly crossing exposed wet soil subgrades can damage the subgrades to the point that over-excavation may be required.

The contractor should be prepared to provide adequate methods to control the infiltration of surface water into open excavations. We recommend subgrades be sufficiently sloped to provide rapid drainage. Water that collects in excavations should be removed as soon as possible to prevent softening the subgrade soils.

Maintenance of the exposed subgrade surface will be important to achieve moisture control and to prevent softening of the surface soils due to rainwater infiltration. We recommend keeping the ground surface free from depressions or ruts that would hold water, and sealing the surface using rubber tired equipment to reduce water infiltration.

9.0 Other Considerations

Testing for soil pH levels was outside the original scope of our services. However, corrosivity of subsurface pipes is typically not a concern with the soils in this geological setting and similar to those encountered onsite.

10.0 Follow-Up Services

Our services should not end with the submission of this geotechnical report. S&ME should be kept involved throughout the design and construction process to maintain continuity and to determine if our recommendations are properly interpreted and implemented. To achieve this, we should review project plans and specifications with the designers to see that our recommendations are fully incorporated and have not been misinterpreted. We also should be retained by the owner to monitor and test the site preparation and foundation construction.

S&ME's familiarity with the site and foundation recommendations makes us a valuable part of your construction quality assurance team. S&ME recommends that we be retained by the owner on a full time basis to observe earthwork and foundation construction. Our personnel are uniquely qualified to recognize unanticipated ground conditions and can offer responsive remedial recommendations should these unanticipated conditions occur.

Appendix I -

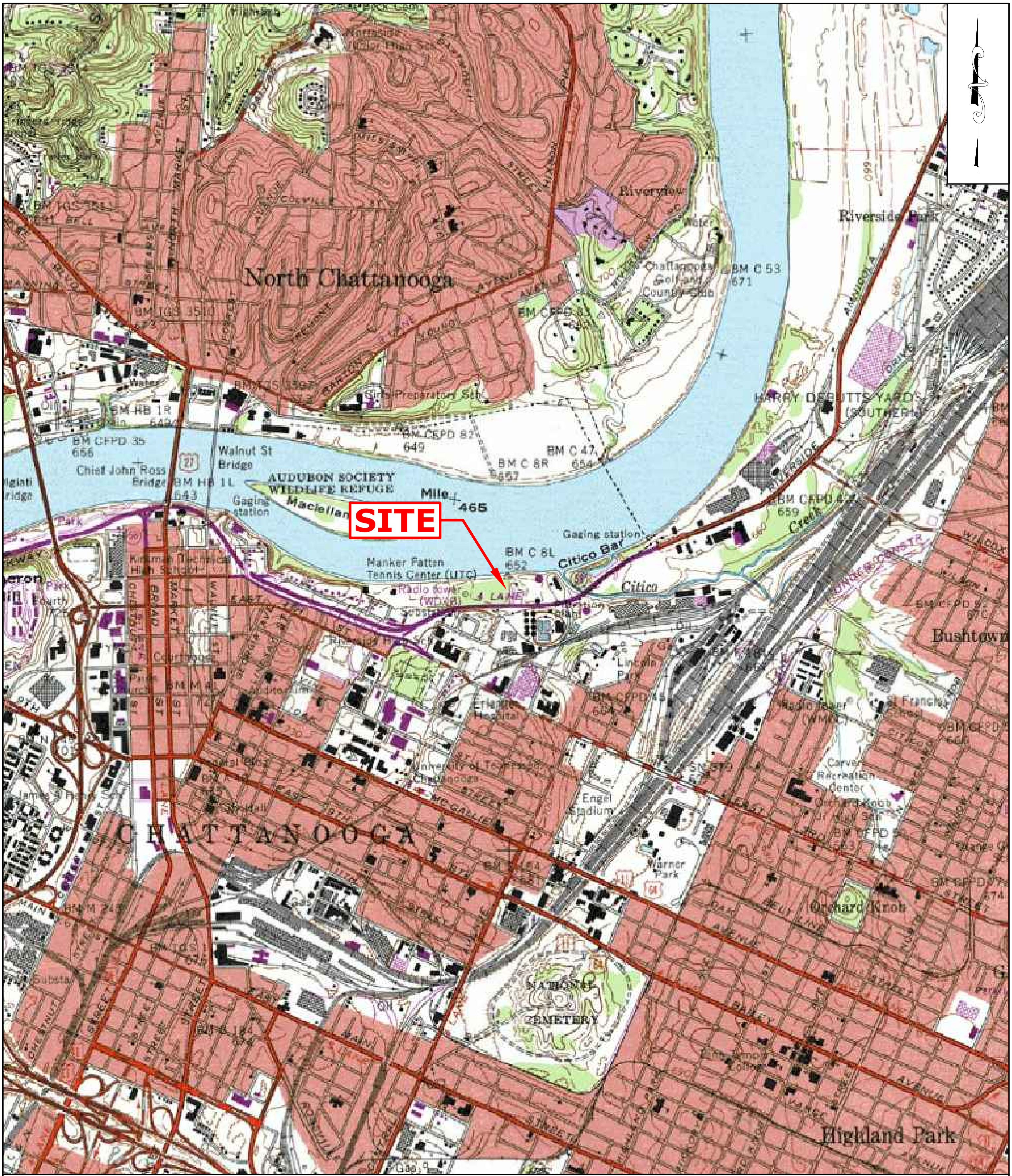
Figure 1 - Site Location Plan

Figure 2 - Boring and Subsurface Profile Location Plan

Figure 3 – Subsurface Profile

Figure 4 – Shear Wave Velocity Test Location Plan

Figure 5 – Shear Wave Velocity Profile



SOURCE: USGS 7.5 Minute Topographic Map -- CHATTANOOGA, TENNESSEE (1976)
DRAWING FOR ILLUSTRATION PURPOSES ONLY

S&ME

SITE LOCATION PLAN
CITICO PUMP RELIABILITY IMPROVEMENTS
CHATTANOOGA, TENNESSEE

JOB NUMBER:	1281-17-015	**APPROXIMATE SCALE:**	1"=2000'
DRAWN BY:	JLN	**CHECKED BY:**	DMG
DATE:	3/17/2017	**FIGURE:**	1

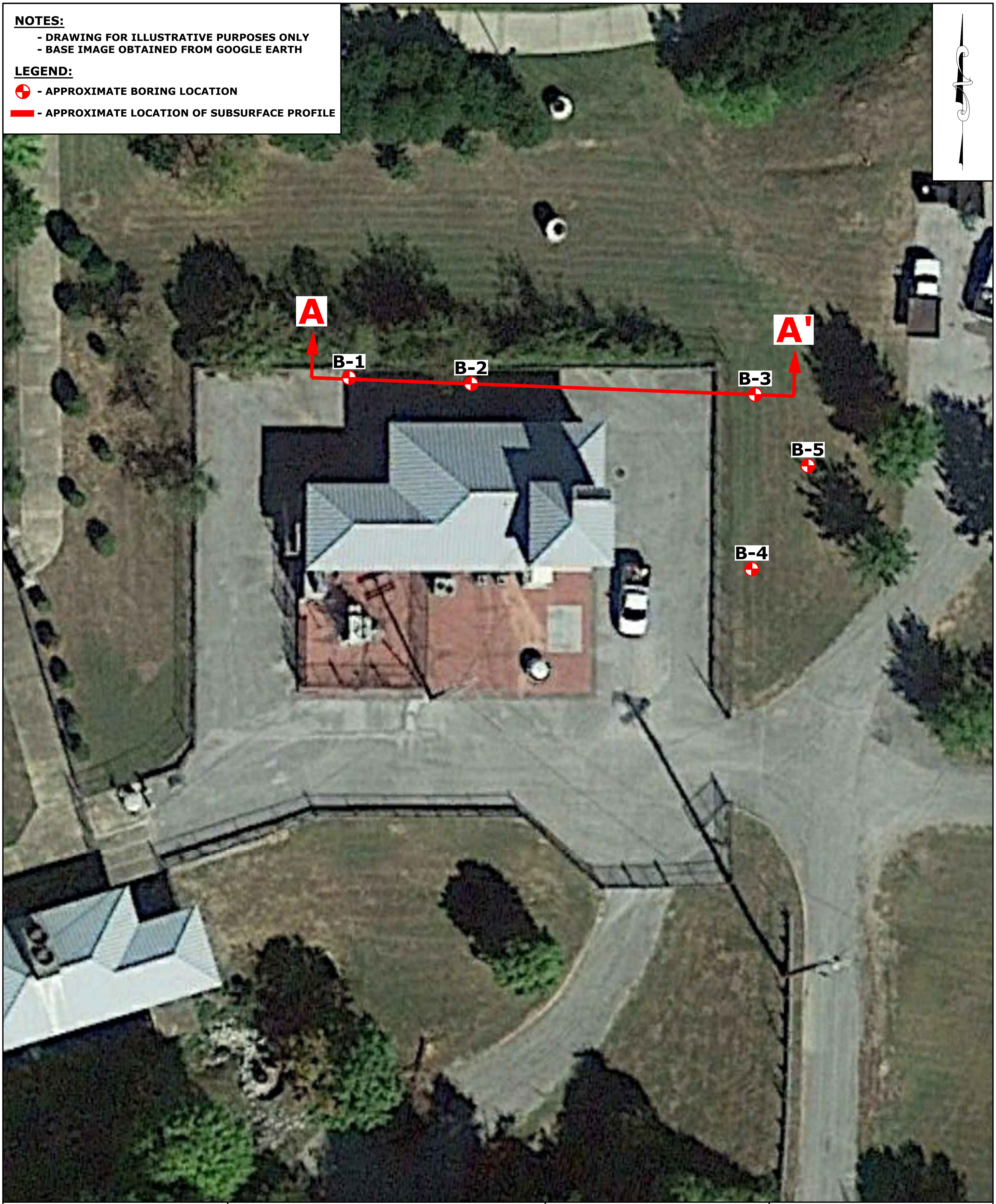
NOTES:

- DRAWING FOR ILLUSTRATIVE PURPOSES ONLY
- BASE IMAGE OBTAINED FROM GOOGLE EARTH

LEGEND:

