1. Basis of Design: Ruskin #ADC3 with cam type closers. Use largest standard square size acceptable by duct.

2. Door:

   a. Double wall, rectangular.

   b. Latches: cam latches.

   c. Fabricate doors airtight and suitable for duct pressure class.

3. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

2.11 FLEXIBLE CONNECTORS

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. **Ductmate Industries, Inc.**

   2. **Duro Dyne Inc.**

   3. **Ventglass, Inc.**

   4. **Ward Industries, Inc.; a division of Hart & Cooley, Inc.**

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 attached to 2 strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets to provide 4” metal-to-metal separation. Provide metal compatible with connected ducts.

2.12 FLEXIBLE DUCTS

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. **Flexmaster U.S.A., Inc.**

   2. **McGill AirFlow LLC.**

   3. **Ward Industries, Inc.; a division of Hart & Cooley, Inc.**

B. **Insulated, Flexible Duct**: Shall be Thermalflex Type M-KE, Hart & Cooley, Flex Master or as approved. Duct shall be in accord with NFPA 90A requirements and shall be UL approved and rated for flame spread less than 25 smoke development not more than 50.

Pressure rated for 6 inches WG. Flexible duct shall be insulated with an R value of not less than 5 and shall be manufactured with a fiberglass reinforced vapor barrier jacket.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.

2. Maximum Air Velocity: 4,000 fpm.

3. Temperature Range: Minus 10 to plus 160 deg F.

C. **Flexible Duct Connectors**:

1. Bands for securing flexible duct core liner to sheet metal connectors shall be stainless steel draw bands with screw operators. Bands for securing outer insulation jacket shall be stainless steel draw bands or may be nylon "zip-ties" not less than ¼" in width made specifically for the purpose.

2. Sealant tape for sealing the core liner to sheet metal connectors shall be "FoilGirp" as manufactured by Hardcast or approved equivalent product. Tape shall have a 2-mil aluminum foil facing with a modified BUTYL adhesive and shall be rated for SMACNA seal classes A, B, and C for duct static pressures up to 6" w.g. for a temperature range of -20°F to 220°F. tape shall be 2" in width and shall have a flamespread rating of less than 25 and a smoke development rating of less than 50. Submit complete product literature for sealing tapes.

2.13 DUCT ACCESSORY HARDWARE

A. **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.

B. **Adhesives**: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.14 LOUVERS AND PENTHOUSES

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. **Airolite**

2. **Airstream**

3. **American Warming & Ventilating**

4. **Carnes**

5. **Perfco**

6. **Ruskin**

7. **United Sheet Metal**

B. Sizes, materials, types and finishes shall be as noted in the schedules or elsewhere on the drawings. Substitute louvers shall not have less free area than the specified units.

C. All louvers furnished for mounting in masonry wall construction shall be furnished with an extended or separate sill.

D. Unless indicated otherwise, all louvers fro masonry walls will be box frame without face flange.

E. Penthouse units shall be provided with factory or field fabricated curbs as required or shown on the plans. Curbs shall take into account the pitch of the roof to provide a level surface/frame for mounting of the penthouse.

F. Penthouses shall be furnished with special materials, finishes, bird screens, snow screens, backdraft dampers, insulated top or other accessories as listed on the schedule.

PART 3 - EXECUTION

3.1 INSTALLATION

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.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. 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.

1. Install steel volume dampers in steel ducts.

2. Install aluminum volume dampers in aluminum ducts.

E. All dampers shall operate smoothly through their entire range. Provide locking mechanisms to secure volume dampers in position. Mark all damper axles permanently to indicated damper blade position using a file, scratch awl or similar tool.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated.

H. Install fire and smoke dampers according to UL listing.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.

2. Downstream from manual volume dampers, control dampers, turning vanes, and equipment.

3. 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.

4. At each change in direction and at maximum 50-foot spacing.

5. Upstream of turning vanes.

6. Elsewhere as indicated.

J. Install access doors with swing against duct static pressure.

K. **Access Door Sizes**:

1. One-Hand or Inspection Access: 8 by 5 inches.

2. Two-Hand Access: 12 by 6 inches.

3. Head and Hand Access: 18 by 10 inches.

4. Head and Shoulders Access: 21 by 14 inches.

5. Body Access: 25 by 14 inches.

6. Body plus Ladder Access: 25 by 17 inches.

7. At splitter dampers (use 8" X 8" door).

8. At volume dampers (use 8" X 8" door).

9. At fire dampers (use largest standard square size duct will accept).

10. At motorized dampers (use largest standard square size duct will accept or multiple 12" X 12" size to provide service access to the entire damper).

11. At duct coils (use largest standard square size duct will accept or multiple 12" X 12" size to provide service access to the entire coil. Access shall be provided at both sides of the coil to facilitate cleaning of coil). Immediately downstream of all duct-mounted humidifiers (Use largest standard square size duct will accept or multiple 12" X 12" size to provide service access to the entire coil. Access shall be provided at both sides of the coil to facilitate cleaning of coil) to provide access to entire humidifier grid.

L. Label access doors to indicate the purpose of access door. If access door is intended for access of mechanical equipment provide the mechanical unit callout number on the access door label.

M. Install flexible connectors to connect ducts to equipment with at least 4" metal-to-metal. Flexible connections shall be airtight.

N. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

O. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

P. Connect diffusers or light troffer boots to low-pressure ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

Q. Connect flexible ducts to metal ducts with adhesive draw bands.

R. Install duct test holes where required for testing and balancing purposes.

S. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

T. Provide air volume extractors or extended, tapered inlet connection where branch ducts are set into the side of trunk ducts as indicated on the plans.

U. Spin-in connector for round duct connection shall be conical in design unless otherwise noted on plans. Connectors for branch ducts which attach to main duct runs shall be fitted with volume damper.

V. Flexible Ducts

1. Support all flexible ducts with strap hangers in accordance with SMACNA recommendations and mechanical code requirements. Support ducts at an interval not exceeding 4 feet on center and limit sag to less than ½" per foot. Support duct to prevent contract with structural members, ceilings and all sources of heat such as lights and piping.

2. Install sheet metal elbows for all bends with a turning radius of less than four feet. All sheet metal elbows, connectors, etc., shall be insulated as specified for sheet metal ductwork.

3. Secure the inner duct liner to sheet metal connectors and fittings with two wraps of sealant tape. Install a stainless-steel draw band over the sealant tape and liner. The liner shall overlap the sheet metal connector by not less than 2".

4. After securing the inner liner, secure the outer insulation jacket with stainless steel or nylon draw bands. Fold the insulation jacket under the draw band so that no fiberglass insulation is exposed.

W. Wall and Floor Penetrations

1. Provide sheet metal sleeves in all concrete or masonry walls and floors. Frame or sleeve openings through stud walls.

2. Sleeves and openings sized to accept the duct with insulation. Pack insulation in after duct is installed.

3. Grout sleeves in place in existing masonry walls or floors.

4. Provide finishing collars on each side of wall or floors at all penetrations.

5. Seal the space between ductwork and sleeves with mildew resistant silicone caulk.

3.2 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 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.

- END OF SECTION -

SECTION 23 34 23 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. **This Section includes the following**:

1. Centrifugal wall ventilators.
2. Ceiling-mounting ventilators.
3. In-line centrifugal fans.

1.2 SUBMITTALS

A. **Product Data**: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

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.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.3 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.

B. **NEMA Compliance**: Motors and electrical accessories shall comply with NEMA standards.

C. **UL Standard**: Power ventilators shall comply with UL 705.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. **Basis-of-Design Product**: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Greenheck.
2. Loren Cook Company.
3. Soler and Palau, USA
4. Or Equal

2.2 CENTRIFUGAL WALL VENTILATORS

A. **Description**: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.

B. **Housing**: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.

C. **Fan Wheel**: Aluminum hub and wheel with backward-inclined blades.

D. **Belt-Driven Drive Assembly**: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

3. Pulleys: Cast-iron, adjustable-pitch motor pulley.

E. **Accessories**:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.

2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.

3. Wall Grille: Ring type for flush mounting.

4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.

2.3 CEILING-MOUNTING VENTILATORS

A. **Description**: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.

B. **Housing**: Steel, lined with acoustical insulation.

C. **Fan Wheel**: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

D. **Grille**: Plastic, louvered grille with flange on intake and thumbscrew attachment to fan housing.

E. **Electrical Requirements**: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. **Accessories**:

1. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.

2. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.

3. Filter: Washable aluminum to fit between fan and grille.

4. Isolation: Rubber-in-shear vibration isolators.

5. Manufacturer's standard roof jack or wall cap and transition fittings.

2.4 IN-LINE CENTRIFUGAL FANS

A. **Description**: In-line, direct -driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

B. **Housing**: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. **Direct-Driven Units**: Motor mounted in airstream; factory wired to disconnect switch located on outside of fan housing.

D. **Belt-Driven Units**: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. **Fan Wheels**: Aluminum, airfoil blades welded to aluminum hub.

F. **Accessories**:

1. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.

2. Companion Flanges: For inlet and outlet duct connections.

3. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.

4. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.5 MOTORS

A. Comply with requirements in Specification Section 23 05 13 Common Motor Requirements for HVAC Equipment.

B. **Enclosure Type**: Totally enclosed, fan cooled.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using spring isolators having a static deflection of 1 inch.

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

D. **Ceiling Units**: Suspend units from structure; use steel wire or metal straps.

E. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch.

F. Install units with clearances for service and maintenance.

G. 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 specification Section 23 33 00 Air Duct Accessories.

H. Install ducts adjacent to power ventilators to allow service and maintenance.

I. Ground equipment according to Division 26 Section

J. Connect wiring according to Division 26 Section

3.2 FIELD QUALITY CONTROL

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

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that the 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.

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

- END OF SECTION -

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SECTION 23 37 13 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. **Section Includes**:

1. Round ceiling diffusers
2. Rectangular and square ceiling diffusers
3. Perforated diffusers
4. Louver face diffusers
5. Linear bar diffusers
6. Linear slot diffusers
7. Adjustable bar registers, grilles, registers and grilles
8. Fixed face registers, grilles, registers and grilles
9. Linear bar grilles

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

B. **Product Data**: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

C. **Samples**: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. **Subject to compliance with requirements, provide products by one of the following or approved Equal**:

a. **Carnes**

b. **Titus**

c. **Tuttle & Bailey**

d. **Krueger**

2.2 CEILING DIFFUSERS

A. **Round Ceiling Diffuser**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

B. **Rectangular and Square Ceiling Diffusers**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

C. **Perforated Diffuser**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

D. **Louver Face Diffuser**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

2.3 REGISTERS AND GRILLES

A. **Adjustable Bar Register**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

B. **Adjustable Bar Grille**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

C. **Fixed Face Register**:

Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

D. **Fixed Face Grille**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

2.4 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

3.1 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.

3.2 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

- END OF SECTION -

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SECTION 23 63 13 - AIR COOLED REFRIGERANT CONDENSERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes design, refrigerants, controls, and installation requirements for air-cooled scroll compressor condensing units.

1.2 REFERENCES

A. Comply with the applicable Standards and/or Codes of ETL, cETL, NEC, ASHRAE Standard 90.1, and OSHA as adopted by the state.

1.3 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each model indicated, including rated capacities of selected model clearly indicated, dimensions, required clearances, shipping, installed, and operating weights, furnished specialties, accessories, and installation and startup instructions.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location of each field connection. Detail equipment mounting to supporting structure.

1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Commissioning Reports: Indicate results of startup and testing commissioning requirements. Submit copies of checklists.

D. All submittals shall be in accordance with specification Section 01 33 00 – Contractor Submittals.

1.4 QUALITY ASSURANCE

A. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.

1. The condensing unit shall be safety certified by ETL and the nameplate shall carry the agency label.

1.5 DELIVERY AND HANDLING

A. Condensing unit shall be delivered to the jobsite with factory holding charge and be factory charged with oil by the manufacturer.

B. Comply with the manufacturer's instructions for rigging and handling equipment.

1.6 WARRANTY

A. The refrigeration equipment manufacturer's warranty shall be for a period of one year from date of equipment start up but not more than 18 months from date of original equipment shipment from the factory. The warranty shall cover material and workmanship that prove defective within the above period, excluding refrigerant.

B. **Options**:

1. Compressors shall carry a 5 year warranty from date of original equipment shipment from the factory.

PART 2 - PRODUCTS

2.1 CONDENSING UNITS

A. **Unit Description:** Provide and install as shown on the plans, factory assembled, air-cooled scroll compressor condensing units in the quantity specified. Each unit shall consist of an air-cooled condenser section with hermetic scroll compressor and isolated control compartment containing: control system, suction and liquid connection valves, and all components necessary for safe and controlled unit operation when connected to the specified low side equipment.

B. **Construction**:

1. Unit shall be completely factory assembled, piped, and wired and shipped in one section.

2. Unit shall be specifically designed for outdoor application.

3. The condenser coil shall be mechanically protected from physical damage by painted galvanized steel louvers covering the full area of the coil.

4. Options (Multiple selections are permissible):

a. Paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B117-95 test procedure.

b. The condenser coil shall be mechanically protected from physical damage by a wire guard covering the full area of the coil.

2.2 DESIGN REQUIREMENTS

A. **General:** Provide a complete scroll compressor condensing unit as specified herein and as shown on the drawings. The unit shall be in accordance with the standards referenced in this specification and any local codes in effect.

B. **Performance:** Refer to the schedule of performance on the unit rating page. The unit shall be capable of stable cooling operation to a minimum of 32°F outdoor temperature.

2.3 CONDENSING UNIT FEATURES

A. **Compressor**:

1. The compressor shall be two step, single circuited, sealed hermetic scroll type, with inherent thermal overload protection and shall be mounted on rubber vibration isolators.

2. Each compressor shall be furnished with a crankcase heater.

3. Options:

a. The compressor shall be covered by a high-density foam sound attenuating blanket to reduce radiated noise.

B. **Condenser**:

1. The condenser coil shall consist of seamless copper tubes mechanically bonded into plate type aluminum fins. The fins shall have full drawn collars to completely cover the tubes. A subcooling section shall be an integral part of the main condenser coil.

2. The condenser fan shall be propeller type arranged for vertical air discharge and driven by a direct drive fan motor. The fan discharge area shall be equipped with a heavy-gauge fan guard.