⊕ - APPROXIMATE BORING LOCATION

▬ - APPROXIMATE LOCATION OF SUBSURFACE PROFILE

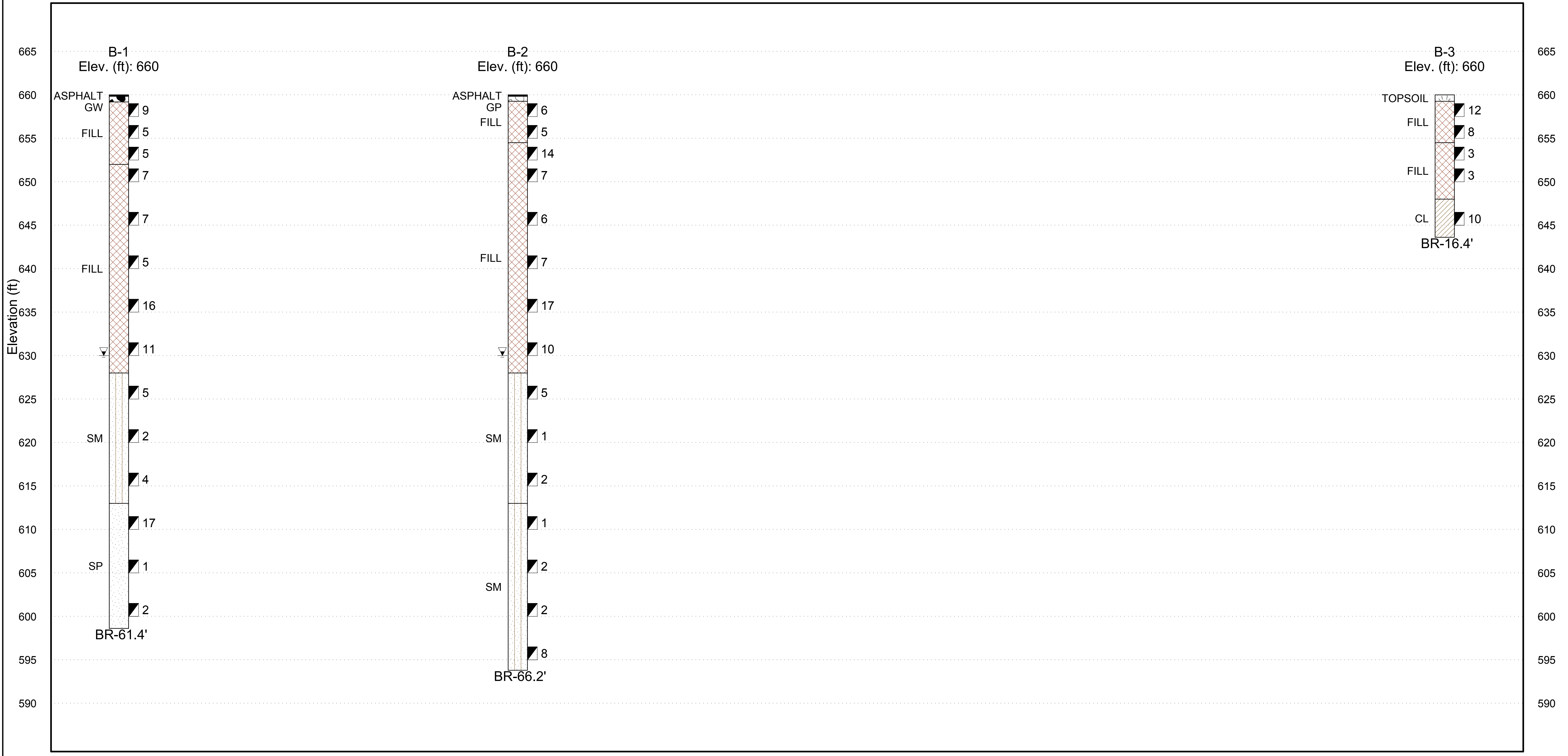


S&ME

BORING LOCATION AND SUBSURFACE PROFILE PLAN

CITICO PUMP RELIABILITY IMPROVEMENTS
CHATTANOOGA, TENNESSEE

JOB NUMBER:	1281-17-015	**APPROXIMATE SCALE:**	1"=30'
DRAWN BY:	JLN	**CHECKED BY:**	DMG
DATE:	3/17/2017	**FIGURE:**	2



Lithology Graphics

- ■ Asphalt (ASPHALT)
- ▨ USCS Well-graded Gravel (GW)
- ▨ Fill (made ground) (FILL)
- ▨ USCS Silty Sand (SM)
- ▨ USCS Poorly-graded Sand (SP)
- ▨ USCS Poorly-graded Gravel (GP)
- ▨ Topsoil (TOPSOIL)
- ▨ USCS Low Plasticity Clay (CL)

▽ WATER TABLE AT TIME OF EXPLORATION

BR - BORING REFUSAL (AUGER REFUSAL)

Burns and McDonnell

S&ME

DATE:
3/23/2017

JOB NO
1281-17-015

FIGURE:
4

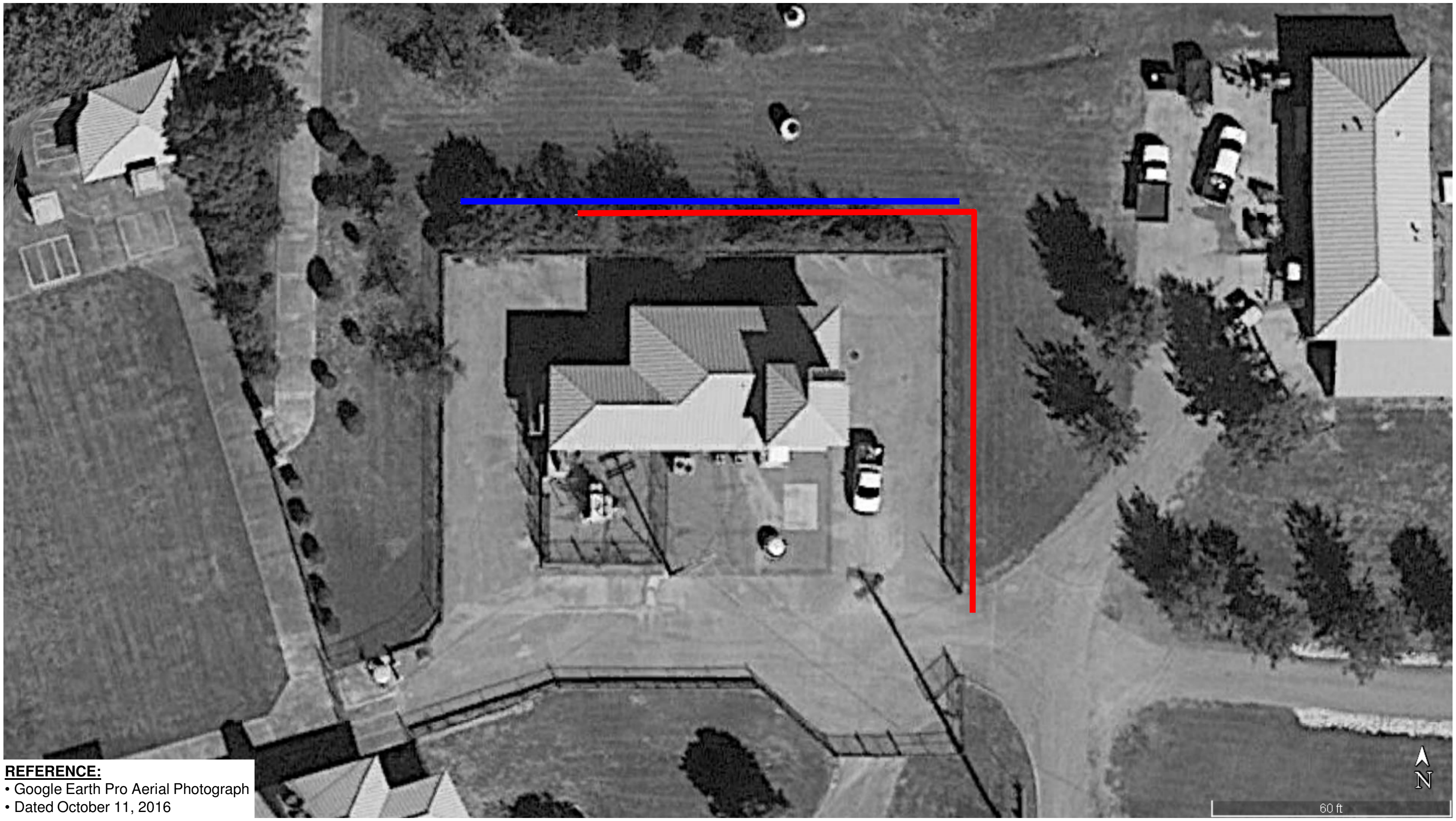
Subsurface Profile A-A'

Citico Pump Reliabitiy Improvements
Chattanooga, Tennessee

BORING PROFILE - ELEV CITICO PUMP STATION.GPJ 2016.GDT 3/23/17

🟥 Approximate Location of MAM

🟦 Approximate Location of MASW



REFERENCE:
- Google Earth Pro Aerial Photograph
- Dated October 11, 2016

SCALE:	AS SHOWN
DRAWN BY:	JBC
CHECKED BY:	DMG
DATE:	4/10/2017

S&ME

SHEAR WAVE VELOCITY TEST LOCATION PLAN

Citico Pump Reliability Improvements

Chattanooga, Tennessee

PROJECT NO.: 1281-17-015

FIGURE NO.

4

S&ME

Shear Wave Velocity Profile SW-2
Citico Pump Station
Chattanooga, Tennessee
1281-17-015

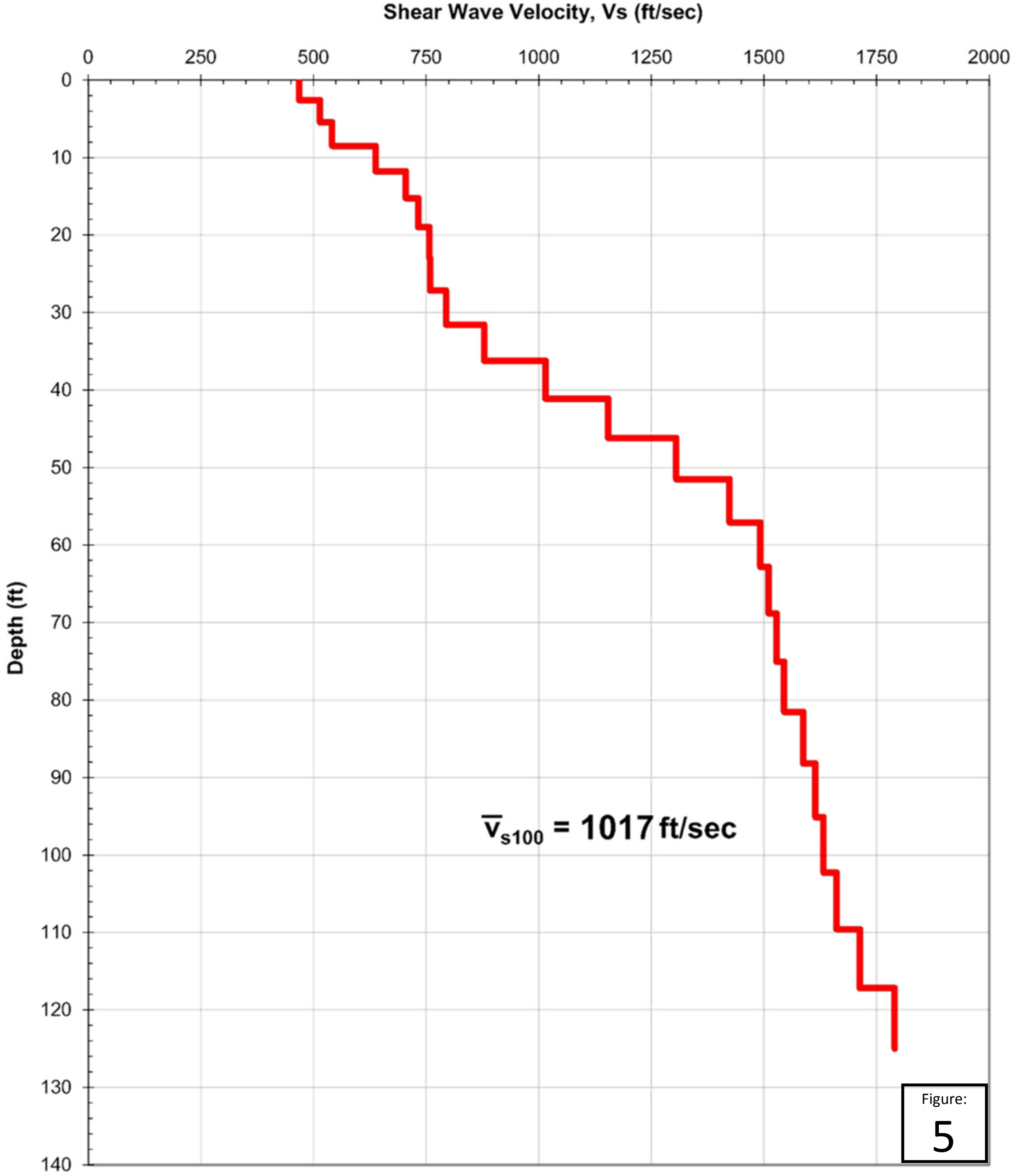


Figure:
5

Appendix II

Field Exploration Procedures

Test Boring Record Legend

Test Boring Records

HOLLOW STEM AUGERING PROCEDURES WITH STANDARD PENETRATION RESISTANCE TESTING

ASTM D 1586

The borings were advanced using auger drilling techniques. At regular intervals, soil samples were obtained with a standard 1.4-inch I.D., 2.0-inch O.D., split-tube sampler. The sampler was initially seated 6 inches to penetrate any loose cuttings and then driven an additional foot with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot is the standard penetration resistance. Standard penetration resistance, when properly evaluated, is an index to the soil's strength and density. The criteria used during this exploration are presented on the Test Boring Record Legend.

Representative portions of the soil samples, thus obtained, were placed in sealed containers and transported to the laboratory. The engineer selected samples for laboratory testing. The Test Boring Records in this Appendix provide the soil descriptions and penetration resistances.

Soil drilling and sampling equipment may not be capable of penetrating hard cemented soils, thin rock seams, large boulders, waste materials, weathered rock, or sound continuous rock. Refusal is the term applied to materials that cannot be penetrated with soil drilling equipment or where the standard penetration resistance exceeds 100 blows per foot. Core drilling is needed to determine the character and continuity of the refusal materials.

UNDISTURBED SAMPLING PROCEDURES

ASTM D 1587

Relatively undisturbed samples were obtained for laboratory testing. A 3-inch O.D., 16-gauge, steel tube was slowly and uniformly pushed into the soil at the desired sampling level. The tube was then removed from the ground and the encased soil was sealed at the ends to prevent loss of moisture. The depth at which undisturbed samples were taken is indicated on the Test Boring Records.

MULTI-CHANNEL ANALYSIS OF SURFACE WAVES AND MICROTREMOR ARRAY MEASUREMENTS

The analysis of surface waves (R-waves) can be used to determine shear-wave velocities (Vs) as surface waves are fundamentally similar in behavior to shear waves (S-waves) and surface waves propagate to depths that are proportional to their frequencies. The recorded surface waves are converted from time domain into frequency domain, from which the phase characteristics of the surface waves can be calculated. A dispersion curve is developed allowing the phase velocity (Cf) of particular frequency waves to be calculated. Through a complex inversion process, a shear wave-velocity profile is developed. The combination of Multi-Channel Analysis of Surface Waves (MASW) and Microtremor Array Measurements (MAM) provides the greater depth of penetration using microtremor analyses (low frequency surface waves) without sacrificing resolution at shallower depths from MASW (higher frequency surface waves). Both surveys can be performed on soil and/or pavement surfaces.

Depth of penetration using surface wave methods is mainly controlled by the shear properties of the subsurface materials and frequency range of site surface waves (generated active or ambient passive). Generally, penetration depth is greater for stiffer profiles as the signal does not attenuate as rapidly. However, because relatively low energy sources are required to determine the shear wave velocity of soils, sometimes velocities of underlying very stiff materials (competent rock, etc.) are difficult to obtain using traditional active or ambient sources.

TEST BORING/PIT RECORD LEGEND

FINE AND COARSE GRAINED SOIL INFORMATION

COARSE GRAINED SOILS (SANDS & GRAVELS)

N	Relative Density
0-4	Very Loose
5-10	Loose
11-20	Firm
21-30	Very Firm
31-50	Dense
Over 50	Very Dense

FINE GRAINED SOILS (SILTS & CLAYS)

N	Consistency	Qu, KSF Estimated
0-1	Very Soft	0-0.5
2-4	Soft	0.5-1
5-8	Firm	1-2
9-15	Stiff	2-4
16-30	Very Stiff	4-8
Over 31	Hard	8+

PARTICLE SIZE

Boulders	Greater than 300 mm (12 in)
Cobbles	75 mm to 300 mm (3 to 12 in)
Gravel	4.74 mm to 75 mm (3/16 to 3 in)
Coarse Sand	2 mm to 4.75 mm
Medium Sand	0.425 mm to 2 mm
Fine Sand	0.075 mm to 0.425 mm
Silts & Clays	Less than 0.075 mm

The **STANDARD PENETRATION TEST** as defined by ASTM D 1586 is a method to obtain a disturbed soil sample for examination and testing and to obtain relative density and consistency information. A standard 1.4-inch I.D./2-inch O.D. split-barrel sampler is driven three 6-inch increments with a 140 lb. hammer falling 30 inches. The hammer can either be of a trip, free-fall design, or actuated by a rope and cathead. The blow counts required to drive the sampler the final two increments are added together and designate the N-value defined in the above tables.

ROCK PROPERTIES

ROCK QUALITY DESIGNATION (RQD)

Percent RQD	Quality
0-25	Very Poor
25-50	Poor
50-75	Fair
75-90	Good
90-100	Excellent

ROCK HARDNESS

Very Hard:	Rock can be broken by heavy hammer blows
Hard:	Rock cannot be broken by thumb pressure, but can be broken by moderate hammer blows.
Moderately Hard:	Small pieces can be broken off along sharp edges by considerable hard thumb pressure; can be broken with light hammer blows.
Soft:	Rock is coherent but breaks very easily with thumb pressure at sharp edges and crumbles with firm hand pressure.
Very Soft:	Rock disintegrates or easily compresses when touched; can be hard to very hard soil.

$$\text{RQD} = \frac{\text{Sum of 4 in. and longer Rock Pieces Recovered}}{\text{Length of Core Run}} \text{ X100}$$

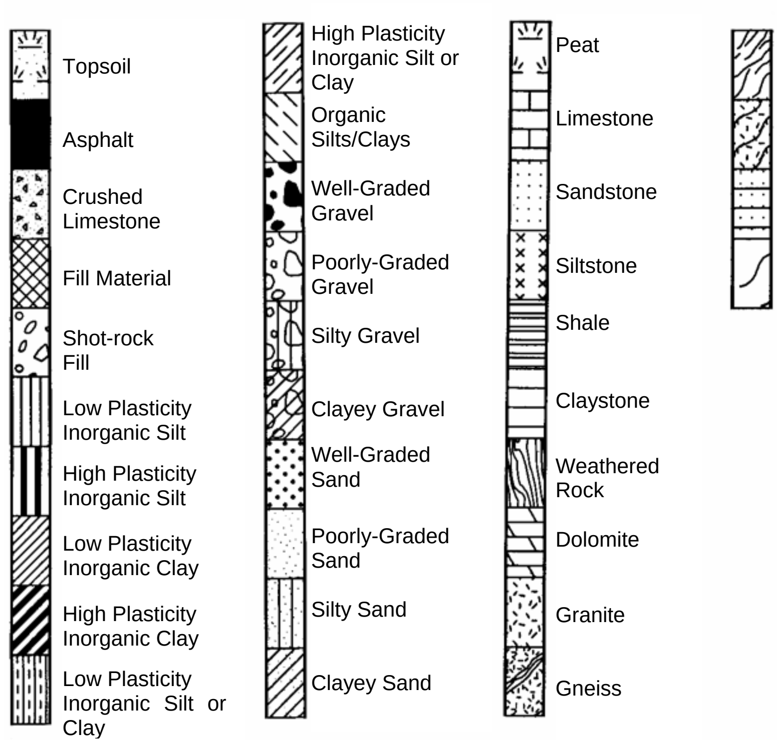
$$\text{Recovery} = \frac{\text{Length of Rock Core Recovered}}{\text{Length of Core Run}} \text{ X100}$$