3. Fan motor shall be weather protected, single phase, direct drive, ECM 2.3 motor.

4. Options:

a. Coil shall have a flexible epoxy polymer e-coat uniformly applied to all coil surface areas without material bridging between fins. Coating process shall ensure complete coil encapsulation and a uniform dry film thickness from 0.8 to 1.2 mils on all surface areas including fin edges. Superior hardness characteristics of 2H per ASTM D3363-92A and a cross-hatch adhesion of 4B-5B per ASTM B3359-93. Impact resistance shall be up to 160 in/lb per ASTM D2794-93. Humidity and water immersion resistance shall be up to a minimum 1000 and 250 hours respectively (ASTM D2247-92 and ASTM D870-92). Corrosion durability shall be confirmed through testing to no less than 6000 hours salt spray per ASTM B117-90. Coated coils shall receive a spray-applied, UV-resistant polyurethane topcoat to prevent UV degradation of e-coat.

b. Coil shall be copper tubes with copper fins mechanically bonded to the tubes.

C. **Refrigerant Circuit**:

1. The condensing unit shall operate with R-410A refrigerant. The condensing unit shall be furnished with a liquid line filter drier and service valves for liquid and suction connections. The finished field installed refrigerant circuit furnished by the contractor shall include the low side cooling components, refrigerant, thermal expansion valve, liquid line, insulated hot gas bypass line, insulated hot gas line, and insulated suction line.

2. Options:

    a. External hot gas bypass shall be provided on the refrigerant circuit.

    b. Condensing unit shall be provided with adjustable condenser head pressure control to allow cooling operation down to 35°F.

    c. Unit shall dehumidify using modulating hot gas reheat control valves, an electronic controller, and a matching air handler that includes a hot gas reheat coil. Field installed liquid line receiver tank shall be factory provided.

D. **Control System**:

1. A centrally located weatherproof control panel shall be isolated from condenser coil airflow, and shall contain the field power connection points, control terminal block and control system.

2. Power and starting components shall include fan motor contactors, 5 minute off time delay relays for the compressor, inherent fan motor overload protection and unit power terminal blocks for connection to remote disconnect switch. Safety and operating controls shall include a manually reset high pressure switch and an automatic reset low pressure switch. Barrier panels shall be furnished to protect against accidental contact with line voltage when accessing the control system.

3. Option:

    a. Control circuit transformer and wiring shall provide 24V control voltage from the line voltage provided to the unit.

E. **Wiring Diagrams**:

1. Color-coded and marked wiring diagrams shall be provided to match the color and markings of the unit wiring.

2. Diagrams shall be laminated in plastic and permanently fixed to the control compartment door.

3. Installation, Operation, and Maintenance manual shall be supplied with unit within the control compartment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in strict accordance with manufacturer's requirements, shop drawings, and contract documents.

B. Adjust and level unit on supports.

C. Install refrigerant piping in accordance with drawings.

D. Evacuate the system and charge with refrigerant in accordance with standard practice.

E. Coordinate electrical installation with electrical contractor.

F. Coordinate controls with control contractor.

G. Provide all appurtenances required to insure a fully operation and functionally system.

3.2 STARTUP

A. Check and assure proper system charge of refrigerant and oil.

B. Provided testing, and starting of system, and instruct the Owner in its proper operation and maintenance.

- END OF SECTION -

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SECTION 23 82 39 - UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. **Section Includes**:

1. Cabinet unit heaters with centrifugal fans and electric coils.
2. Propeller unit heaters with hot-water and electric coils.
3. Electric resistance wall heaters

1.2 SUBMITTALS

A. **Product Data**: Include rated capacities, operating characteristics, furnished specialties, and accessories for each 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. Plans, elevations, sections, and details.
2. Location and size of each field connection.
3. Equipment schedules to include rated capacities, furnished specialties, and accessories.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.3 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.

PART 2 - PRODUCTS

2.1 CABINET UNIT HEATERS

A. **Basis-of-Design Product**: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Qmark
2. Trane.
3. Indeeco.

4. TPI

5. Or Approved Equal

B. **Description**: A factory-assembled and -tested unit complying with ARI 440.

1. Comply with UL 2021.

C. **Cabinet**: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.

1. Vertical Unit, Exposed Front Panels: Minimum 0.0677-inch- thick, galvanized sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.

2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0677-inch- thick, galvanized, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.

3. Recessing Flanges: Steel, finished to match cabinet.

4. Control Access Door: Key operated.

5. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware

D. **Fan and Motor Board**: Removable.

1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.

2. Motor: Permanently lubricated multispeed; resiliently mounted on motor board. Comply with requirements in specification Section 23 05 13 – Common Motor Requirements for HVAC Equipment.

3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

E. Control devices and operational sequences are specified in Section 23 09 00 – Instrumentation and Control for HVAC.

F. **Basic Unit Controls**:

1. Scheduled Operation: Thermostat with Occupied and unoccupied modes on seven-day clock with a minimum of four programmable periods per day.

2. Unit Supply-Air Fan Operations:

a. Occupied Periods: Fan runs continuously.

b. Unoccupied Periods: Fan cycles to maintain setback room temperature.

G. **Electrical Connection**: Factory wire motors and controls for a single field connection.

H. **Capacities and Characteristics**:

1. Cabinet:

a. Vertical, Semirecessed: Upflow.

1) Air Inlet: Front, punched louver grille.

2) Air Outlet: Front

2.2 WALL AND CEILING HEATERS

A. **Basis-of-Design Product**: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Berko Electric Heating

2. Chromalox, Inc.

3. TPI Corporation.

4. Marley Electric Heating.

5. QMark Electric Heating

6. Trane.

7. Or Approved Equal

B. **Description:** An assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

C. **Cabinet**:

1. Front Panel: Stamped-steel louver, with removable panels fastened with tamperproof fasteners.

2. Finish: Baked enamel over baked-on primer with manufacturer's standard color, applied to factory-assembled and -tested wall and ceiling heaters before shipping.

D. **Surface-Mounting Cabinet Enclosure**: Steel with finish to match cabinet.

E. **Electric-Resistance Heating Coil**: Nickel-chromium heating wire, free from expansion noise and hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high temperature protection. Provide integral circuit breaker for overcurrent protection.

F. **Fan**: Aluminum propeller directly connected to motor.

1. Motor: Permanently lubricated, multispeed. Comply with requirements in specification Section 23 05 13 – Common Motors Requirements for HVAC Equipment.

G. **Controls**: Unit-mounted thermostat.

H. **Electrical Connection**: Factory wire motors and controls for a single field connection.

2.3 DOWNFLOW CEILING MOUNTED HEATERS

A. **Basis-of-Design Product**: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Berko Electric Heating.
2. Chromalox, Inc.
3. TPI Corporation.
4. Marley Electric Heating.
5. QMark Electric Heating.
6. Trane.
7. Or Approved Equal

B. **Description:** An assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

C. **ELEMENTS:** Elements shall consist of Nickel Chromium alloy resistance wire embedded and completely surrounded in Magnesium Oxide, enclosed and swagged into corrosion resistant sheaths. Corrosion resistant steel fins shall be permanently attached to the sheaths to provide maximum heat transfer to the air stream.

D. **MOTORS:** Motors shall be single phase, resilient mounted, totally enclosed, industrial rated with an automatic reset thermal overload protective device. Motors on heaters up to 20 KW capacity shall be permanently lubricated shaded pole type. Over 20 KW, motors shall be permanent split capacitor type. Motors shall be mounted out of the main air stream in such a manner as to allow ambient air to be drawn over the motor to reduce motor temperature. Motor shall be separately removable from beneath the heater without removing the entire heater from mounting bracket.

E. **FAN BLADES:** Fan blades shall be heavy-duty individually balanced axial flow type. Fan speed shall not exceed 1570 RPM.

F. **THERMAL OVERLOAD PROTECTION:** All heaters shall be equipped with a manual reset thermal cutout which disconnects elements and motor in the event normal operating temperatures are exceeded.

G. **WIRING:** Heaters shall be designed for a single supply circuit with elements, motor and control circuits subdivided and fused to conform with the latest National Electric Code and OSHA requirements. All three phase heaters shall have balanced phases.

E. **CONTROLS:** Heaters shall be controlled by a low voltage wall mounted thermostat. All heaters 25 KW and larger shall be wired for 2 stage operation. 5 KW through 20 KW units are single stage. All heaters shall be equipped with a fan safety device that causes fan to operate after elements are de-energized to purge unit of residual heat.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install heaters to comply with NFPA 90A.

B. Suspend cabinet unit heaters from structure with elastomeric hangers and seismic restraints. Vibration isolators and seismic restraints are specified in specification Section 22 - Vibration and Seismic Controls.

C. Suspend propeller unit heaters from structure with all-thread hanger rods and spring hangers. Hanger rods and attachments to structure are specified in specification Section 22 05 48 - Vibration and Seismic Controls. Vibration hangers are specified in specification Section 22 05 48 - Vibration and Seismic Controls.

D. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

E. Install new filters in each unit within two weeks of Substantial Completion.

F. Comply with safety requirements in UL 1995.

G. Ground equipment and connect wiring in accordance with specification 26 05 83 Wire & Cable.

3.2 FIELD QUALITY CONTROL

A. **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 motor rotation and unit operation.

2. Operate electric heating elements through each stage to verify proper operation and electrical connections.

3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

- END OF SECTION -

SECTION 23 83 00 - Electric Radiant Heaters

Part 1 - **PART 1 – GENERAL**

1.1 SUMMARY

A. This section includes electric radiant heaters used for heating applications.

B. The CONTRACTOR shall provide the electric heaters, and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

C. Where 2 or more heaters or appurtenances of the same type or size are required, they shall be furnished by the same manufacturer

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. National Electrical Code

B. NFPA 70

C. Canadian Electrical Code, Part 1, C22.1

1.3 CONTRACTOR SUBMITTALS

A. Submittals shall be furnished in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

B. Show mounting methods and reflector details.

C. The submittals shall include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

1.4 QUALITY

A. Codes and Permits

1. The WORK shall be in strict accordance with the California State Mechanical Code, the State of California building code, local codes and any other authorities having jurisdiction.

2. The CONTRACTOR shall have the required certification and be thoroughly familiar with the local codes.

3. The CONTRACTOR shall obtain and pay for necessary permits.

B. Diligent Care

1. Care shall be taken at all times to protect floors, stairways, and walls during the make-up, erection of piping and placing of equipment.
2. The CONTRACTOR shall remove all stains and repair all damage before final acceptance of the WORK.

C. Materials

1. The materials used in connection with the electric heating system work shall:
   .1 be new;
   .2 be free from flaws and defects;
   .3 be fully equal to the quality specified; and,
   .4 conform to the requirements of applicable specifications and standards.
2. If during the construction of the Project the ENGINEER finds materials that have identifying marks removed, or lacking such marks completely, such items may be rejected until the CONTRACTOR has shown proof that said items conform to the indicated requirements, where the adequacy and extent of such proof shall be determined by the ENGINEER.Products

1.5 WARRANTY

A. The electric radiant heater equipment manufacturer's warranty shall be for a period of one year from date of equipment start up but not more than 18 months from date of original equipment shipment from the factory. The warranty shall cover material and workmanship that prove defective within the above period.

1.6 GENERAL

A. Motors shall be in conformance with the requirements of Section 26 05 10 Low-Voltage AC Electric Motors.

B. The electrical system and components for electric heating systems shall be in conformance with the requirements of Section 23 05 00 HVAC General.

1.7 ELECTRIC RADIANT HEATERS

A. Provide electric radiant space heaters as indicated.

B. Heater elements shall be:

1. single-ended;

2. 0.475-inch diameter;

3. alloy-sheathed;

4. UL-listed for indoor and outdoor applications;

5. of moisture-resistant construction such that the entire assembly can be hosed down to remove dust and dirt;

6. provided with a polished aluminum reflector housing; and, of lightweight construction.

C. The heaters shall be rated at as noted on the drawings.

D. Electric Radiant Heaters Manufacturers, or Equal

1. Chromalox

2. TPI

3. Indeeco

4. SRP

E. Type 1: Ceiling mount type

1. High density radiant panel heater designed for ceiling mounted or roof structure suspended installation.

2. Plaster frame for flush installation in gypsum board ceilings where required.

3. Unit constructed of min 24 ga corrosion resistant steel with radiant surface finished on high emmissivity textured latex acrylic paint. Assembly to incorporate insulation mass on back of heating element.

1.8 CONTROLS

A. Thermostat and solid state

Part 2 - **EXECUTION**

2.1 INSTALLATION

A. Install infrared heaters and controls as indicated and in accordance with manufacturer's instructions.

B. Ensure that manufacturer's mounting instructions for each fixture, including minimum distances from ceiling, walls, or combustible materials, are followed.

C. Make power and control connections.

2.2 COMMISSIONING

A. With all circuits connected and prior to waterproofing and sealing, perform resistance tests on each circuit with an ohmmeter. Measured resistance must equal calculated resistance using the following formula:

$$\text{Resistance (ohms)} = \frac{(\text{Design voltage})^2}{\text{Total Wattage}}$$

B. Recheck all connections and re-do as necessary until measured resistance is equal to calculated resistance.

C. Waterproof and seal all connections according to manufacturer's instructions.

D. Recheck resistance measurements to ensure resistance is the same as previously measured.

E. Notify ENGINEER immediately if any discrepancy is found.

F. Check and confirm satisfactory operation of radiant heating system.

2.3 QUALIFIED INSTALLER

A. The entire installation, wiring and testing shall be done by a trained installer.

- END OF SECTION -

SECTION 26 00 00 - BASIC ELECTRICAL REQUIREMENTS

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide electrical WORK, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section apply to all sections in Division 26, except as indicated otherwise.

C. Concrete, excavation, backfill, and steel reinforcement required for encasement, installation, or construction of the WORK of the various sections of Division 26 is included as a part of the WORK under the respective sections, including duct banks, manholes, handholes, equipment housekeeping pads, and light pole bases.