43 RQD
NQ
63 REC

Core Diameter	Inches
BQ	1-7/16
NQ	1-7/8
HQ	2-1/2

SYMBOLS

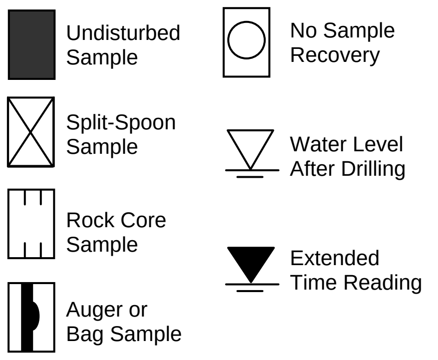
KEY TO MATERIAL TYPES



SOIL PROPERTY SYMBOLS

N:	Standard Penetration, BPF
M:	Moisture Content, %
LL:	Liquid Limit, %
PI:	Plasticity Index, %
Qp:	Pocket Penetrometer Value, TSF
Qu:	Unconfined Compressive Strength Estimated Qu, TSF
γ_D:	Dry Unit Weight, PCF
F:	Fines Content

SAMPLING SYMBOLS



4291 Highway 58
Chattanooga, Tennessee 37416

TEST BORING RECORD

BORING NO.: B-1

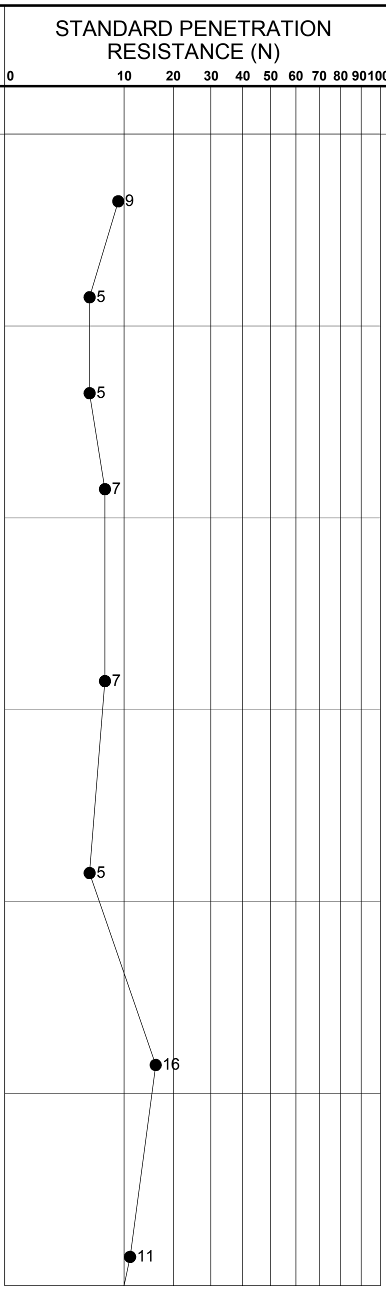
PROJECT: Citico Pump Reliabitiy Improvements	JOB NO: 1281-17-015	SHEET 1 OF 3
PROJECT LOCATION: Chattanooga, Tennessee		

ELEVATION: 660 feet ±	BORING STARTED: 3/1/2017	RIG TYPE:CME-550	BORING DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 3/1/2017	HAMMER: Automatic	

GROUNDWATER:
▽ 30 feet ATD
▼ 25.5 feet on 3/13/17
▼ 25.6 feet on 3/20/17

Remarks:

ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	M	BLOWS/6"
660.0	0				
659.8	0.17'	ASPHALT - 2 inches			
659.2	0.82'	CRUSHED STONE - 8 inches			
		SANDY CLAY (CL) with chert fragments, brown and red-brown, firm	FILL	20.1	4 - 5 - 4 **(9)**
				27.4	2 - 2 - 3 **(5)**
				27.5	2 - 2 - 3 **(5)**
652.0	8'	SILTY CLAY (CH) with chert fragments, red-brown, moist, firm, very stiff, and stiff		19.7	2 - 3 - 4 **(7)**
				21.5	2 - 3 - 4 **(7)**
				25.8	2 - 2 - 3 **(5)**
				25.5	5 - 8 - 8 **(16)**
				25.5	3 - 4 - 7 **(11)**



BORING RECORD S&ME - SPLIT LITHOLOGY CITICO PUMP STATION.GPJ 2016.GDT 4/3/17

Borehole ID: 1

Project Manager: D. Grass, PE

TEST BORING RECORD

BORING NO.: B-1

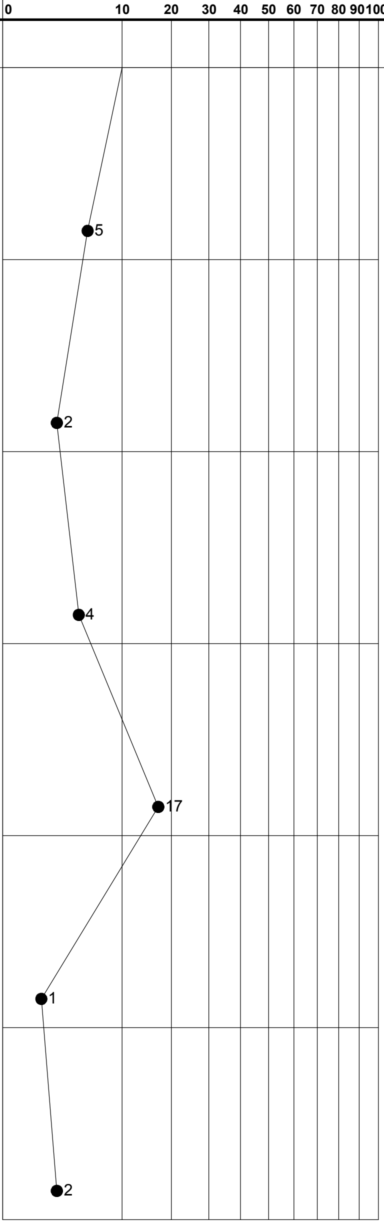
4291 Highway 58
Chattanooga, Tennessee 37416

PROJECT: Citico Pump Reliabitiy Improvements		JOB NO: 1281-17-015	SHEET 2 OF 3
PROJECT LOCATION: Chattanooga, Tennessee			
ELEVATION: 660 feet ±	BORING STARTED: 3/1/2017	RIG TYPE:CME-550	BORING DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 3/1/2017	HAMMER: Automatic	

GROUNDWATER:
- ▽ 30 feet ATD
- ▼ 25.5 feet on 3/13/17
- ▼ 25.6 feet on 3/20/17

Remarks:

G	P	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N)	BLOWS/6"
			30								
		628.0	32'	SILTY SAND (SM), gray, firm, loose to very loose	ALLUVIUM						
								30.1		5	2 - 2 - 3 **(5)**
			35								
							17.2% <200	39.0		2	0 - 1 - 1 **(2)**
			40								
								28.3		4	1 - 2 - 2 **(4)**
			45								
		613.0	47'	SAND and GRAVEL, brown and red-brown, wet, firm to very loose							
								10.3		17	10 - 10 - 7 **(17)**
			50								
								42.2		1	0 - 0 - 1 **(1)**
			55								
								60.7		2	0 - 1 - 1 **(2)**
			60								



Project Manager: D. Grass, PE

BORING RECORD S&ME - SPLIT LITHOLOGY CITICO PUMP STATION.GPJ 2016.GDT 4/3/17

Borehole ID: 1

S&ME
4291 Highway 58
Chattanooga, Tennessee 37416

TEST BORING RECORD

BORING NO.: B-1

PROJECT: Citico Pump Reliabitiy Improvements	JOB NO: 1281-17-015	SHEET 3 OF 3

PROJECT LOCATION: Chattanooga, Tennessee

ELEVATION: 660 feet ±	BORING STARTED: 3/1/2017	RIG TYPE:CME-550	BORING DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 3/1/2017	HAMMER: Automatic	

GROUNDWATER:
▽ 30 feet ATD
▼ 25.5 feet on 3/13/17
▼ 25.6 feet on 3/20/17

Remarks:

G	P	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) 0 10 20 30 40 50 60 70 80 90100	BLOWS/6"
			60								
		598.6		*Auger refusal at 61.4 feet, boring terminated*							
			65								
			70								
			75								
			80								
			85								
			90								