1.2 RELATED SECTIONS

A. The WORK of this Section is required for operation of electrically-driven equipment provided under specifications in other Divisions. The CONTRACTOR'S attention is direction to the requirement for proper coordination of the WORK of this Section with the WORK of HVAC, process and instrumentation control, and other equipment sections, including, but not limited to the following:

1. Section 23 05 00 – Heating, Ventilation, and Air Conditioning, General
2. Section 35 79 13 – Traveling Belt Intake Screen
3. Section 40 90 00 – Process Instrumentation and Control, General
4. Section 40 90 05 – Control Enclosures and Devices
5. Section 40 90 10 – Instrumentation for Process Systems
6. Section 40 90 18 – Vendor Package Control Systems
7. Section 44 35 04 – Packaged Booster Pump System
8. Section 44 35 35 – Horizontal End Suction Centrifugal Pumps
9. Section 44 35 56 – Submersible Sump Pumps

1.3 REFERENCE STANDARDS

A. The following apply to all sections in Division 26, except as indicated otherwise:

California Air Resources Board (CARB)

California Code of Regulations (CCOR)

Title 24 – California Building Standards Code

California Public Utilities Commission (CPUC)

General Order No. 128 – Construction of Underground Electric Supply and Communication Systems

National Electrical Contractors Association (NECA)

National Electrical Installation Standards

National Electrical Manufacturers Association (NEMA)

250 Enclosure for Electrical Equipment (1000 Volts Maximum)

Z535.4 Product Safety Signs and Labels

International Electrical Testing Association (NETA)

National Fire Protection Association (NFPA)

70 National Electrical Code (NEC)

B. Electrical equipment shall be listed by and shall bear the label of Underwriters' Laboratories, Inc. (UL) or an independent testing laboratory acceptable to the local code enforcement agency having jurisdiction.

C. Installation of electrical equipment and materials shall comply with OSHA Safety and Health Standards (29 CFR 1910 and 29 CFR 1926, as applicable), state building standards, and applicable local codes and regulations.

D. Where the requirements of the specifications conflict with UL, NEMA, NFPA, or other applicable standards, the more stringent requirements shall govern.

1.4 SIGNAGE AND MARKINGS

A. **Identification**: Provide danger, caution, and warning signs and equipment identification markings in accordance with applicable federal and state OSHA and NEC requirements.

B. Each local disconnect switch for motors and equipment shall be legibly marked to indicate its purpose unless the purpose is indicated by the location and arrangement.

1.5 PERMITS AND INSPECTION

A. Permits shall be obtained and inspection fees shall be paid according to the General Conditions.

1.6 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Contractor Submittals and with the specific requirements of each section in Division 26.

B. Only submit catalog cutsheets relevant to the WORK. Entire catalogs and catalog sections submitted that contain a small percentage of equipment relevant to the WORK will be rejected.

C. **General Submittal Requirements:** Provide the following:

1. Complete material lists stating manufacturer and brand name of each item or class of material.

2. Front, side, rear elevations, and top views with dimensional data.

3. Connection diagrams, terminal numbers, internal wiring diagrams, conductor size, and cable numbers.

4. Method of anchoring, seismic requirements, weight.

5. Types of materials and finish.

6. Nameplates.

7. Temperature limitations, as applicable.

8. Voltage requirement, phase, and current, as applicable.

9. Front and rear access requirements.

10. Grounding requirements.

11. Catalog cuts of bulletins or brochures for applicable standard equipment. Catalog data sheets shall be stamped to indicate the project name, applicable Section and paragraph, model number, and options.

D. **Technical Manuals:** Complete information in accordance with Section 01 33 00 – Contractor Submittals.

1.7 AREA DESIGNATIONS

A. Electric WORK specifically indicated in sections within any of the specifications shall comply with the requirements of those sections unless indicated otherwise.

B. CONTRACTOR shall avoid installing electrical equipment in the vicinity of equipment or structures known to routinely splash or spray water, such as fish raceways. Where electrical equipment could be subject to such conditions, coordinate with OWNER to determine alternate locations and conduit routing paths. If installing electrical equipment in such areas cannot be avoided, as determined by OWNER, CONTRACTOR will provide NEMA 4 or better enclosures, and raceway and equipment suitable for such areas.

C. **The following areas are designated as wet areas:**

1. Outdoor areas.

2. Below-grade areas, such as vaults and handholes.

D. **The following areas are designated as wet areas with splashing or spraying water:**

1. Coho Building: 72” above finished floor and below.

2. Chinook Incubation Building: 72” above finished floor and below.

3. Spawning Building: 72” above finished floor and below.

E. **The following areas are designated as dry areas:**

1. Chinook Incubation Building Electrical Room.

F. Areas not mentioned above are designated as general industrial areas.

1.8 ENCLOSURES

A. Above-grade raceway system enclosures shall be provided in accordance with Section 26 05 33 – Electrical Raceway Systems.

B. Below-grade raceway system enclosures shall be provided in accordance with Section 26 05 43 – Underground Raceway Systems.

C. Provide the following NEMA 250 enclosure types for electrical equipment, unless indicated otherwise:

1. **Wet Areas:** NEMA 3R.

2. **Wet Areas with Splashing or Spraying Water:** NEMA 4.

3. **Dry Areas:** NEMA 1.

4. **General Industrial Areas:** NEMA 12.

D. **Material Requirements:**

1. NEMA 1, 3R, 4, and 12 enclosures shall be steel, primed and coated with ANSI 61 light grey paint.

1.9 QUALITY ASSURANCE

A. Short circuit and arc flash studies shall be prepared by a Professional Electrical Engineer registered in the State of California.

1.10 ELECTRICAL STUDY SEQUENCING AND SCHEDULING

A. Initial short circuit study shall be submitted and accepted before OWNER’S REPRESENTATIVE will review submittals on electrical distribution equipment.

B. Revised short circuit and arc flash studies, and arc flash labels shall be submitted and accepted prior to energizing electrical equipment.

C. Final short circuit and arc flash studies shall be submitted and accepted prior to Substantial Completion. Final version of studies shall include as-installed equipment and materials.

D. Submit final arc flash labels as described herein prior to Substantial Completion.

1.11 TESTS

A. Perform in accordance with 26 01 26 – Electrical Testing.

B. The CONTRACTOR shall be responsible for factory and field tests required by specifications in Division 26 and by the OWNER'S REPRESENTATIVE or other authorities having jurisdiction. The CONTRACTOR shall furnish necessary testing equipment and pay costs of tests, including replacement parts and labor, due to damage resulting from damaged equipment or from testing and correction of faulty installation.

C. Where test reports are indicated, proof of design test reports for mass-produced equipment shall be submitted with the Shop Drawings, and factory performance test reports for custom-manufactured equipment shall be submitted and be approved prior to shipment. Field test reports shall be submitted for review prior to Substantial Completion.

D. Equipment or material that fails a test shall be removed and replaced or, if the OWNER'S REPRESENTATIVE approves, may be repaired and retested for compliance. Corrections to equipment or materials with a factory warranty shall be as recommended by the manufacturer and shall be done in a manner that does not void the warranty.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Equipment and materials shall be new, shall be listed by UL, and shall bear the UL label where UL requirements apply.

B. Equipment and materials shall be the products of experienced and reputable manufacturers in the industry.

C. Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

D. Equipment and materials shall be of industrial grade standard of construction.

E. Where a NEMA enclosure type is indicated in a non-hazardous location, the CONTRACTOR shall utilize that type of enclosure, even though certain modifications such as cutouts for control devices may negate the NEMA rating.

2.2 MOUNTING HARDWARE

A. **Nuts, Bolts, and Washers:** Provide in accordance with Section 05 50 00 – Miscellaneous Metalwork.

B. **Threaded Rods for Trapeze Supports:** Provide in accordance with Section 05 50 00 – Miscellaneous Metalwork.

C. **Anchors for Attaching Equipment to Concrete Walls, Floors, and Ceilings**: Provide in accordance with Section 05 50 00 – Miscellaneous Metalwork.

D. **Framing Channel:**

1. Types:

    a. Carbon steel, with hot-dip galvanization.

    b. Carbon steel, with electro-deposited, rust-inhibiting paint coating.

2. Steel framing channel shall be 12-gauge minimum.

3. Where contact with concrete or dissimilar metals may cause galvanic corrosion, suitable non-metallic insulators shall be utilized to prevent such corrosion.

4. Manufacturers, or equal:

    a. **Unistrut**.

    b. **B-Line**.

    c. **Power-Strut**.

2.3 ARC FLASH WARNING LABELS

A. Provide arc flash warning labels printed in color on thermally-bonded, adhesive-backed, UV- and weather-resistant labels, and in compliance with NEMA Z35.4.

2.4 ELECTRICAL IDENTIFICATION

A. **Nameplates:** Nameplates shall be fabricated from white-letter, black-face laminated plastic engraving stock, **Formica Type ES-1** or equal. Each shall be fastened securely, using fasteners of stainless steel screwed into inserts or tapped holes as required. Engraved characters shall be block style with no characters smaller than 1/8-inch top to bottom. Adhesive material shall not be the only form of attaching nameplates.

B. **Conductor and Equipment Identification:** In accordance with Section 26 05 83 – Wire & Cable.

PART 3 -- EXECUTION

3.1 GENERAL

A. **Incidentals:** The CONTRACTOR shall provide materials and incidentals required for a complete and operable system, even if not required explicitly by the Contract Documents. Typical incidentals are terminal lugs not furnished with vendor-supplied equipment, compression connectors for cables, splices, junction and terminal boxes, and control wiring required by vendor-furnished equipment to connect with other equipment indicated in the Contract Documents.

B. Raceway routing shall be in accordance with Section 26 05 33 – Electrical Raceway Systems.

C. **Field Control of Location and Arrangement:** The Drawings diagrammatically indicate the desired location and arrangement of outlets, conduit runs, equipment, and other items. Exact locations shall be determined by the CONTRACTOR in the field based on the

physical size and arrangement of equipment, finished elevations, and other obstructions. Locations on the Drawings, however, shall be followed as closely as possible.

1. Equipment shall be installed in such a manner as to avoid obstructions, to preserve headroom, and keep openings and passageways clear. Lighting fixtures, switches, convenience outlets, and similar items shall be located as indicated. If equipment is installed without instruction and must be moved, it shall be moved without additional cost to the OWNER. Lighting fixture locations shall be adjusted slightly to avoid obstructions and to minimize shadows.

2. Wherever conduits and wiring for lighting and receptacles are not indicated, it shall be the CONTRACTOR'S responsibility to provide lighting and receptacle-related conduits and wiring as required, based on the actual installed fixture layout and the circuit designations as indicated.

D. **Workmanship:** Materials and equipment shall be installed in strict accordance with printed recommendations of the manufacturer. Installation shall be accomplished by workers skilled in the WORK. Installation shall be coordinated in the field with other trades to avoid interferences.

E. **Protection of Equipment and Materials:** The CONTRACTOR shall fully protect materials and equipment against damage from any cause. Materials and equipment, both in storage and during construction, shall be covered in such a manner that no finished surfaces will be damaged, marred, or splattered with water, foam, plaster, or paint. Moving parts shall be kept clean and dry. The CONTRACTOR shall replace or refinish damaged materials or equipment, including faceplates of panels and switchboard sections, as part of the WORK.

3.2 GENERAL REQUIREMENTS FOR ELECTRICAL STUDIES

A. Equipment and component tags used in the studies shall be identical to equipment and component tags shown on the Contract Documents.

B. Perform studies using one of the following software packages, or approved equal:

1. SKM Power Tools for Windows.

2. ETAP.

3. Paladin.

4. Easy Power.

C. Utilize proposed load data for studies obtained from Contract Documents and verified by CONTRACTOR for final design.

D. Make minor modifications to equipment as required to accomplish conformance with short circuit study.

E. Notify OWNER’S REPRESENTATIVE in writing of required major equipment modifications.

F. Provide laminated one-line diagrams (minimum 11 inches by 17 inches) to post on interior of doors to rooms where electrical equipment is located. Post diagrams on main distribution panel where electrical equipment is only accessible by hatch and ladder.

G. Provide arc flash warning labels on equipment as specified in this section.

3.3 SHORT CIRCUIT STUDY

A. Prepare in accordance with IEEE 399.

B. Prepare separate studies for each unique utility service tap to different sites of the WORK.

C. Use cable impedances based on copper conductors, except where aluminum conductors are specified or shown.

D. Use bus impedances based on copper bus bars, except where aluminum bus bars are specified or shown.

E. Use cable and bus resistances calculated at 25 degrees C.

F. Use medium voltage cable reactances based on use of typical dimensions of shielded cables with 133 percent insulation.

G. Use 600-volt cable reactances based on use of typical dimensions of THHN/THWN or XHHW conductors, where specified.

H. Use transformer impedances 92.5 percent of “nominal” impedance based on tolerances specified in IEEE C57.12.00.

I. Each study shall include:

1. Calculation methods and assumptions.

2. Typical calculation.

3. Tabulations of calculated quantities.

4. Results, conclusions, and recommendations.

5. Selected base per unit quantities.

6. One-line diagrams.

7. Source impedance data, including electric utility system and motor fault contribution characteristics.

8. Impedance diagrams.

9. Zero-sequence impedance diagrams.

J. **Three-Phase Bolted Fault:** Calculate short circuit interrupting and momentary (when applicable) duties for an assumed three-phase bolted fault at each:

1. Electric utility's supply termination point.
2. Service entrance circuit breaker disconnect.
3. Main distribution panelboard.
4. Standby generator, or portable generator termination cabinet (where applicable).
5. Branch circuit panelboard.

K. **Line-to-Ground Bolted Fault:** Calculate bolted line-to-ground fault current for areas as defined for three-phase bolted fault.

L. Verify the following for each study:

1. Equipment and protective devices are applied within their ratings.
2. Adequacy of panelboard bus bars to withstand short circuit stresses.
3. Adequacy of transformer windings to withstand short circuit stresses.
4. Cable sizes for ability to withstand short circuit current heating, in addition to normal load currents.

M. **Tabulations:**

1. General Data:
    a. Short circuit reactances of rotating machines.
    b. Cable and conduit material data.
    c. Bus data.
    d. Transformer data.
    e. Circuit resistance and reactance values.
2. Short Circuit Data:
    a. Fault impedances.
    b. X/R ratios.
    c. Asymmetry factors.
    d. Motor contributions.
    e. Short circuit kVA.
    f. Symmetrical and asymmetrical fault currents.

3. Equipment Evaluation:

    a. Equipment bus bracing, equipment short circuit rating, transformer, cable.

    b. Maximum fault current available.

N. Provide a written summary of the following for each study:

1. Scope of studies performed.

2. Explanation of bus and branch numbering system.

3. Prevailing conditions.

4. Selected equipment deficiencies.

5. Results of short circuit study.

6. Comments or suggestions.

O. Suggest changes and additions to equipment rating and/or characteristics.

P. Notify OWNER'S REPRESENTATIVE in writing of existing circuit protective devices improperly rated for new fault conditions.