Project Manager: D. Grass, PE

4291 Highway 58
Chattanooga, Tennessee 37416

TEST BORING RECORD

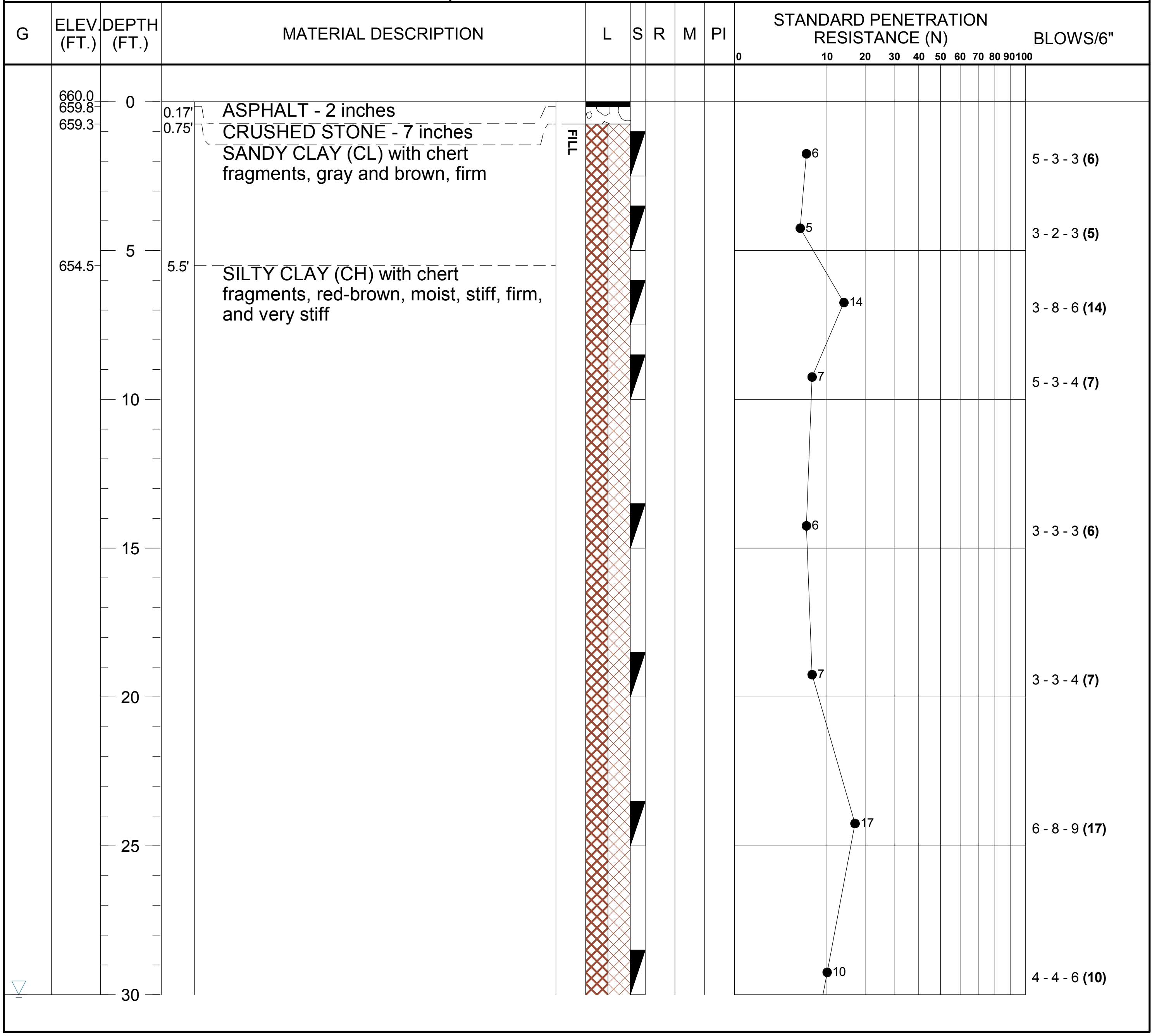
BORING NO.: B-2

PROJECT: Citico Pump Reliabitiy Improvements	JOB NO: 1281-17-015	SHEET 1 OF 3
PROJECT LOCATION: Chattanooga, Tennessee		

ELEVATION: 660 feet ±	BORING STARTED: 3/2/2017	RIG TYPE:CME-550	BORING DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 3/2/2017	HAMMER: Automatic	

GROUNDWATER:
▽ 30 feet ATD

Remarks:



ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION
660.0	0	
659.8	0.17'	ASPHALT - 2 inches
659.3	0.75'	CRUSHED STONE - 7 inches
		SANDY CLAY (CL) with chert fragments, gray and brown, firm
654.5	5.5'	SILTY CLAY (CH) with chert fragments, red-brown, moist, stiff, firm, and very stiff

N	BLOWS/6"
6	5 - 3 - 3 **(6)**
5	3 - 2 - 3 **(5)**
14	3 - 8 - 6 **(14)**
7	5 - 3 - 4 **(7)**
6	3 - 3 - 3 **(6)**
7	3 - 3 - 4 **(7)**
17	6 - 8 - 9 **(17)**
10	4 - 4 - 6 **(10)**

Borehole ID: 2

Project Manager: D. Grass, PE

S&ME

4291 Highway 58
Chattanooga, Tennessee 37416

TEST BORING RECORD

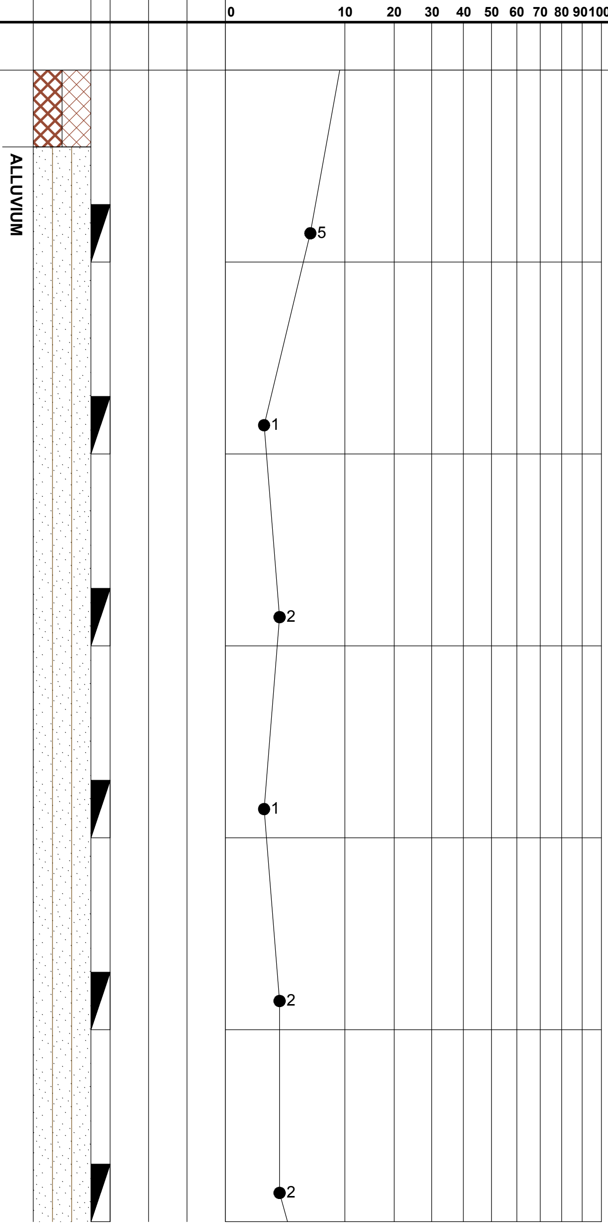
BORING NO.: B-2

PROJECT: Citico Pump Reliabitiy Improvements
JOB NO: 1281-17-015
SHEET 2 OF 3
PROJECT LOCATION: Chattanooga, Tennessee
ELEVATION: 660 feet ±
BORING STARTED: 3/2/2017
RIG TYPE:CME-550
BORING DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers
BORING COMPLETED: 3/2/2017
HAMMER: Automatic

GROUNDWATER:
▽ 30 feet ATD

Remarks:

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N)	BLOWS/6"
		30								
	628.0	32'	SILTY SAND (SM), gray, wet, loose to very loose	ALLUVIUM						
		35							5	2 - 2 - 3 **(5)**
		40							1	0 - 1 - 0 **(1)**
		45							2	1 - 1 - 1 **(2)**
	613.0	47'	SILTY SAND (SM) with gravel, brown, wet, very loose to loose							
		50							1	0 - 1 - 0 **(1)**
		55							2	0 - 1 - 1 **(2)**
		60							2	1 - 1 - 1 **(2)**