Q. Revise data for "as-installed" condition.

3.4 ARC FLASH STUDY

A. Perform arc flash hazard study after short circuit study has been completed, reviewed, and accepted.

B. Perform arc flash study in accordance with NFPA 70E, OSHA 29 CFR, Part 1910 Subpart S, and IEEE 1584.

C. **Base Calculation:** For each major part of the electrical; power system, determine the following:

1. Flash hazard protection boundary.

2. Limited approach boundary.

3. Restricted approach boundary.

4. Incident energy level.

5. Personal Protective Equipment (PPE) required.

D. Produce arc flash warning labels that list items in Paragraph Base Calculation and the following additional items:

1. Bus name.

2. Bus voltage.

E. Produce bus detail sheets that list items in Paragraph Base Calculation and the following additional items:

1. Bus name.

2. Upstream protective device name, type, and settings.

3. Bus line-to-line voltage.

F. Produce arch flash evaluation summary sheet listing the following additional items:

1. Bus name.

2. Upstream protective device name, type, and settings.

3. Bus line-to-line voltage.

4. Bus bolted fault.

5. Protective device bolted fault current.

6. Arcing fault current.

7. Protective device trip/delay time.

8. Breaker opening time.

9. Solidly grounded column.

10. Equipment type.

11. Gap.

12. Arc flash boundary.

13. Working distance.

14. Incident energy.

G. Analyze short circuit and arc flash calculations and highlight equipment that is determined to be under-rated or causes incident energy values greater than 8 cal/cm^2. Propose approaches to reduce energy levels.

H. Prepare report summarizing arc flash study with conclusions and recommendations which may affect integrity of electric power distribution system. As a minimum, include the following:

1. Equipment manufacturer's information used to prepare study.

2. Assumptions made during study.

3. Reduced copy of one-line drawing; 11 inches by 17 inches maximum.

4. Arch flash evaluations summary spreadsheet.

5. Bus detail sheets.

6. Arc flash warning labels printed in color on thermally-bonded, adhesive-backed UV and weather-resistant labels.

3.5 CONCRETE PADS

A. Provide concrete pads for indoor and outdoor free-standing electrical equipment in accordance with the Contract Documents.

B. Concrete housekeeping curbs shall be provided for conduit stub-ups in indoor locations that are not concealed by equipment enclosures. Such curbing shall be 3-inches above finished floor or grade.

3.6 FRAMING CHANNEL

A. Install where required for mounting and supporting electrical equipment and raceway.

B. Framing Channel Type:

1. Steel Raceway: Galvanized or paint-coated carbon steel channel.

C. Paint cut ends prior to installation with the following:

1. Galvanized carbon steel channel: Zinc-rich primer.

2. Painted carbon steel channel: Rust-inhibiting paint.

3.7 EQUIPMENT ANCHORING

A. Floor-supported and wall- or ceiling-hung equipment and raceway shall be anchored in place by methods that will meet seismic requirements in the area where the project is located and Contract installation requirements.

B. Anchoring methods and leveling criteria in the printed recommendations of the equipment manufacturers are a part of the WORK of this Contract. Such recommendations shall be submitted as Shop Drawings under Section 01 33 00 – Contractor Submittals.

3.8 EQUIPMENT IDENTIFICATION

A. Nameplates shall be provided for panelboards, control and instrumentation panels, starters, switches, and pushbutton stations. In addition to nameplates, control devices shall be equipped with standard collar-type legend plates.

B. Control devices within enclosures shall be identified as indicated. Identification shall be similar to the subparagraph above.

C. Toggle switches that control loads out of sight of switches and multi-switch locations of more than 2 switches shall have suitable labeled finish plates.

D. Equipment names and tag numbers, where indicated on the Drawings, shall be utilized on nameplates.

E. The CONTRACTOR shall furnish typewritten circuit directories for panelboards; circuit directory shall accurately reflect the outlets connected to each circuit.

F. Termination points on terminal blocks shall be labeled by identifiers on the blocks. Identifiers shall be preprinted by the terminal manufacturer or custom-printed. Hand lettered markers will not be acceptable.

G. Distribution equipment, stand-alone disconnects, starters, and VFDs shall be tagged with appropriate arc-flash labels.

3.9 CLEANING

A. Before final acceptance, the electrical WORK shall be thoroughly cleaned to the OWNER'S satisfaction:

1. Exposed parts shall be thoroughly cleaned of cement, plaster, and other materials.

2. Temporary tags, markers, stickers, etc. shall be removed.

3. Oil and grease spots shall be removed with a non-flammable cleaning solvent. Such surfaces shall be carefully wiped, and cracks and corners scraped out.

4. Touch-up paint shall be applied to scratches on panels and cabinets.

5. Electrical cabinets or enclosures shall be vacuumed.

6. Light fixtures shall be cleaned inside and out.

B. Debris and refuse from cleaning shall be disposed of off the Site.

- END OF SECTION -

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SECTION 26 01 00 - BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 -- GENERAL

1.1 REFERENCE STANDARDS

A. The following is a list of standards which may be referenced in this section:

National Electrical Manufacturers Association (NEMA)

AB 1	Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
KS 1	Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum)
WD 1	General Color Requirements for Wiring Devices
WD 6	Wiring Devices – Dimensional Specifications

Underwriters Laboratories, Inc. (UL)

98	Enclosed and Dead-Front Switches
467	Grounding and Bonding Equipment
486E	Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors
486F	Bare and Covered Ferrules
489	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
498	Standard for Attachment Plugs and Receptacles
1059	Standard for Terminal Blocks

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Sections 01 33 00 - Contractor Submittals, and 26 00 00 – Basic Electrical Requirements.

B. **Product Data:**

1. Circuit Breakers:

a. Enclosures.

b. Time-current curves for breaker frames larger than 125A.

c. Electronic trip unit data, where applicable.

d. Accessories.

e. Wiring diagrams for accessories, such as shunt trip coils.

2. Non-fused safety switches.

3. Intrusion switches.

4. Wiring devices.

5. Device plates.

6. Grounding connectors.

7. Ground rods.

PART 2 -- PRODUCTS

2.1 MOLDED-CASE CIRCUIT BREAKER, LOW VOLTAGE

A. Molded-case circuit breakers shall be manufactured in accordance with NEMA AB 1 and UL 489.

B. Trip ratings as shown on Drawings.

C. Voltages: 120, 240, 277, 480, and 600 volts ac, as indicated.

D. Provide 100% rated circuit breakers where shown. Otherwise, provide 80% rated circuit breakers.

E. Where indicated, provide circuit breakers and accessories labeled for use as a service entrance.

F. **Operating Mechanism:**

1. Toggle-type operating handle, with quick-make and quick-break action.

2. Locking provisions for padlocking in the OPEN position.

3. ON, OFF, and TRIPPED indicating positions of operating handle.

G. **Trip Mechanism, Thermal Magnetic Type:**

1. Individual thermal and magnetic trip elements in each pole.

2. Adjustable, continuous magnetic trip elements with adjustment range of 3- to 10-times rated current for frames greater than 125A.

3. Two- and three-pole breakers shall be common trip.

4. Mechanism opens all poles when overcurrent occurs on any single pole.

5. Test button on cover.

6. Using single-pole circuit breakers with handle ties to make multi-pole circuit breakers will not be acceptable.

H. **Solid State (Electronic) Trip Type:**

1. Provide electronic trip circuit breaker where indicated on Drawings with some combination or all of the letters 'L', 'S', 'I', and 'G'. These letters indicate required trip unit functions, as defined below.

2. Electronic trip units shall be UL listed.

3. Includes current sensors and logic circuits integral to breaker frame.

4. True rms sensing, with LED long-time pickup and trip indication.

5. Where indicated, equipped with the following adjustable settings:

   a. 'L': Long-time pickup and time delay.

   b. 'S': Short-time pickup and time delay.

   c. 'I': Instantaneous pickup.

   d. 'G': Ground fault trip and time delay.

6. Trip button on front cover of breaker to permit manual tripping of breaker.

7. Cause-of-trip troubleshooting function, via LEDs or LCD display.

I. **Short Circuit Interrupting Ratings:**

1. Not less than the following rms symmetrical currents for the indicated trip ratings or as shown on the Contract Drawings:

   a. 250 volts ac and less, 100A and less: 10 kA.

   b. 250 to 600 volts ac, 100A and less: 14 kA.

   c. More than 100A: 18 kA.

J. **Accessories:**

1. Provide interlocks, handle locks, double lugs, and mounting bases as shown or as required.

K. **Connections:**

1. Capable of line side conductors landing at either end.

2. Mechanical lugs, except crimp compression lugs where shown.

3. Removable/replaceable lugs for frames rated more than 100A.

4. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.

L. **Independent Enclosures for Circuit Breaker Mounting:**

1. Enclosure: NEMA 250, type as indicated in Section 26 00 00 – Basic Electrical Requirements.

2. Service Entrances: Where indicated, provide circuit breakers and accessories in enclosures labeled for use as a service entrance.

3. Interlock: Enclosure and breaker handle shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel.

2.2 INTRUSION SWITCHES

A. Rugged industrial switches designed for magnetic intrusion detection on entry doors and overhead doors.

B. Switches shall be UL listed.

C. Switches shall be gray and have concealed screw terminals.

D. Voltage: 24 Vdc.

E. Configuration: One SPDT (form C) contact.

F. Gap Distance: Up to 1-1/4 inches.

G. Manufacturer and Model, or Equal:

1. **GE Security; 1047TN**.

2.3 WIRING DEVICES

A. Devices shall be manufactured in accordance with NEMA WD 1 and WD 6, and UL 498.

B. **Color:** Gray.

C. **Lighting Switches:**

1. Industrial grade, totally enclosed, ac type, with quiet tumbler switches and screw terminals.

2. Rivetless one-piece brass or copper alloy contact arm with silver alloy contacts.

3. Rating: 20 amps, 120/277 volts.

4. Automatic grounding clip and integral grounding terminal on mounting strap.

5. Single Pole Manufacturer and Model, or Equal:

a. **Bryant; 4901**.

b. **Hubbell; HBL1221**.

c. **Leviton; 1221 series.**

D. **Receptacles, General Purpose:**

1. Industrial grade, duplex, two-pole, three-wire grounding type with screw terminals.
2. Impact-resistant nylon body, with finder grooves in face.
3. Rivetless one-piece construction.
4. Rating: 5-20R, 20 amps, 125 volts.
5. Integral ground contact on mounting strap.
6. Sized for 2-inch by 4-inch outlet box.
7. Manufacturers, or Equal:
   a. **Cooper; 5362 series.**
   b. **Hubbell Bryant; HBL5362 series.**
   c. **Leviton; 5362 series.**

E. **Receptacle, Ground Fault Circuit Interrupter (GFCI):**

1. Meet requirements of Receptacle, General Purpose subparagraph.
2. Listed Class A to UL 943, tripping at 5 mA.
3. Listed weather-resistant per NFPA 70, Article 406.8.
4. Feed-Through Capability: 20 amps.
5. Manufacturers, or Equal:
   a. **Cooper; WRVGF20 series.**
   b. **Hubbell Bryant; GFTR20 series.**
   c. **Leviton; 7899 series.**

F. **Device Boxes:**

1. In accordance with Section 26 05 33 – Electrical Raceway Systems, unless noted otherwise.
2. Surface-mounted switches and receptacles:
   a. Dry Areas: Sheet steel boxes.
   b. Outdoor and Indoor Wet or Damp Areas: Cast metal device boxes.

G. **Device Plates and Covers:**

1. Sectional type plate not permitted.
2. Stainless steel screws and hardware, unless noted otherwise.
3. Sheet Steel:
    a. For use only on sheet steel device boxes.
    b. Zinc electroplate finish.
4. Cast Metal:
    a. For use only on cast metal devices boxes, unless noted otherwise.
    b. Same material as box, weatherproof, with gaskets.
5. Weatherproof:
    a. Receptacle, Weatherproof While in Use:
        1) UL listed for wet locations while in use.
        2) Die cast metal cover.
        3) Manufacturer, or Equal:
            a) **TayMac**.
            b) **Red Dot**.
    b. Receptacle, Weatherproof While Closed:
        1) UL listed for wet locations while closed and for damp locations open or closed.
        2) Gasketed cast aluminum with self-closing individual caps over each receptacle opening.
        3) Manufacturer, or Equal:
            a) **Crouse-Hinds**.
            b) **Appleton**.
    c. Lighting Switch, Weatherproof Toggle:
        1) Gasketed cast metal, with external operator for switch.
        2) Manufacturer, or Equal:

a) **Crouse-Hinds**.

b) **Appleton**.

d. Lighting Switch, Weatherproof Dimmer:

1) Gasketed cast metal, with self-closing cap or hood over opening.

2) Cap or hood shall be sufficiently deep to house dimmer switch controls without negating the weatherproof listing.

3) Manufacturer, or Equal:

a) **Crouse-Hinds**.

b) **Appleton**.

2.4 NONFUSED SWITCH, INDIVIDUAL, 600 VOLTS

A. Components shall be manufactured in accordance with NEMA KS 1 and UL 98.

B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

C. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

D. **Enclosure:** NEMA 250, type as indicated in Section 26 00 00 – Basic Electrical Requirements.

E. Enclosure and switch to prevent opening cover with switch in the ON position.

2.5 TERMINAL BLOCKS, 600 VOLTS

A. Components shall be manufactured in accordance with UL 486F and UL 1059.

B. Size components to allow insertion of necessary wire sizes.

C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.

D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.

E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.

F. Yoke shall guide all strands of wire into terminal.

G. Current bar shall ensure vibration-proof connection.

H. Terminals:

1. Capable of wire connections without special preparation other than stripping.

2. Capable of jumper installation with no loss of terminal or rail space.

3. Short-circuiting type for current transformer leads.

I. Marking system, allowing use of preprinted or field-marked tags.

2.6 GROUNDING

A. Components of the grounding electrode system shall be manufactured in accordance with UL 467 and shall conform to the applicable requirements of NFPA 70, Article 250 and local codes.

B. **Ground Rods:**

1. Copper-clad steel construction.

2. Minimum 3/4-inch diameter and 10-foot length.

3. Sectional-type, joined by threaded copper alloy couplings.

C. **Equipment Grounding Circuit Conductors:**

1. The conductors shall be the same type and insulation as the load circuit conductors.

2. The minimum size shall be as outlined in Table 250.122 of NFPA 70, unless indicated otherwise.

3. Metallic conduit systems shall have an equipment grounding wires as well as being equipment grounding conductors themselves.

D. **Connectors:**

1. Exothermic Weld:

a. Outdoor welds shall be suitable for exposure to elements or direct burial.

b. Indoor welds shall utilize a low-smoke, low-emission process.

2. Compression:

a. Compress-deforming type.

b. Wrought copper extrusion material.

c. Prefilled with oxide-inhibiting and anti-seizing compound and sealed.

3. Mechanical:

a. Split-bolt, saddle, or cone screw type.

b. Copper alloy material.

E. Grounding Materials Manufacturer, or Equal:

1. **Erico**.

2. **ThermOweld**.

3. **FCI-Burndy**.

PART 3 -- EXECUTION

3.1 GENERAL

A. Install equipment in accordance with manufacturer's recommendations.

B. Use appropriate conduit and conductor entry fittings with enclosures to maintain the specified enclosure environmental capability after installation.

C. Equipment locations, if shown on Drawings, are approximate. Final locations shall be determined in accordance with field conditions and subject to OWNER's approval.

3.2 WIRING DEVICES

A. Perform WORK in accordance with the requirements of NFPA 70.

B. Keep boxes free of debris, dust, paint, and other material that may contaminate the raceway system.

C. **Device Installation:**

1. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.

2. Do not remove surface protection, such as plastic film and smudge covers, until last possible moment.

3. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.

4. Use torque screwdriver when a torque is recommended or required by manufacturer.

5. Tighten unused terminal screws on device.

D. **Lighting Switches:**

1. Box Mounting Height: 48 inches above finished floor or grating or finished grade, unless noted otherwise.

2. Install on lock side of doors.

3. Install with switch operation in vertical position.

4. Install single-pole, two-way switches such that toggle is in up position when switch is on.

E. **Receptacles:**

1. Box Mounting Height, unless noted otherwise:

a. Indoor Areas: 48 inches above finished floor or grating.

b. Outdoor Areas: 24 inches above finished grade.

2. Install with grounding slot up, except where horizontal mounting is shown, in which case install with neutral slot up.

3. Weatherproof Receptacle: Install such that cover hinge or hinges are above openings.

4. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for downstream conventional receptacles.

F. **Grounding:**

1. Devices shall be grounded in accordance with NFPA 70, Article 250, and the provisions in this section.

2. Switches and associated metal plates shall be grounded through the switch mounting yoke, outlet box, and raceway system.

3.3 DEVICE PLATES

A. Securely fasten to wiring device; ensure a tight fit to box.

B. For surface-mounted boxes, plates shall not extend beyond sides of box, unless plates have no sharp corners or edges.

C. Install with alignment tolerance to box of 1/16-inch.

D. Do not use oversized or extra deep plates.

E. **Types:**

1. Indoor Dry Areas: Sheet steel.

2. General Industrial Areas: Cast metal.

3. Receptacles, Indoor Wet Areas: Weatherproof while in use.

4. Receptacles, Outdoor Areas: Weatherproof while in use.

5. Switches, Wet Areas: Weatherproof toggle or weatherproof dimmer, as required and as shown.

3.4 GROUNDING

A. Provide a separate grounding conductor, securely grounded in each raceway independent of raceway material.

B. Provide a separate grounding conductor for each motor and connect at motor box.

C. Do not use the motor box bolts or cover as grounding connectors.

D. Sizes shall be as indicated on the Drawings and in accordance with NEC Article 250.

E. Provide a grounding-type bushing for secondary feeder conduits that originate from the secondary section of each MCC section, switchboard, or panelboard.

F. Individually bond the raceway to the ground bus in the secondary section.

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

H. Provide a separate grounding conductor in each individual raceway for parallel feeders.

I. **Ground Rods:**

1. Provide ground rods at the indicated locations.

2. Install full length with conductor connection at upper end.

3. Install with connection point below finished grade.

4. Space multiple ground rods by one rod length.

5. Install to 8 feet below local frost depth.

6. A single electrode that does not have resistance-to-ground of 5 ohms or less shall be augmented by additional electrodes to obtain this value.

7. Take the resistance-to-ground measurement during dry weather, a minimum of 48 hours after a rainfall.

8. Rods forming an individual ground array shall be equal in length.

J. **Connections:**

1. Above Grade, Concealed or Exposed: Use compression or mechanical connectors.

2. Above Grade, Embedded or Under-Slab: Use exothermic weld connectors.

3. Below Grade: Use exothermic weld connectors.

4. Underground and grounding connections embedded in concrete shall be UL-listed ground grid connectors.

5. The connection shall be made in accordance with the manufacturer's instructions.

6. Notify ENGINEER prior to backfilling ground connections.

K. **Shield Grounding:**

1. Shielded instrumentation cable shall have its shield grounded at one end only unless the Shop Drawings indicate that the shield will be grounded at both ends.

2. The grounding point shall be at the control panel or at the receiving end of the signal carried by the cable.

3. The termination of the shield drain wire shall be on its own terminal screw.

4. Jumper together the terminal screws, using manufactured terminal block jumpers or a No. 14 green insulated conductor.

5. Connect the ground bus via a green No. 12 conductor to the main ground bus for the panel.

- END OF SECTION -

SECTION 26 01 26 - ELECTRICAL TESTING

PART 1 -- GENERAL

1.1 SUMMARY

A. This Section specifies the WORK necessary to test, commission, and demonstrate that the electrical work satisfies the criteria of these Specifications and functions as required by the Contract Documents.

B. Field tests shall be performed by a certified test organization, or may be performed by the CONTRACTOR, if specifically approved by the OWNER'S REPRESENTATIVE. Test results shall be submitted to the OWNER'S REPRESENTATIVE for review and acceptance.

C. Testing Support:

1. The WORK of this Section includes furnishing the labor, equipment, and power required to support the testing indicated in other Divisions of these Specifications.

2. Electrical testing indicated herein, and functional testing of power and controls not tested under other Sections of Division 26 shall be completed before commencement of the 7-day test of Section 01 75 00 – Startup and Adjustments.

3. This scope may require the CONTRACTOR to activate circuits, shutdown circuits, run equipment, make electrical measurements, replace blown fuses, install temporary jumpers, and the like.

D. Corrections and Replacements:

1. Before final acceptance, each part of the WORK shall be thoroughly tested, and each test shall be documented.

2. Any materials or equipment failing any test shall be corrected or replaced as required to pass the test at no additional cost to the OWNER.

3. Any materials or equipment failing any test shall be re-tested after correction or replacement to verify compliance.

4. Any failures shall again be corrected or replaced, and then re-tested.

5. The correction/replacement/re-testing cycle shall continue until the item passes the required test(s).

1.2 REFERENCE STANDARDS

A. The following is a list of standards which may be referenced in this section:

Institute of Electrical and Electronics Engineers (IEEE)

81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1): Normal Measurements

National Electrical Manufacturers Association (NEMA)

AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications

International Electrical Testing Association (NETA): Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (ATS)

National Fire Protection Association (NFPA)

70, National Electrical Code (NEC)

70E, Standard for Electrical Safety Requirements for Employee Workplaces

101, Life Safety Code

110, Standard for Emergency and Standby Power Systems

Occupational Safety and Health Administration (OSHA): CFR 29, Part 1910, Occupational Safety and Health Standards

1.3 CONTRACTOR SUBMITTALS

A. **Technical Manuals:** Include the following:

1. Energization Plan: Prior to initial energization of new electrical equipment, submit the following:

   a. OWNER'S REPRESENTATIVE's sign-off form for complete and accurate arc flash labeling and proper protective device settings for equipment to be energized.

   b. Staged sequence of initial energization of electrical equipment.

   c. Lock Out Tag Out (LOTO) plan.

   d. Barricading, signage, and communication plan notifying personnel of newly energized equipment.

2. Submit test or inspection reports and certificates for each electrical item tested within 15 days after completion of test.

3. Operation and Maintenance Data: After test or inspection reports and certificates have been reviewed by OWNER'S REPRESENTATIVE and returned, include a copy of each as part of the electrical Operation and Maintenance Manual.

1.4 GENERAL TESTING

A. Carry out the tests indicated herein for individual items of materials and equipment in other Sections.

B. Subsystems shall be defined as individual and collections of pumps, conveyor systems, screen cleaning systems, standby generator systems, and the like.

C. **Sequencing and Scheduling:**

1. Perform inspection and tests after equipment has been installed.

2. Perform tests with equipment de-energized whenever feasible.

3. Inspection and tests on energized equipment shall be scheduled with OWNER and minimized to avoid extended period of interruption to the operating plant equipment.

4. Notify OWNER at least 24 hours prior to performing tests on energized electrical equipment.

D. The following test requirements supplement test and acceptance criteria that may be indicated elsewhere:

1. Demonstrate mechanical and electrical interlocking by attempting to subvert the intended sequence.

2. Functional Testing:

a. A functional test and check of electrical components shall be required prior to performing subsystem testing and commissioning.

b. Compartments and equipment shall be cleaned as required by other provisions of these Specifications before commencement of functional testing.

c. Functional testing shall consist of:

1) Inspect for physical damage, proper anchorage and grounding.

2) Check tightness of bolted connections, including conductor terminations of each type of conductors.

3) Visual and physical check of cables, circuit breakers, transformers, and connections associated with each item of new and modified equipment.

4) Verification that electrical equipment has been labeled with Arc Flash protection boundary and PPE levels.

5) Circuit Breakers:

a) Circuit breakers 600V and below that have adjustable time or pick-up settings for ground current, instantaneous overcurrent, short-time overcurrent, or long-time overcurrent, shall be field-adjusted by CONTRACTOR.

b) Adjustable time and pickup settings for circuit breakers shall be derived from the system studies performed under Section 26 00 00 – Basic Electrical Requirements.

c) Settings shall be tabulated and proven for each circuit breaker in its installed position.

3. Complete ground testing of grounding electrodes in accordance with the requirements indicated below prior to operating the equipment.

E. Subsystem testing shall occur after the proper operation of alarm and status contacts has been demonstrated or otherwise accepted by the OWNER'S REPRESENTATIVE, and after process control devices have been adjusted as accurately as possible.

F. **Manual and Automatic Mode Demonstration:**

1. After the initial settings have been completed, each subsystem shall be operated in the manual mode and it shall be demonstrated that operation complies with the indicated requirements.

2. Once the manual mode of operation has been successfully demonstrated, automatic operation shall be demonstrated to verify such items as proper start and stop sequences, proper operation of moving equipment, proper speed control, and the like.

G. **Ground Resistance Testing:**

1. Provide ground resistance tests on the main grounding electrode or system in the presence of the OWNER'S REPRESENTATIVE and submit results.

2. Utilize the fall-of-potential method or alternative in accordance with IEEE Standard 81.

1.5 COMMISSIONING

A. Commissioning during the 7-day test as indicated in Section 01 75 00 – Startup and Adjustments shall not be attempted until each subsystem has been found to operate satisfactorily.

B. Commissioning shall be attempted only as a function of normal plant operation, in which plant process flows and levels are routine, and equipment is operating automatically in response to sensor input parameters or computer command, as applicable.

PART 2 -- PRODUCTS – Not Used

PART 3 -- EXECUTION

3.1 GENERAL

A. Perform tests in accordance with requirements of Section 01 75 00 – Startup and Adjustments.

B. Tests and inspections shall establish:

1. Electrical equipment is operational within industry and manufacturer's tolerances and standards.

2. Installation operates properly.

3. Equipment is suitable for energization.

4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, NFPA 101, and IEEE C2.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

D. Set, test, and calibrate protective devices, circuit breakers, fuses, power monitoring meters, and other applicable devices in accordance with values established by short circuit and coordination studies as specified in Section 26 00 00 – Basic Electrical Requirements.

E. Adjust mechanisms and moving parts of equipment for free mechanical movement.

F. Verify nameplate data for conformance to Contract Documents and approved Submittals.

G. Realign equipment not properly aligned and correct unlevelness.

H. Properly anchor electrical equipment found to be inadequately anchored.

I. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screwdriver to manufacturer's recommendations, or as otherwise specified in NETA ATS.

J. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

K. Provide proper lubrication of applicable moving parts.

L. Inform OWNER'S REPRESENTATIVE of working clearances not in accordance with NFPA 70.

M. Investigate and repair or replace:

1. Electrical items that fail tests.

2. Active components not operating in accordance with manufacturer's instructions.

3. Damaged electrical equipment.

N. **Electrical Enclosures:**

1. Remove foreign material and moisture from enclosure interior.

2. Vacuum and wipe clean enclosure interior.

3. Remove corrosion found on metal surfaces.

4. Repair or replace, as determined by OWNER'S REPRESENTATIVE, door and panel sections having dented surfaces.

5. Repair or replace, as determined by OWNER'S REPRESENTATIVE, poor fitting doors and panel sections.

6. Repair or replace improperly operating latching, locking, or interlocking devices.

7. Replace missing or damaged hardware.

8. Finish: Provide matching paint and touch up scratches and mars.

O. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals. Revisions from the approved Submittals shall take precedence over the original Contract Documents.

3.2 CHECKOUT AND STARTUP

A. Voltage Field Test:

1. Check voltage at point of termination of interconnecting power company supply system to Project when installation is essentially complete and is in operation.

2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.

3. Record supply voltage (all three phases simultaneously on same graph) for 24 hours during normal working day. Submit Voltage Field Test Report to OWNER'S REPRESENTATIVE within 7 days of test.

4. Unbalance Corrections:

a. Make written request to interconnecting power company to correct condition if balance (as defined by NEMA) exceeds 1.0%, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4.0% of nominal.

b. Obtain written certification from responsible power company official that voltage variations and unbalance are within their normal standards if corrections are not made.

B. Equipment Line Current Tests:

1. Check line current in each phase for each piece of equipment.

2. Make line current check after interconnecting power company has made final adjustments to supply voltage magnitude or balance.

3. If phase current for a piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken. Submit all such reports to OWNER'S REPRESENTATIVE.

3.3 WIRE AND CABLES, 600 VOLTS AND BELOW

A. Inspections and tests shall be performed after installation and prior to placing cable in service.

B. **Inspect for the following:**

1. For each individual power conductor #6 AWG and larger:

a. Physical damage.

b. Conformance of connections with Drawings.

c. Bends exceeding manufacturer's minimum allowable bending radius.

d. Conformance of color coding and identification with Specifications.

2. Mechanical connections for proper lug type, proper lug installation, and bolt torque level in accordance with NETA ATS, Table 100.12.