Project Manager: D. Grass, PE

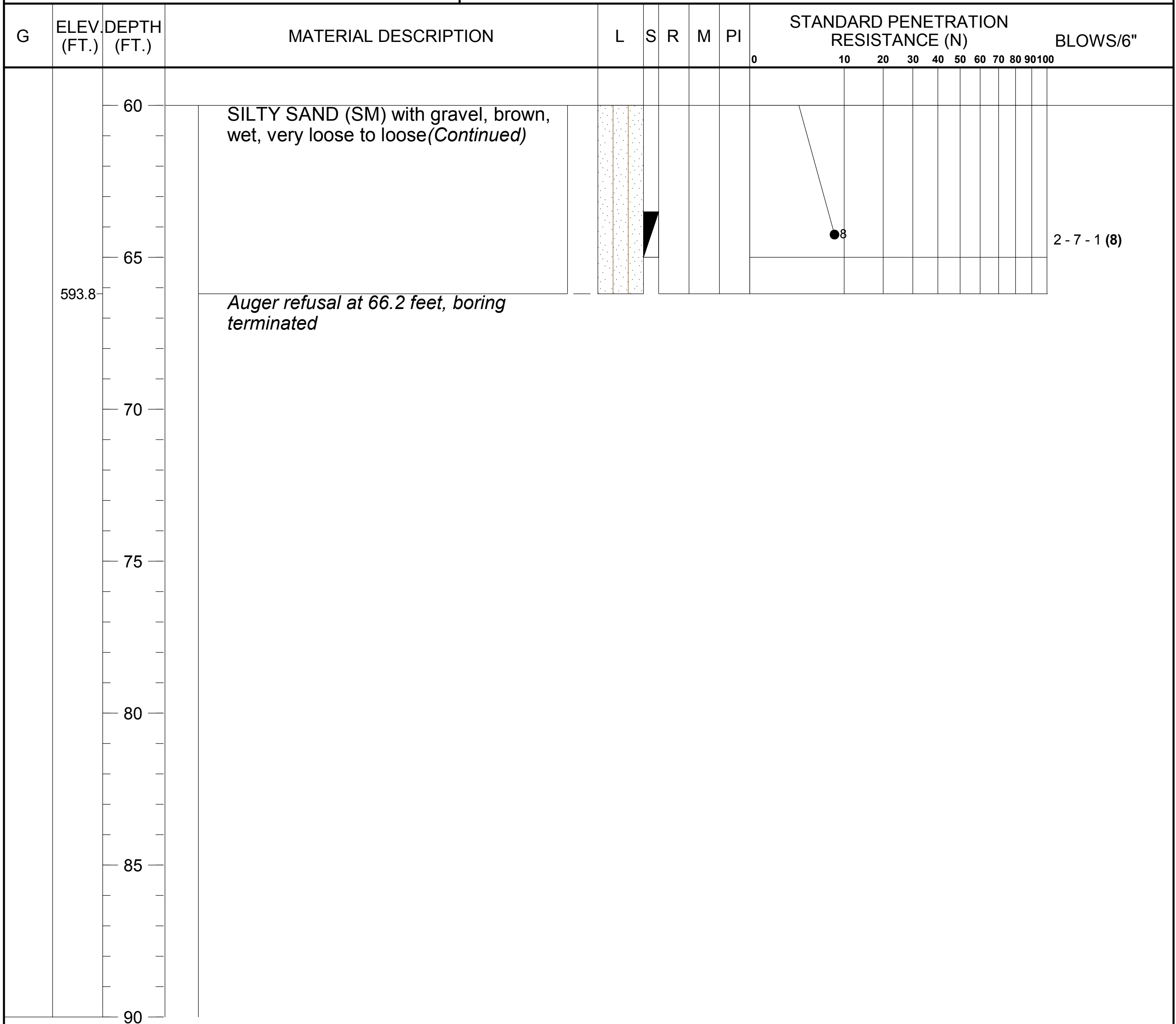
TEST BORING RECORD

BORING NO.: B-2

PROJECT: Citico Pump Reliabitiy Improvements	JOB NO: 1281-17-015	SHEET 3 OF 3
PROJECT LOCATION: Chattanooga, Tennessee		
ELEVATION: 660 feet ±	BORING STARTED: 3/2/2017	RIG TYPE:CME-550	BORING DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 3/2/2017	HAMMER: Automatic

GROUNDWATER:
∇ 30 feet ATD

Remarks:



G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N)	BLOWS/6"
		60	SILTY SAND (SM) with gravel, brown, wet, very loose to loose*(Continued)*						8	2 - 7 - 1 **(8)**
	593.8		*Auger refusal at 66.2 feet, boring terminated*							

Project Manager: D. Grass, PE

S&ME
4291 Highway 58
Chattanooga, Tennessee 37416

TEST BORING RECORD

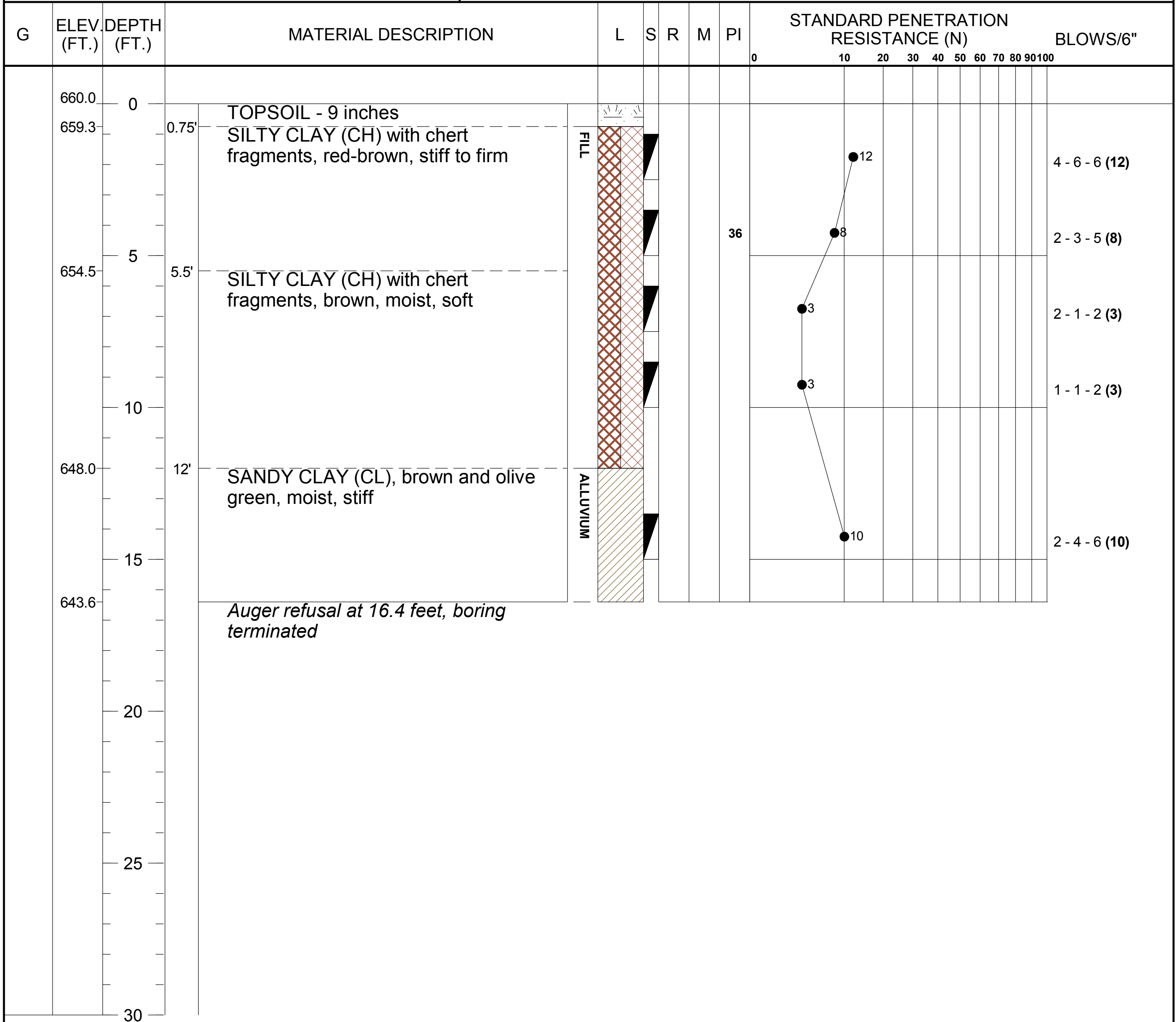
BORING NO.: B-3

PROJECT: Citico Pump Reliabitiy Improvements
JOB NO: 1281-17-015
SHEET 1 OF 1
PROJECT LOCATION: Chattanooga, Tennessee
ELEVATION: 660 feet ±
BORING STARTED: 3/2/2017
RIG TYPE:CME-550
BORING DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers
BORING COMPLETED: 3/2/2017
HAMMER: Automatic

GROUNDWATER:
Dry ATD

Remarks:

ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	PI	BLOWS/6"
660.0	0	TOPSOIL - 9 inches		
659.3	0.75'	SILTY CLAY (CH) with chert fragments, red-brown, stiff to firm		4 - 6 - 6 **(12)**
			36	2 - 3 - 5 **(8)**
654.5	5.5'	SILTY CLAY (CH) with chert fragments, brown, moist, soft		2 - 1 - 2 **(3)**
				1 - 1 - 2 **(3)**
648.0	12'	SANDY CLAY (CL), brown and olive green, moist, stiff		2 - 4 - 6 **(10)**
643.6		*Auger refusal at 16.4 feet, boring terminated*		



Project Manager: D. Grass, PE

4291 Highway 58
Chattanooga, Tennessee 37416

TEST BORING RECORD

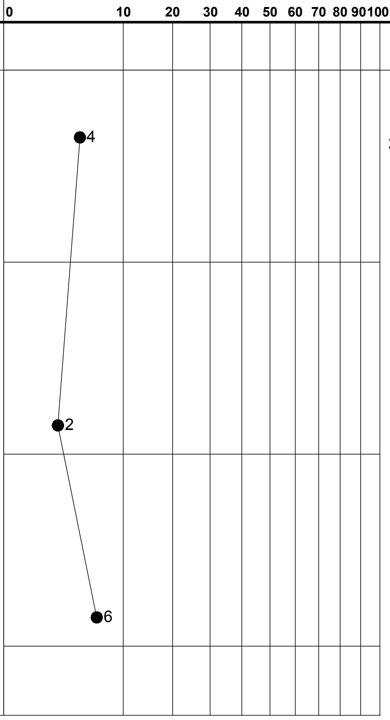
BORING NO.: B-4

PROJECT: Citico Pump Reliabitiy Improvements		JOB NO: 1281-17-015	SHEET 1 OF 1
PROJECT LOCATION: Chattanooga, Tennessee			
ELEVATION: 662 feet ±	BORING STARTED: 3/2/2017	RIG TYPE:CME-550	BORING DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 3/2/2017	HAMMER: Automatic	

GROUNDWATER:
Dry ATD

Remarks:

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N)	BLOWS/6"
	662.0	0	TOPSOIL - 9 inches							
	661.3	0.75'	SILTY CLAY (CH) with chert fragments, yellow-brown and red-brown, soft	FILL					4	3 - 2 - 2 **(4)**
	658.0	4'	SHELBY TUBE ATTEMPT (8 1/2 inches recovery)							
	656.0	6'	SHELBY TUBE ATTEMPT (15 inches recovery)							
	654.0	8'	SILTY CLAY (CH) with chert fragments, yellow-brown and red-brown, soft						2	1 - 1 - 1 **(2)**
	649.0	13'	SILTY CLAY (CH) with glass fragments, brown, firm						6	1 - 2 - 4 **(6)**
	645.2		*Auger refusal at 16.8 feet, boring terminated*							