3. Proper shield grounding, termination, and identification of shielded instrumentation cables.

4. Proper termination and identification of control cables.

5. Proper termination of neutrals and grounds for power cables terminated through window-type CTs.

C. **Perform the following tests for each individual power conductor #6 AWG and larger:**

1. Insulation Resistance Tests:

a. Apply 1,000-volt dc megohmmeter for 600-volt insulated conductors.

b. Test each conductor from phase-to-phase and phase-to-ground for one minute.

c. Evaluate ohmic values by comparison with conductors of same length and type.

d. Investigate values less than 50 megohms.

2. Continuity test by ohmmeter method to ensure proper cable connections.

D. Control wire and instrumentation cable shall be tested for continuity, polarity, undesirable ground, and origination.

E. Cables failing the tests shall be replaced with a new cable or repaired. Repair methods shall be as recommended by the cable manufacturer and shall be performed by persons certified by the industry.

3.4 DRY-TYPE TRANSFORMERS

A. **Inspect for the following:**

1. Damage to the transformer or insulators.

2. Proper winding connections.

3. Bolt torque level in accordance with NETA ATS, Table 100.12.

4. Defective wiring.

5. Proper operation of fans, indicators, and auxiliary devices.

6. Removal of shipping brackets, fixtures, or bracing.

7. Free and properly installed resilient mounts.

8. Cleanliness and improper blockage of ventilation passages.

9. Tap changer is set at correct ratio for rated voltage under normal operating conditions, unless adjusted intentionally as required under the relevant installation specification, or as directed by OWNER'S REPRESENTATIVE.

10. Proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. **Perform the following tests:**

1. Insulation Resistance Tests:

   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:

      1) Winding-to-winding.

      2) Winding-to-ground.

   b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, one minute, and 10 minutes.

   c. Temperature correct results in accordance with NETA ATS, Table 100.14.

   d. Temperature corrected insulation resistance values shall be equal to, or greater than, ohmic values established by manufacturer.

   e. Insulation resistance test results shall be within 1.0% of adjacent windings.

2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.

3.5 PANELBOARDS

A. **Inspect for the following:**

1. Defects and physical damage.

2. Labeling and nameplate compliance with requirements of up-to-date Drawings and panelboard schedules.

3. Check panelboard mounting, area clearances, and alignment and fit of components.

4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.

5. Perform visual and mechanical inspection for overcurrent protective devices.

B. **Perform the following tests in accordance with manufacturer's instructions:**

1. Exercise and perform operational tests of mechanical components and other operable devices.

2. Insulation Resistance Tests:

a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.

b. Each phase of each bus section.

c. Phase-to-phase and phase-to-ground for one minute.

d. With breakers open and with breakers closed.

e. Insulation resistance values shall be equal to, or greater than, ohmic values established by manufacturer.

3. Ground continuity test ground bus to system ground.

3.6 INDUCTION MOTORS

A. Inspection and testing limited to motors rated 5 hp and larger.

B. **Inspect for the following:**

1. Proper electrical and grounding connections.

2. Shaft alignment.

3. Blockage of ventilating air passageways.

4. Proper operation of space heaters and brakes, as applicable.

5. With the motor operating, check for:

a. Excessive mechanical and electrical noise.

b. Overheating.

c. Correct rotation.

d. Proper operation of vibration detectors, resistance temperature detectors, and other motor-inherent protective devices.

e. Excessive vibration, in excess of values in NETA ATS Table 100.10.

C. **Perform the following tests:**

1. Insulation Resistance Tests:

a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 100.11 for a duration of one minute with resistances tabulated at 30 and 60 seconds.

b. Insulation resistance values shall be equal to, or greater than, ohmic values established by manufacturer.

2. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.

3. Measure running current and voltage and evaluate relative to load conditions and nameplate full-load amps.

3.7 SURGE ARRESTERS

A. **Inspect for the following:**

1. Adequate clearances between arresters and equipment enclosures or buildings.

2. Proper ground connections to ground bus.

3. Shortest practical jumper connections to line.

3.8 MOLDED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers with frames rated 100A and larger and to motor circuit protectors rated 50A or larger.

B. **Inspect for the following:**

1. Proper mounting and cracked casings.

2. Proper conductor size.

3. Proper operation of switch handle for each enclosed breaker intended for use as a disconnecting means.

4. Conformance of service or feeder designation to Contract Documents.

5. Connection bolt torque level in accordance with NETA ATS, Table 100.12.

6. Conformance of frame size and trip setting to Contract Documents.

7. Suitability of terminals for 75 degrees C rated insulated conductors.

C. **Perform the following tests:**

1. Operate breaker to verify smooth operation.

2. Insulation Resistance Tests:

a. Applied 1,000-volt dc megohmmeter for 480V breakers in accordance with NETA ATS, Table 100.1.

b. Pole-to-pole and pole-to-ground with breaker contacts opened for one minute.

c. Pole-to-pole and pole-to-ground with breaker contacts closed for one minute.

d. Insulation resistance values shall comply with NETA ATS, Table 100.1.

3.9 INSTRUMENT TRANSFORMERS

A. **Inspect for the following:**

1. Cracked insulation, broken leads, defective wiring, proper connections, and adequate clearances between primary and secondary circuit wiring of current, potential, and control transformers.

2. Good contact for grounding and shorting connections.

3. Proper operation of withdrawal mechanism and grounding, where applicable.

B. **Perform the following tests:**

1. Current Transformers:

a. Insulation resistance test from winding-to-ground at 1,000 volts dc for 30 seconds.

b. Polarity test.

2. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 100.5.

3.10 METERING

A. **Inspect for the following:**

1. Conformance of meter types, scales, and connections with Contract Drawings.

2. Verify meter multipliers.

3. Proper calibration of meters and electrical transducers.

3.11 SAFETY SWITCHES, 600 VOLTS AND BELOW

A. **Inspect for the following:**

1. Proper blade alignment and operation of switch handle.

2. Proper cable connection bolt torque level in accordance with NETA ATS, Table 100.12.

3. Proper phase barrier material and installation.

B. **Perform the following tests:**

1. Mechanical operation test. Verify electrical and mechanical interlocking system operation and sequencing.

2. Insulation Resistance Tests:

a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.

b. Phase-to-phase and phase-to-ground for one minute on each pole.

c. Insulation resistance values shall be equal to, or greater than, ohmic values established by manufacturer.

3. Perform contact resistance test across each blade.

3.12 GROUNDING SYSTEMS

A. **Inspect for the following:**

1. Proper connection and tightness of equipment and circuit grounds in motor control centers, panelboards, and switchgear assemblies.

2. Proper termination and tightness of ground bus connections in motor control centers, panelboards, and switchgear assemblies.

3. Effective core and equipment grounding.

4. Proper fit and tightness of accessible connections to grounding electrodes.

5. Inspect accessible exothermic weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. **Perform the following tests:**

1. Fall-of-Potential Test:

a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.

b. Record data and provide to OWNER'S REPRESENTATIVE.

2. Two-Point Direct Method Test:

a. In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.

b. Record data and provide to OWNER'S REPRESENTATIVE.

3. Neutral Bus Isolation:

a. Test each neutral bus individually with neutral bonding jumper removed at Service Entrance or separately derived system.

b. Evaluate ohmic values by measuring resistance between ground bus and neutral bus.

c. Investigate values less than 50 megaohms.

d. Record data and provide to OWNER'S REPRESENTATIVE.

3.13 MOTOR CONTROL SYSTEMS

A. **Inspect for the following:**

1. Inspect for proper operation of indicating and monitoring devices.

2. Inspect for proper overload protection.

3. Check for blockage of air-cooling passages.

4. Check door and protective device interlocking by:

a. Closure attempt of device when door is open.

b. Opening attempt of device when door is closed.

5. Check nameplates for proper identification in accordance with drawings.

6. Compare control wiring to schematic diagrams.

7. Check control wiring for proper bundling, identification, termination, and connection.

8. Exercise active components.

9. Inspect contactors for correct mechanical operations, correct contact gap, wipe, alignment, and pressure, and correct torque of connections.

10. Compare motor protector with motor characteristics for proper size.

B. **Perform the following tests:**

1. Test for insulation resistance from phase-to-phase and phase-to-ground on motor protector and 480V power wiring.

2. Test for insulation resistance from phase-to-ground and across open contacts on contactor.

3. With control voltage applied, test voltage levels at each point on terminal board and each device terminal.

4. Perform operational test by initiating control devices to affect proper operation.

3.14 TRANSFER SWITCHES

A. **Inspect for the following:**

1. Inspect doors and panels for proper interlocking.

2. Inspect mechanical and electrical interlock between normal and alternate sources.

3. Check for proper operation:

a. Manual transfer from normal to alternate and back.

b. Generator under load and no-load conditions.

c. Auto-exerciser of generator under load and no-load conditions.

B. **Perform the following tests:**

1. Test for insulation resistance with a 1,000-volt megaohm meter from phase-to-phase and phase-to-ground. Perform this test with switch closed in both source positions.

2. Perform contact resistance test across each blade for both source positions.

3. Verify operation and timing of:

a. Normal and alternate voltage sensing relays.

b. Engine-start sequence.

c. Timing delay upon transfer and retransfer.

d. Engine cooldown and shutdown.

3.15 STANDBY GENERATOR SYSTEMS

A. Conform to NFPA 110.

B. **Inspect for the following:**

1. Visual and Mechanical Inspection:

    a. Inspect for proper electrical and grounding connections.

    b. Inspect for blockage of air inlet and exhaust.

    c. Inspect for proper operation of heaters.

    d. Inspect for proper operation of battery charger.

    e. Inspect integrity of engine cooling and fuel supply systems.

    f. Inspect cooling liquid type and level.

    g. Compare nameplate rating and connection with one-line diagram.

C. **Perform the following tests:**

1. Operate generator and check for:

    a. Excessive noise.

    b. Overheating of engine or generator.

    c. Correct rotation.

    d. Excessive vibration.

2. Inspect for proper operation of meters and instruments.

3. Perform phase rotation tests.

4. Test engine protective shutdown features for low oil pressure, overtemperature, and overspeed.

5. Test Report: Record and report the following:

    a. Electric load on generator.

    b. Fuel consumption.

    c. Exhaust temperature.

    d. Ambient air temperature.

    e. Safety shutdown performance results.

6. After completion of performance tests, manufacturer shall make final adjustments, replace fuel and oil filters, and check belt drive tensions.

7. Demonstrate to OWNER proper operation of control and transfer between normal power and standby power in both directions, including all shedding of non-essential loads.

- END OF SECTION -

SECTION 26 05 10 - LOW-VOLTAGE AC ELECTRIC MOTORS

PART 1 -- GENERAL

1.1 SUMMARY

A. The provisions of this section apply to low-voltage, three-phase or single-phase, alternating current (ac), squirrel-cage induction motors throughout the Contract Documents, except as indicated otherwise.

B. The CONTRACTOR shall assign to the equipment supplier the responsibility to select suitable electric motors for the equipment. The choice of motor manufacturer shall be subject to review by the OWNER'S REPRESENTATIVE.

1.2 REFERENCE STANDARDS

A. The following is a list of standards which may be referenced in this section:

National Electrical Manufacturers Association (NEMA)

MG 1	Motors and Generators

Underwriter's Laboratories (UL)

83	Standard for Thermoplastic-Insulated Wire and Cable
2111	Standard for Overheating Protection for Motors

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Contractor Submittals.

B. Complete motor data shall be submitted with the driven machinery shop drawings. Motor data shall include:

1. Machine name and specification number of driven machine.
2. Motor manufacturer.
3. Motor type or model and dimensional drawing, and motor weight.
4. Nameplate data in accordance with NEMA MG 1:
    a. Nominal horsepower.
    b. NEMA design.
    c. Enclosure type and mounting orientation.
    d. Frame size.
    e. Winding insulation class and temperature rise class.

f. Voltage, phase, and frequency ratings.

5. Service factor.

6. Full load current at rated horsepower for application voltage.

7. Locked rotor current.

8. No load current.

9. Full load speed.

10. Guaranteed minimum full load efficiency, and nominal efficiencies at 1/2 and 3/4 load.

11. Guaranteed minimum full load power factor, and nominal power factor at 1/2 and 3/4 load.

12. Bearing type, lubrication, and life data.

13. Recommendations for lubricants of relubricatable-type bearings.

14. Conduit box dimensions and usable volume.

15. Type of thermal protection or overtemperature protection, if included.

16. Wiring diagram for devices such as motor leak detection, temperature, or zero speed switches, as applicable.

17. Motor sound power level in accordance with NEMA MG 1.

18. Maximum brake horsepower required by the equipment driven by the motor.

19. If utilized with a variable frequency controller, verify motor is inverter duty type. Include minimum speed at which motor may be operated for the driven machinery.

20. Description of submersible motor moisture sensing system.

21. Seismic anchorage and bracing data sheets and drawings as required by Section 43 00 00 – Equipment General Provisions.

C. **O&M Data:**

1. In accordance with Section 01 33 00 – Contractor Submittals.

2. Seismic anchorage and bracing calculations as required by Section 43 00 00 – Equipment General Provisions.

3. Factory test reports.

PART 2 -- PRODUCTS

2.1 MANUFACTURERS, OR EQUAL

A. **U.S. Motors**.

B. **General Electric**.

C. **Reliance Electric**.

D. **MagneTek**.

E. **Baldor**.

F. **TECO-Westinghouse Motor Co**.

G. **WEG**.

2.2 GENERAL REQUIREMENTS

A. Electric motors driving identical machines shall be identical.

B. Drive motor, driven equipment, and specified motor accessories shall be supplied from a single supplier.

C. Meet requirements of NEMA MG 1.

D. Motors for driven equipment shall be designed for the intended use and service conditions, with a NEMA design letter classification to fit the application.

E. Provide lifting lugs on motors weighing 100 lb. or more.

F. Maximum motor loading shall be equal to nameplate horsepower rating or less, exclusive of service factor and be verifiable from the submittal data of the driven machinery.

G. **Motor Capacity:**

1. The CONTRACTOR shall size motors for the larger of the following criteria:

    a. Size motors to continuously carry the maximum load that develops across the full range of driven equipment operation.

    b. Size motors for minimum size indicated.

2. In every case, motor size shall be derated from nameplate values as follows:

    a. Ambient Temperature:

        1) For ambient temperatures up to but not exceeding 40 degrees C, no derating is required.

2) For ambient temperatures exceeding 40 degrees but less than 50 degrees C, derate nameplate horsepower ratings to 85 percent.

b. Site Altitude: No derating is required for altitudes less than 3,300 feet (1,000 meters).