Project Manager: D. Grass, PE

S&ME
4291 Highway 58
Chattanooga, Tennessee 37416

TEST BORING RECORD

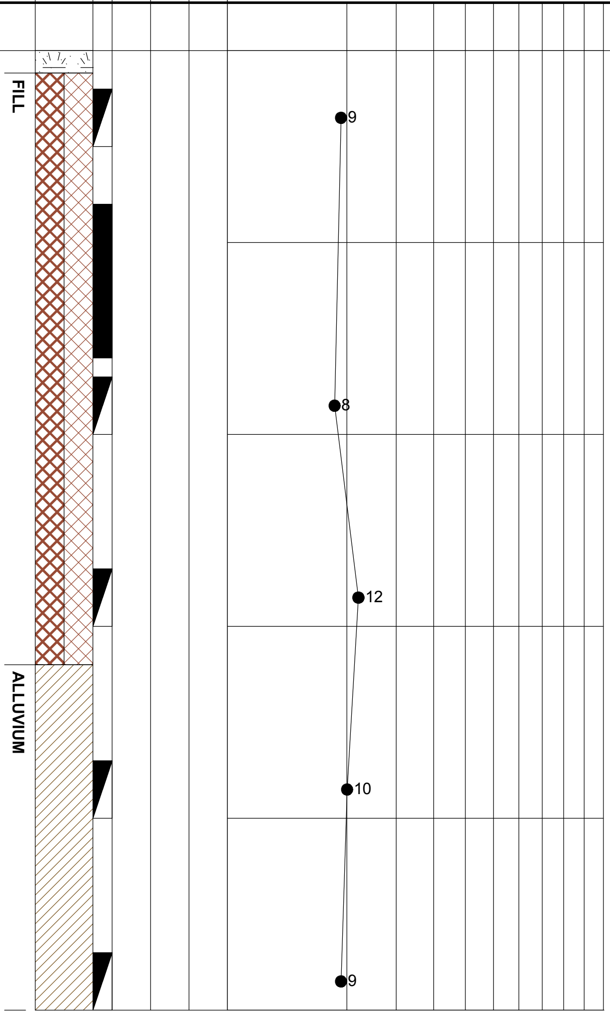
BORING NO.: B-5

PROJECT: Citico Pump Reliabitiy Improvements
JOB NO: 1281-17-015
SHEET 1 OF 1
PROJECT LOCATION: Chattanooga, Tennessee
ELEVATION: 661 feet ±
BORING STARTED: 3/2/2017
RIG TYPE:CME-550
BORING DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers
BORING COMPLETED: 3/2/2017
HAMMER: Automatic

GROUNDWATER:
Dry ATD

Remarks:

ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	BLOWS/6"
661.0	0	TOPSOIL - 7 inches	
660.4	0.58'	SILTY CLAY (CH) with chert fragments, bornw and yellow-brown, stiff and firm	6 - 4 - 5 **(9)**
657.0	4'	SHELBY TUBE ATTEMPT (15 inches recovered)	
655.0	6'	SHELBY TUBE ATTEMPT (15 inches recovered)	
653.0	8'	SILTY CLAY (CH) with chert fragments, bornw and yellow-brown, stiff and firm	2 - 4 - 4 **(8)** 4 - 7 - 5 **(12)**
645.0	16'	SANDY CLAY (CL), brown and gray, stiff	3 - 4 - 6 **(10)** 4 - 4 - 5 **(9)**
636.0	25	*Boring terminated at 25 feet*	



Project Manager: D. Grass, PE

Appendix III

Laboratory Test Procedures

Laboratory Test Results

NATURAL MOISTURE
ASTM D 2216, EM 1110-2-1906

The moisture content of soils is an indicator of various physical properties, including strength and compressibility. Selected samples obtained during exploratory drilling were taken from their sealed containers. Each sample was weighed and then placed in an oven heated to 110oC + 5o. The sample remained in the oven until the free moisture had evaporated. The dried sample was removed from the oven, allowed to cool, and re-weighed. The moisture content was computed by dividing the weight of evaporated water by the weight of the dry sample. The results, expressed as a percent, are shown on the attached Laboratory Test Results Summary.

ATTERBERG LIMITS DETERMINATION
ASTM D 4318/AASHTO T89/T90

Representative samples were subjected to Atterberg limits testing to determine the soil's plasticity characteristics. The plasticity index (PI) is the range of moisture content over which the soil deforms as a plastic material. The liquid limit (LL) marks the transition from the plastic state to the liquid state. The plastic limit (PL) marks the transition from the plastic state to the solid state.

To determine the liquid limit, a soil specimen is wetted until it is in a viscous fluid state. A portion of this soil is then placed in a brass cup of standardized dimensions, and a groove made through the middle of the soil specimen with a grooving tool of standardized dimensions. The cup is attached to a cam that lifts the cup 10 mm, and then allows the cup to fall and strike a rubber base of standardized hardness. The cam is rotated at about 2 drops per second until the two halves of the soil specimen come in contact at the bottom of the groove along a distance of 13 mm. The number of blows required to make this degree of contact is recorded, and a portion of the specimen is subjected to a moisture content determination. Additional water is added to the remainder of the specimen, and the grooving process and cam action process repeated. This testing sequence is repeated until the soil flows as a heavy viscous fluid. The number of blows vs. moisture content is then plotted on semi-logarithmic graph paper, and the moisture content corresponding to 25 blows is designated the liquid limit.

The plastic limit is the lowest moisture content at which the soil is sufficiently plastic to be manually rolled into threads 3 mm in diameter. It is determined by taking a pat of soil remaining from the liquid limit test, and repeatedly rolling, kneading, and air drying the specimen until the soil breaks into threads about 3 mm in diameter and 3 to 10 mm long. The moisture content of these soil threads is then determined, and is designated the plastic limit. The results of these tests are presented on the Laboratory Test Results Summary.

GRAIN SIZE TEST PROCEDURES
ASTM D 1140

The clay and silt content of granular soils affects their physical properties such as strength, compressibility, and permeability. Selected granular soil (sand and gravel) samples were tested to determine the percent, by weight, of soil particles finer than the No. 200 sieve (silt and clay sized particles). Soil particles finer than 75 microns were flushed through a No. 200 sieve using water. The coarse materials retained on the No. 200 sieve were dried to obtain their dry weight. The dry weight of materials retained on the No. 200 sieve was compared to the dry weight of the total test specimen. The difference in weight, expressed as a percentage of the pre-wash weight, is designate as the percentage of "fines" (silt and clay particles). The results are plotted on the Grain Size Distribution Test Reports.

UNCONFINED COMPRESSIVE STRENGTH OF SOIL
ASTM D 2166/AASHTO T208-92

The unconfined compression test is an unconsolidated-undrained triaxial shear test with no lateral confining pressure. This test is used to determine the shear strength (cohesion) of clayey soils and rock. Undisturbed samples were prepared by cutting the ends perpendicular to the applied load. The sample was placed in a testing device and incrementally increasing vertical loads were applied until it failed. The test results are provided on the Unconfined Compression Test Reports.

Citico Pump Station
Chattanooga, Tennessee
Project No. 1281-17-015
Laboratory Test Results

Boring Number	Sample Type	Depth (ft)	Moisture Content (%)	% Passing No. 200	Atterberg Limits		USCS Symbol	Unconfined Compression Test: su (psf)	Dry Unit Weight (pcf)
					LL	PI			
B-1	SPT	1 - 2.5	20.1						
		3.5 - 5	27.4						
		6 - 7.5	27.5						
		8.5 - 10	19.7						
		13.5 - 15	21.5						
		18.5 - 20	25.8						
		23.5 - 25	25.5						
		28.5 - 30	25.5						
		33.5 - 35	30.1						
		38.5 - 40	39.0	17.2					
		43.5 - 45	28.3						
		48.5 - 50	10.3						
		53.5 - 55	42.2						
		58.5 - 60	60.7						
B-3	SPT	3.5 - 5			57	36	CH		
B-5	ST	4 - 6	19.9					1,433	97.8
		6 - 8			42	23	CL		