3. Increased circuit breaker, magnetic starter, and conductor and conduit capacities required for motors larger than the indicated sizes shall be provided as part of the WORK.

H. **Exempt Motors:** Motors for valve operators, submersible pumps, or motors which are an integral part of standard manufactured equipment, i.e., non-NEMA mounting, common shaft with driven element, or part of domestic or commercial use apparatus may be excepted from these requirements to the extent that such variation reflects a necessary condition of motor service or a requirement of the driven equipment.

2.3 DESIGN REQUIREMENTS

A. Electric motors shall comply with NEMA MG 1. Motors used with adjustable frequency drives shall comply with NEMA MG 1, Part 31.

B. **NEMA Design:** Electric motors shall be NEMA Design B, unless otherwise indicated. In no case shall starting torque or breakdown torque be less than the value in NEMA MG 1. Motors shall be suitable for the indicated starting method.

C. **Motor Voltage Ratings:** Low-voltage motors shall have voltage ratings in accordance with the following, unless otherwise indicated:

1. Motors 1 HP and smaller shall be rated 115 volts, single-phase, 60 Hz. Dual voltage motors rated 115/230 volts, 115/208 volts, or 120-240 volts are acceptable, provided all leads are brought out to the conduit box.

2. Motors larger than 1 HP, but less than 3 HP shall be rated 208 volts, three-phase or single-phase, 60 Hz. Dual voltage motors rated 208/230/460 volts are acceptable, provided every lead is brought out to the conduit box.

3. Motors 3 HP and larger shall be rated 460 volts, three-phase, 60 Hz. Dual voltage motors rated 230/460 volts or 208/230/460 volts are acceptable, provided every lead is brought out to the conduit box.

D. **Insulation:**

1. Three-phase motors shall have Class F insulation, rated to operate at a maximum ambient temperature of 40 degrees C and at the altitudes where the motors will be installed and operated, without exceeding Class B temperature rise limits stated in NEMA MG 1.

2. Single-phase motors shall have Class F insulation with temperature rise not to exceed the insulation class.

3. Motors to be operated from adjustable frequency drives shall be provided with insulation systems to withstand 1,600 volt spikes, with dV/dt as defined in NEMA MG 1-31.

E. **Enclosure:** Motors 50 HP or smaller located in non-hazardous areas shall be totally enclosed, fan cooled (TEFC) with a Service Factor of 1.15 unless otherwise indicated. Furnish with drain hole with porous drain/weather plug.

F. **Premium Efficiency Motors:**

1. Motors with a nameplate rating of 1 HP and larger shall be premium efficient units. Motors shall be stamped with the efficiency on the nameplate with the caption "NEMA Nominal Efficiency" or "NEMA Nom. Eff." Such motors shall have efficiencies determined by the test as set forth in ANSI/IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators, Method B.

2. Nominal efficiency and minimum efficiency shall be defined in accordance with NEMA MG 1 for the type of motor provided.

G. **Power Factor:** Manufacturer's standard for guaranteed minimum at full load.

H. Locked rotor kVA code shall be F or lower, if not covered by NEMA MG 1 tables.

I. Two-speed motors shall be of the two-winding type.

2.4 ACCESSORY REQUIREMENTS

A. Motors shall have split-type, oversized cast metal conduit boxes. Motors other than open drip-proof shall be gasketed. Minimum usable volume shall be in accordance with NEMA MG 1 and NFPA 70.

B. **Special Requirements:** The CONTRACTOR shall refer to individual equipment specifications for special requirements such as motor winding thermal protection or multi-speed windings.

C. **Grounding Lugs:** Provide motor grounding lug suitable to terminate ground wire, sized as indicated.

D. **Nameplate:** Motors shall be fitted with permanent stainless steel nameplates indelibly stamped or engraved with NEMA standard motor data in conformance with NEMA MG 1.

E. Provide anchor bolts meeting manufacturer's recommendations and of sufficient size and number for specified seismic condition.

2.5 MOTOR THERMAL PROTECTION

A. **Single Phase Motors:** Single-phase 115-, 208-, or 230-volt motors shall have integral thermal overload protection or shall be inherently current-limited.

B. **Thermostats:**

1. Winding thermostats, provided where required by driven equipment supplier, shall be bi-metallic, temperature-actuated switches.

2. Thermostat contacts shall be normally closed contacts rated 5A at 120 volts ac and embedded in stator windings.

3. Thermostat contacts shall automatically reset.

4. The thermostat switch point shall be pre-calibrated by the manufacturer.

2.6 MOTOR BEARINGS

A. Bearings shall conform to Section 43 00 00 – Equipment General Provisions, except as indicated herein.

B. Motors greater than 1 HP shall have bearings designed for 17,500 hours (belted) or 100,000 hours (coupled) L-10 life.

C. **Fractional Horsepower:** Motors with fractional horsepower through 1 HP shall be provided with lubricated-for-life ball bearings.

D. **Horizontal Motors Over 1 HP:** Motors larger than 1 HP shall be provided with relubricatable ball bearings. Lubrication shall be per manufacturer's recommendation for smooth operation and long life of the bearings.

E. **Vertical Motors Over 1 HP:** Vertical motors larger than 1 HP shall be provided with relubricatable ball, spherical, roller, or plate type thrust bearings. Lubrication shall be per manufacturer's recommendation for smooth operation and long life of the bearings.

2.7 SUBMERSIBLE MOTORS

A. Requirements in this article take precedence over conflicting features specified elsewhere in this section.

B. Motor shall be capable of running dry continuously.

C. **Enclosure:** Hermetically sealed, watertight, for continuous submergence up to 70 feet of depth.

D. **Bearing and Lubrication:** Permanently sealed and lubricated, with replaceable antifriction guide and thrust bearings. Minimum 15,000 hours L-10 bearing life.

E. Locked rotor kVA code shall be F or lower.

F. **Connecting Cables:**

1. Unless noted otherwise, each motor shall have one cable containing power, control, and grounding conductors.

2. Cables shall be suitable for hard service, submersible duty with watertight seal at motor cable entrance.

3. Length: 70 feet minimum, or manufacturer's standard.

4. UL 83 listed and sized in accordance with NFPA 70.

2.8 FACTORY TESTING

A. Perform In accordance with IEEE 112 for polyphase motors.

B. Routine tests in accordance with NEMA MG 1.

C. For energy efficient motors, test efficiency and power factor at 1/2, 3/4, and full load.

D. Except where specific testing or witnessed shop tests are required by the specifications for driven equipment, factory test reports may be copies of routine test reports of electrically duplicate motors.

E. Test report shall indicate test procedure and instrumentation used to measure and record data.

F. Test report shall be certified by the motor manufacturer's test personnel.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Motor installation shall be performed in accordance with the motor manufacturer's written recommendations and the written requirements of the manufacturer of the driven equipment.

B. Related electrical WORK involving connections, controls, switches, and disconnects shall be performed in accordance with the applicable sections of Division 26.

C. Align motor carefully and properly with driven equipment.

D. Secure equipment to mounting surface with anchor bolts.

3.2 FIELD TESTING

A. The CONTRACTOR shall perform the following field tests:

1. Inspect each motor installation for any deviation from rated voltage, phase, frequency, and improper installation.

2. Visually check for proper phase and ground connections. Verify that multi-voltage motors are connected for proper voltage.

3. Check winding and bearing temperature detectors and space heaters for functional operation.

4. Test for proper rotation prior to connection to the driven equipment.

5. Visually check that motor overload heaters are properly sized and that MCP breaker settings are correct for the motor installed.

6. Test insulation (megger test) of new and re-used motors in accordance with NEMA MG 1. Test voltage shall be 1,000 VAC plus twice the rated voltage of the motor.

- END OF SECTION -

SECTION 26 05 33 - ELECTRICAL RACEWAY SYSTEMS

PART 1 -- GENERAL

1.1 RELATED SECTIONS

A. Refer to the following sections for other requirements related to this section:

1. Section 26 05 43 – Underground Raceway Systems.

1.2 REFERENCE STANDARDS

A. The following is a list of standards which may be referenced in this section:

ASTM International

A123/123M	Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
A167	Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
A240/A240M	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
D149	Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

National Electrical Manufacturers Association (NEMA)

C80.1	Electric Rigid Steel Conduit (ERSC)
C80.6	Electrical Intermediate Metal Conduit (EIMC)
TC 2	Electrical Polyvinyl Chloride (PVC) Conduit
TC 3	Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing
TC 6	Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation

Telecommunications Industry Association (TIA):

569B	Communication Building Standard for Telecommunications Pathways and Spaces

Underwriters Laboratories Inc. (UL)

6	Electrical Rigid Metal Conduit – Steel
360	Standard for Liquid-Tight Flexible Metal Conduit
514A	Metallic Outlet Boxes

514B	Conduit, Tubing, and Cable Fittings
651	Standard for Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
870	Standard for Wireways, Auxiliary Gutters, and Associated Fittings
1242	Standard for Electrical Intermediate Metal Conduit – Steel
1990	Standard for Nonmetallic Underground Conduit with Conductors

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Sections 01 33 00 - Contractor Submittals, and 26 00 00 – Basic Electrical Requirements.

B. **Product Data:**

1. Submit catalog cuts on the following:

a. Rigid galvanized steel conduit.

b. Intermediate metal conduit.

c. PVC Schedule 80 conduit.

d. Flexible metal, liquid-tight conduit.

e. Conduit fittings.

f. Wireways.

g. Large junction and pullboxes.

PART 2 -- PRODUCTS

2.1 CONDUIT

A. **Rigid Galvanized Steel (RGS) Conduit:**

1. Rigid steel conduit shall be manufactured in accordance with NEMA C80.1 and UL 6.

2. Rigid steel conduit shall be manufactured of mild steel, hot-dip galvanized inside and out, with additional protective coating.

B. **Intermediate Metal Conduit (IMC):**

1. Intermediate metal conduit shall be manufactured in accordance with NEMA C80.6 and UL 1242.

2. Intermediate metal conduit shall be manufactured of mild steel, hot-dip galvanized inside and out, with additional protective coating.

C. Electrical Metallic Tubing (EMT) will not be accepted.

D. **Rigid Nonmetallic Conduit:**

1. Rigid nonmetallic conduit shall be manufactured in accordance with NEMA TC 2 and UL 651.

2. Rigid nonmetallic conduit shall be of Schedule 80 PVC.

3. Rigid nonmetallic conduit shall be UL listed for concrete encasement, underground direct burial, sunlight exposure, and 90 degrees C insulated conductors.

E. **Liquid-Tight Flexible Metal Conduit:**

1. Liquid-tight flexible conduit shall be constructed of a flexible galvanized metal core with a sunlight-resistant, extruded thermoplastic outer jacket.

2. Liquid-tight flexible conduit shall be manufactured in accordance with the requirements of UL 360 for 105 degrees C insulated conductors.

2.2 FITTINGS

A. Cast and malleable iron fittings for use with metallic conduit shall be of the threaded type with 5 full threads.

B. **Gaskets and Covers:**

1. Fittings shall be provided with neoprene gaskets and non-magnetic stainless steel screws.

2. Covers shall be attached by means of holes tapped into the body of the fitting.

3. Covers for fittings attached by means of clips or clamps will not be accepted.

C. **Terminations:**

1. In wet areas, conduit shall be terminated in rain tight hubs as manufactured by **Myers, O.Z. Gedney**, or equal.

2. In general industrial areas, sealed locknuts and bushings shall be used.

D. **Rigid Steel Conduit and Intermediate Metal Conduit Fittings:**

1. Rigid steel conduit fittings shall be manufactured in accordance with UL 514B.

2. Fittings for use with galvanized steel conduit shall be of malleable iron or gray-iron alloy with zinc plating.

3. Conduit Bodies: Sized in accordance with NFPA 70.

4. Cable Sealing Fittings:

a. Provide to form watertight nonslip cable connection to conduit.

b. For conductors with small outer diameters (1/2-inch or less): Provide neoprene bushing at connector entry.

5. Manufacturers, or Equal:

a. **O.Z. Gedney**.

b. **Crouse-Hinds**.

c. **Appleton**.

E. **PVC Fittings:**

1. PVC Fittings shall be manufactured in accordance with NEMA TC 3.

2. Fittings for use with rigid non-metallic conduit shall be manufactured of PVC, of the solvent welded type.

3. Provide welding solvent as required for the installation of PVC conduit and fittings.

4. Manufacturers, or Equal:

a. **Carlon**.

b. **Crouse-Hinds**.

c. **Hoffman**.

F. **Liquid-Tight Flexible Metal Fittings:**

1. Fittings for use with liquid-tight flexible metal shall be of mild steel with zinc plating and protective coating.

2. Liquid-tight, insulated throat connectors with integral nylon or plastic bushing and sealing O-rings.

3. Manufacturers, or Equal:

a. **O.Z. Gedney; Series 4Q**.

b. **Thomas & Betts; Series 5331**.

2.3 BOXES

A. **Outlet and Device Boxes:**

1. Boxes for use with steel conduit shall be of malleable iron or gray-iron alloy with zinc plating.

2. Boxes shall have threaded hubs and cast-mounted lugs.

3. Cast Iron:

    a. Malleable iron or gray-iron alloy with zinc plating.

    b. Threaded hubs and cast-mounted lugs.

4. Covers shall be same material as box, with neoprene gaskets and non-magnetic stainless steel screws.

5. Manufacturers, or Equal:

    a. **Crouse-Hinds; FS or FD series**.

    b. **Appleton; FS or FD series**.

    c. **Killark; FS or FD series**.

B. **Junction and Pullboxes:**

1. Outlet boxes, as specified under Paragraph Outlet and Device Boxes, are acceptable for use as junction and pullboxes.

2. Conduit bodies, as specified under Paragraph Fittings, are acceptable for use as junction boxes.

3. At or Below Grade Boxes: In accordance with Section 26 05 43 – Underground Raceway Systems.

4. Large Boxes:

    a. NEMA 250 Type 1 rated, steel enclosure with ANSI gray finish for dry areas.

    b. NEMA 250 Type 12 rated, steel enclosure with ANSI gray finish for general industrial areas.

    c. NEMA 250 Type 3R rated, steel enclosure with ANSI gray finish for outdoor or wet areas.

    d. NEMA 250 Type 4 rated, steel enclosure with ANSI gray finish for wet areas with splashing or spraying water.

    e. Steel boxes shall be a minimum of 14-gauge thickness.

    f. Covers shall be hinged with clamps with neoprene gasket.

2.4 WIREWAY

A. The wireway shall be of the lay-in type and shall be NEMA-rated for the area in which it is to be installed in accordance with the requirements of Section 26 00 00 – Basic Electrical Requirements.