SPT – Standard Penetration Test Sample
ST – Shelby Tube Sample

Form No: TR-D422-WH-1Gb
Revision No. 0
Revision Date: 07/14/08

Sieve Analysis of Soils

S&ME

ASTM D 422

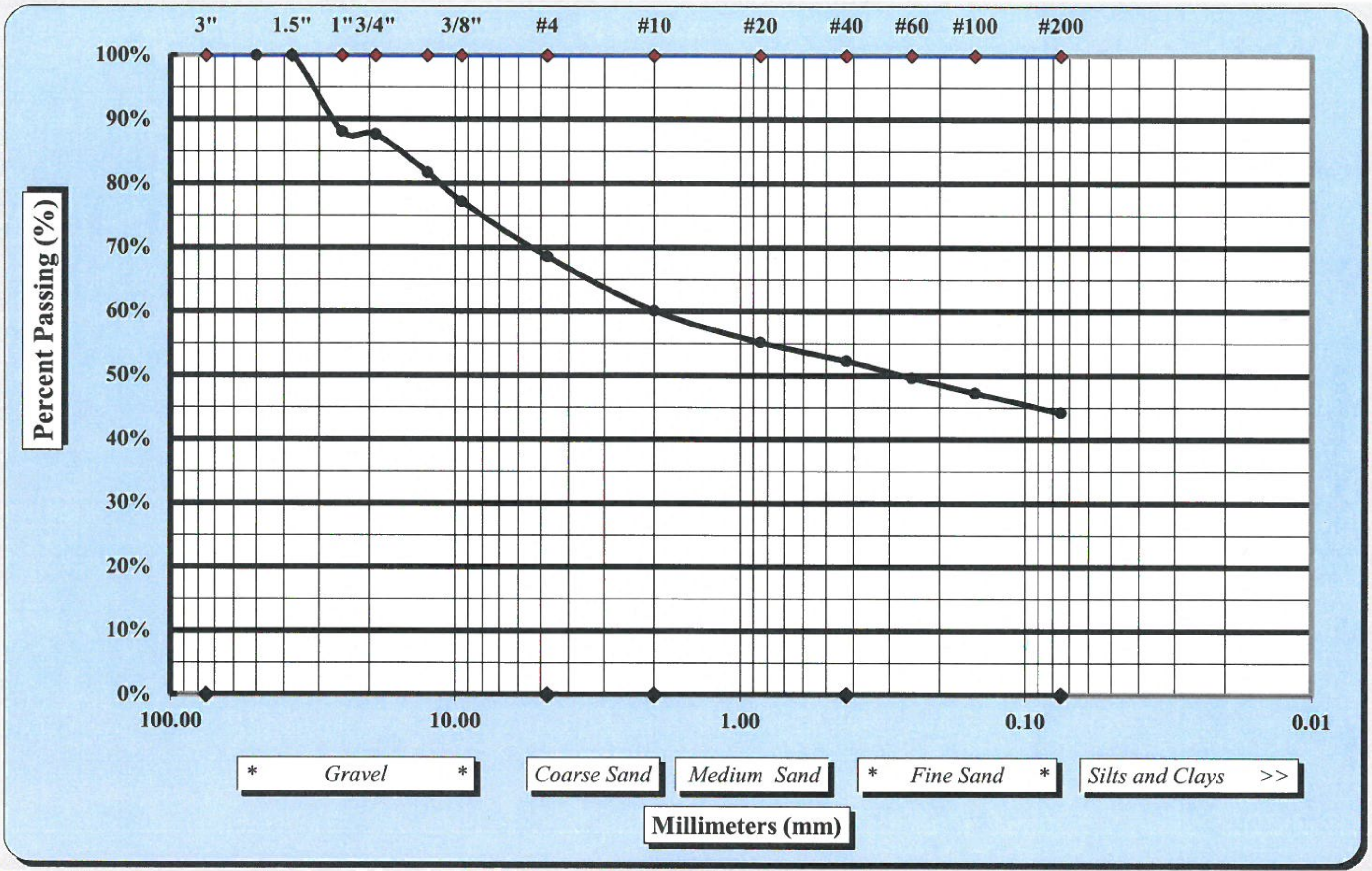
Quality Assurance

S&ME, Inc. Atlanta, 4350 River Green Parkway, Suite 200, Duluth, GA 30096

Project #:	**1281-17-015**	Report Date:	3/15/17
Project Name:	Citico Pump Station	Test Date(s):	3/13-3/15/17
Client Name:	Burns & McDonnell		
Client Address:	3650 Mansell Road, Alpharetta, GA		

Sample Id.	B-5	Type:	U.D.	Sample Date:	3/1/17
Location:	N/A	Sample:	3	Elevation:	6'-8'

Sample Description: Yellowish brown Clayey Gravel with Sand (GC)



Maximum Particle Size	1"	Coarse Sand	8.5%	Fine Sand	8.1%
Gravel	31.4%	Medium Sand	7.8%	Silt & Clay	44.2%
Liquid Limit	42	Plastic Limit	19	Plastic Index	23

Coarse Sand	8.5%	Medium Sand	7.8%	Fine Sand	8.1%

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒
Hard & Durable ☒ Soft ☐ Weathered & Friable ☐

Notes / Deviations / References:

Nathan Price		Laboratory Manager	3/15/2017
Technical Responsibility	*Signature*	*Position*	*Date*

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Form No. TR-D2166-01
Revision No. : 0
Revision Date: 3/29/13

UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOILS

S&ME

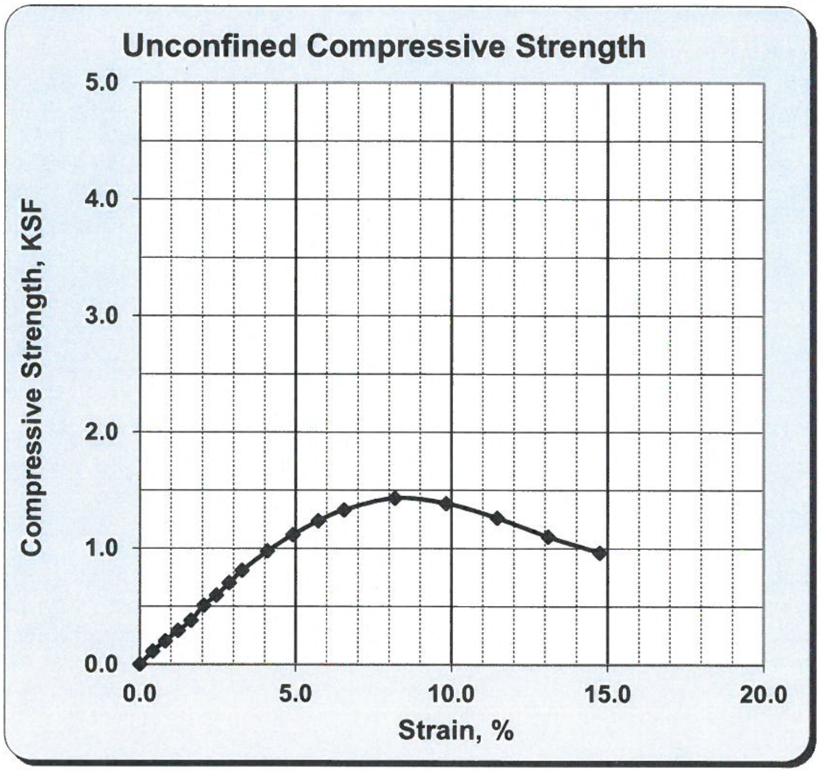
ASTM D2166

Quality Assurance

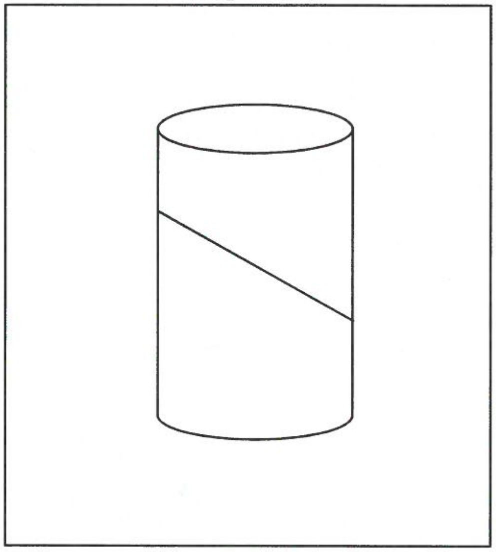
S&ME, Inc. Atlanta, River Green Parkway, Suite 200, Duluth, GA 30096

Project No.: 1281-17-015 Log No.: N/A Report Date: 3/9/2017
Project Name: Citico Pump Station Test Date(s): 3/9-3/10/17
Client Name: Burns & McDonnell
Client Address: 3650 Mansell Road, Alpharetta, GA
Boring No.: B-5 Sample No. 2 Sample Date: 3/1/2017
Location: N/A Depth: 4'-6'
Sample Description: Yellowish brown Clayey Gravel with Sand

Type and Specification	*S&ME ID #*	*Cal Date:*	*Type and Specification*	*S&ME ID #*	*Cal Date:*
Balance (0.1 gram)	25128	03/15/16	Load Cell 2000 lbs.	26344	03/22/16
Calipers (0.001 inches)	26631	11/02/16	Deflection (inches)	26637	03/20/16



Failed Specimen



Type of Sample: Intact
Source of Moisture Sample: Test Specimen

Liquid Limit: N/A
Plasticity Index: N/A

Initial Dry Unit Weight: 97.8 pcf Initial Water Content: 19.9%
Height to Diameter Ratio: 2.1
Unconfined Compressive Strength, q_u: **1.433** KSF
Rate of Strain (%/m): 1.5
Undrained Shear Strength, s_u: **0.716** KSF
Strain at Failure: 8.2

References / Comments / Deviations:

Nathan Price
Technical Responsibility

Signature

Laboratory Manager
Position

3/9/2017
Date

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Appendix IV

Important Information About Your Geotechnical Engineering Report

Important Information About Your Geotechnical Engineering Report

Variations in subsurface conditions can be a principal cause of construction delays, cost overruns and claims. The following information is provided to assist you in understanding and managing the risk of these variations.

Geotechnical Findings Are Professional Opinions

Geotechnical engineers cannot specify material properties as other design engineers do. Geotechnical material properties have a far broader range on a given site than any manufactured construction material, and some geotechnical material properties may change over time because of exposure to air and water, or human activity.

Site exploration identifies subsurface conditions at the time of exploration and only at the points where subsurface tests are performed or samples obtained. Geotechnical engineers review field and laboratory data and then apply their judgment to render professional opinions about site subsurface conditions. Their recommendations rely upon these professional opinions. Variations in the vertical and lateral extent of subsurface materials may be encountered during construction that significantly impact construction schedules, methods and material volumes. While higher levels of subsurface exploration can mitigate the risk of encountering unanticipated subsurface conditions, no level of subsurface exploration can eliminate this risk.

Scope of Geotechnical Services

Professional geotechnical engineering judgment is required to develop a geotechnical exploration scope to obtain information necessary to support design and construction. A number of unique project factors are considered in developing the scope of geotechnical services, such as the exploration objective; the location, type, size and weight of the proposed structure; proposed site grades and improvements; the construction schedule and sequence; and the site geology.

Geotechnical engineers apply their experience with construction methods, subsurface conditions and exploration methods to develop the exploration scope. The scope of each exploration is unique based on available project and site information. Incomplete project information or constraints on the scope of exploration increases the risk of variations in subsurface conditions not being identified and addressed in the geotechnical report.

Services Are Performed for Specific Projects

Because the scope of each geotechnical exploration is unique, each geotechnical report is unique. Subsurface conditions are explored and recommendations are made for a specific project. Subsurface information and recommendations may not be adequate for other uses. Changes in a proposed structure location, foundation loads, grades, schedule, etc. may require additional geotechnical exploration, analyses, and consultation. The geotechnical engineer should be consulted to determine if additional services are required in response to changes in proposed construction, location, loads, grades, schedule, etc.

Geo-Environmental Issues

The equipment, techniques, and personnel used to perform a geo-environmental study differ significantly from those used for a geotechnical exploration. Indications of environmental contamination may be encountered incidental to performance of a geotechnical exploration but go unrecognized. Determination of the presence, type or extent of environmental contamination is beyond the scope of a geotechnical exploration.

Geotechnical Recommendations Are Not Final

Recommendations are developed based on the geotechnical engineer's understanding of the proposed construction and professional opinion of site subsurface conditions. Observations and tests must be performed during construction to confirm subsurface conditions exposed by construction excavations are consistent with those assumed in development of recommendations. It is advisable to retain the geotechnical engineer that performed the exploration and developed the geotechnical recommendations to conduct tests and observations during construction. This may reduce the risk that variations in subsurface conditions will not be addressed as recommended in the geotechnical report.

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APPENDIX D -RECORD DRAWINGS

Record Drawings Provided in
Digital PDF Format Only