B. Power, control, signal and communications cables shall be separated by grounded metallic dividers in wireways or shall be run in separate wireways.

C. **Fittings and Covers:**

1. Fittings and sections shall have non-magnetic stainless steel screws.

2. Covers shall be attached by hinges and clamps to the bodies.

3. Covers attached by means of clips or screws will not be accepted.

4. Covers and bodies shall be a minimum of 14-gauge steel construction.

D. **Grounding:**

1. Metallic wireway bodies shall be grounded.

2. Dividers shall be steel with steel wireways and shall be grounded by means of an individual grounding conductor.

3. Non-metallic dividers will not be accepted.

2.5 ACCESSORIES

A. **Wraparound Duct Band:**

1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.

2. Width: 50 mm minimum.

3. Manufacturers, or Equal:

a. **Raychem; Type TWDB**.

PART 3 -- EXECUTION

3.1 GENERAL

A. Wiring shall be run in raceway unless indicated otherwise.

B. Raceways shall be installed between equipment as indicated.

C. Raceway systems shall be electrically and mechanically complete before conductors are installed.

D. **Bends and Offsets:**

1. Bends and offsets shall be smooth and symmetrical, and shall be accomplished with tools designed for this purpose.

2. Factory elbows shall be utilized wherever possible.

E. **Routing:**

1. Where raceway routings are indicated, follow those routings to the extent possible.

2. Where raceways are indicated but routing is not indicated, such as home runs or on conduit developments and schedules, raceway routing shall be the CONTRACTOR's choice and in strict accordance with the NEC as well as customary installation practice.

3. Raceway shall be encased, exposed, concealed, or under-slab as indicated, except that conduit in finished areas shall be concealed, unless specifically indicated otherwise.

4. Conduits encased in a slab shall be sized for conduit OD to not exceed one-third of the slab thickness and be laid out and spaced to not impede concrete flow.

5. Raceway routings, whether indicated or not, shall be adjusted to avoid structural and/or mechanical obstructions, to preserve headroom, and to keep openings and passageways clear.

6. Exposed raceways shall be installed parallel or perpendicular to structural beams.

F. **Coordination:**

1. Coordinate between trades prior to installing the raceways.

2. The lack of such coordination shall not be justification for extra compensation, and removal and re-installation to resolve conflicts shall be by the CONTRACTOR as part of the WORK.

G. Support rod attachment for ceiling-hung trapeze shall meet the seismic requirements in the area where the Project is located.

H. Wireways shall be supported in accordance with the manufacturer's recommendations for the seismic requirements indicated in Section 26 00 00 – Basic Electrical Requirements.

I. **Expansion Fittings:**

1. Install expansion fittings with external bonding jumpers wherever exposed raceways cross building expansion joints.

2. Install expansion/deflection fittings where conduit movement is expected in more than one dimension and where conduits transition out of structures in locations where differential settlement may occur.

3. Encased Expansion Fittings:

a. Install encased expansion fittings wherever encased conduits cross building expansion joints.

b. Deflection type fittings shall not be required for encased conduits crossing an expansion joint within a single structure.

4. Expansion and expansion/deflection fittings shall be of the same material as the raceway to which they are installed.

J. Install expansion fittings with bonding jumpers wherever raceways cross building expansion joints.

K. Exposed raceways shall be installed at least 1/2 inch from walls or ceilings except that at locations above finished grade where damp conditions do not prevail, exposed raceways shall be installed at least 1/4 inch from the face of walls or ceilings by the use of clamp backs or struts.

L. Wherever contact with concrete or dissimilar metals can produce galvanic corrosion of equipment, provide a means of suitable insulation in order to prevent such corrosion.

3.2 CONDUIT

A. Size: 3/4-inch minimum trade size.

B. Exposed conduit shall be RGS or IMC, unless indicated otherwise.

C. Conduit encased in concrete shall be Schedule 80 PVC, unless noted otherwise.

D. Conduit and duct banks buried in soil shall be in accordance with the requirements of Section 26 05 43 – Underground Raceway Systems.

E. Transitions from underground to exposed shall be in accordance with the requirements of Section 26 05 43 – Underground Raceway Systems.

F. Supports shall be installed at distances required by the NEC.

G. **Concrete Encasement:**

1. Where PVC conduit is stubbed up from a concrete encasement, an RGS elbow with a single layer of wraparound duct band shall be utilized. Wraparound duct band shall extend at least 2 inches above and 2 inches below concrete surface.

2. The conduit shall emerge from the concrete in a direction perpendicular to the surface whenever possible.

3. Conduit shall not be encased in the bottom floor slab below grade.

H. **Penetrations:**

1. Conduit passing through walls or floors shall have plastic sleeves.

2. Conduits passing through a slab, wall, or beam shall not significantly impair the strength of the construction.

I. Conduits embedded within a slab, wall, or beam (other than those merely passing through) shall meet the following requirements:

1. Conduits with their fittings embedded within a column shall not displace greater than 4 percent of the gross area of cross section.

2. Conduits shall not be larger in outside dimension than one-third the overall thickness of the slab, wall, or beam in which it is embedded.

3. Conduits shall not be spaced closer than 3 outside diameters on centers.

J. The conduit shall be placed such that cutting, bending, or displacing reinforcement from its proper location will not be required.

K. Threads shall be coated with a conductive lubricant before assembly.

L. **Joints:**

1. Joints shall be tight, thoroughly grounded, secure, and free of obstructions in the pipe.

2. Conduit shall be adequately reamed in order to prevent damage to the wires and cables inside.

3. Strap-wrenches and vises shall be used to install conduit in order to prevent wrench marks on the conduit.

4. Conduit with wrench marks shall be replaced.

M. **Slope:**

1. Wherever possible, conduit runs shall slope to drain at one or both ends of the run.

2. Wherever conduit enters a substructure below grade, the conduit shall be sloped in order to drain water away from the structure.

3. Extreme care shall be taken in order to avoid pockets or depressions in the conduit.

N. **Connections:**

1. Connections to motors, HVAC equipment, and other equipment subject to vibration shall be made with liquid-tight flexible metal conduit not exceeding 4 feet in length.

2. Equipment subject to vibration that is normally provided with wiring leads shall be provided with a cast junction box for the make-up of connections.

O. **Empty Conduits:**

1. Empty conduits shall be tagged at both ends to indicate the final destination.

2. Where it is not possible to tag the conduit, the destination shall be identified by a durable marking on an adjacent surface.

3. A pull-cord shall also be installed in each empty conduit in floors, panels, manholes, equipment, and the like.

4. Empty conduits that terminate below grade, in vaults, manholes, handholes, and junction or pullboxes shall have a removable plug installed.

P. **Identification of Conduits:**

1. Conduits shall be identified at ends and at pulling points.

2. Identification shall be the unique conduit number assigned in the Contract Documents.

3. Conduits not assigned a unique number in the Contract Documents shall have a unique number assigned by the CONTRACTOR following the numbering scheme used in the Contract Documents.

4. Conduit identification shall be by a stamped or engraved non-corroding metal tag attached to the conduit bushing.

5. Markings with a pen or paint will not be accepted.

Q. **Identification of Pullboxes and Junction Boxes:**

1. Pullboxes and junction boxes shall be identified.

2. Identification shall be the unique conduit number assigned in the Contract Documents or by a unique number assigned by the CONTRACTOR following the numbering scheme used in the Contract Documents.

3. Box identification shall be by a stamped or engraved non-corroding metal tag or an engraved phenolic nameplate, in accordance with the requirements of Section 26 00 00 – Basic Electrical Requirements, and attached to the box or enclosure.

4. Markings with a pen or paint will not be accepted.

R. Conduit for data cables shall be provided in accordance with the equipment manufacturer's recommendations, especially regarding separation from low and medium voltage power raceways.

- END OF SECTION -

SECTION 26 05 43 - UNDERGROUND RACEWAY SYSTEMS

PART 1 -- GENERAL

1.1 RELATED SECTIONS

A. Refer to the following sections for other requirements related to this section:

1. Section 26 05 33 – Electrical Raceway Systems.

1.2 REFERENCE STANDARDS

A. The following is a list of standards which may be referenced in this section:

ASTM International

C857	Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Sections 01 33 00 - Contractor Submittals, and 26 00 00 – Basic Electrical Requirements.

B. **Product Data:**

1. Submit catalog cuts on the following, marked where applicable to show proposed materials and finishes:

a. Junction and pullboxes used at or below grade.

b. Handholes, including dimensional drawings and loading information.

C. **Record Drawings:**

1. Show routings, burial depths, handhole locations and sizes, and where applicable, connections to drainage systems.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Handholes, pullboxes, and fittings that are dedicated to the underground raceway system shall comply with the requirements of this Section.

2.2 HANDHOLES AND PULLBOXES

A. Handholes and pullboxes shall be precast concrete with construction and load rating as indicated.

B. **Covers and Frames:**

1. Covers shall be traffic type, H-20 loading.

2. Handhole covers shall be hinged, galvanized steel diamond plate, with torsion springs.

3. Pullbox covers shall be steel diamond plate with locking bolts.

4. Covers shall be identified as "Electric" by raised letters cast into the covers.

5. Covers and lids shall be bolted to cast-in-place steel frames with galvanized steel hardware.

6. Handholes and pullboxes shall have frost-proof and water-tight grey iron frames.

7. Handhole frames shall have a 1/2-inch drilled and tapped hole and lug to accommodate a #4/0 AWG bare stranded copper conductor connected to a ground rod and the ground conductor of power cables passing through the handhole.

C. Provide knockout panels or precast individual raceway openings on all four sides of handholes.

D. Slope floors toward drain points, leaving no pockets or other non-draining areas.

E. Handholes shall be equipped with pulling-in irons opposite and below each ductway entrance.

F. Handholes shall have solid bottom slabs. Open bottom handholes will not be accepted.

G. Open bottom pullboxes are acceptable for use.

H. PVC duct bank conduits shall be provided with end bells.

I. Brackets, **Unistrut Cat. No. P2515** or equal and 60-inch concrete inserts, **Unistrut Cat. NO. P3261** or equal, shall be provided in handholes as required for racking wiring through handholes.

J. Precast handholes and pullboxes shall be **Jensen Precast, Mack, Oldcastle, U.S. Precast**, or equal.

2.3 DUCT BANKS

A. Underground ducts and fittings shall be Schedule 80 PVC or RGS in accordance with Section 26 05 33 – Electrical Raceway Systems.

B. **Spacers:**

1. Modular:

a. Nonmetallic, interlocking, suitable for multiple conduit sizes.

b. Manufacturers, or equal:

1) **Carlon**.

2) **Underground Device, Inc**.

2. Template:

a. HDPE or polypropylene, custom-fabricated one-piece spacers.

b. 1/2-inch minimum thickness, with conduit openings 1 inch larger than conduit outside diameter.

C. **Wraparound Duct Band:**

1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.

2. Width: 50 mm minimum.

3. Manufacturers, or Equal:

a. **Raychem; Type TWDB**.

PART 3 -- EXECUTION

3.1 GENERAL

A. Underground raceways shall be installed between handholes and pullboxes as indicated, and as required.

B. Where used in direct bury applications, RGS conduit shall have wraparound duct band applied along entire length with one-half tape width overlap to obtain two complete layers.

C. Raceway systems shall be electrically and mechanically complete before conductors are installed.

D. Bends and offsets shall be smooth and symmetrical, and shall be fabricated with tools designed for this purpose. Factory elbows shall be utilized wherever possible.

E. Raceway routings on plan views shall be followed to the extent possible.

F. Routings shall be adjusted to avoid obstructions. Coordinate the trades prior to installation of raceways. Lack of coordination shall not be justification for extra compensation, and removal and re-installation to resolve conflicts shall be performed by the CONTRACTOR as part of the WORK.

3.2 HANDHOLES AND PULLBOXES

A. Excavation, shoring, bracing, backfill, and final grade in accordance with Section 31 00 00 – Earthwork.

B. Do not install until final raceway grading has been determined.

C. Install handholes and pullboxes flush with finished grade.

D. Install such that raceway enters at nearly right angle and as near as possible to end, unless otherwise shown.

E. **Grounding:** As specified in Section 26 01 00 – Basic Electrical Materials and Methods.

F. Obtain OWNER'S REPRESENTATIVE's written acceptance prior to installation in paved areas, roadways, or walkways.

G. Use boxes and covers suitable to support anticipated weights.

H. Sections of pre-fabricated handholes and pullboxes shall be assembled with waterproof mastic and shall be set on a 6-inch bed of gravel, as recommended by the manufacturer or as required by field conditions.

3.3 DUCT BANKS

A. Duct shall be assembled using spacers and saddles to provide conduits with vertical and horizontal separation in trench. Install spacers at intervals in accordance with NFPA 70 for the duct type used, but in no case greater than 10 feet.

B. The duct array shall be supported and/or anchored to prevent movement during backfill.

C. The duct shall be laid on a grade line of at least 3 inches per 100 feet, sloping towards pullboxes or handholes.

D. Duct shall be installed and pullbox and handhole depths adjusted so that the top of the duct envelope is a minimum of 12-inches below grade and a minimum of 24-inches below roadways.

E. Changes in direction of the duct envelope by more than 10 degrees horizontally or vertically shall be accomplished using bends with a minimum radius 24 times the duct diameter.

F. Duct couplings shall be staggered a minimum of 6-inches.

G. Provide expansion fittings that allow minimum of 4 inches of movement in vertical conduit runs from underground where exposed conduit will be fastened to or will enter building or structure.

H. Provide expansion/deflection fittings in conduit runs that exit building or structure below grade. Conduit from wall or structure to fitting shall be RGS conduit with two overlapping layers of wraparound duct band.

I. Transitions from underground to exposed shall be RGS conduit with two overlapping layers of wraparound duct band. Wraparound duct band shall extend at least 2 inches above and 2 inches below grade.

J. Buried, vertical 90-degree elbows shall be RGS conduit with two overlapping layers of wraparound duct band.

K. The bottom of trench shall be of select backfill or sand. Controlled low-strength material (CLSM) is an acceptable bedding and duct zone material.

L. Each bore of the completed duct bank shall be cleaned by drawing through it a standard flexible mandrel one-foot long and 1/4-inch smaller than duct inside diameter. After passing of the mandrel, a wire brush and swab shall be drawn through.

M. Duct entrances shall be grouted smooth; ducts shall be terminated with flush end bells.

N. Duct bank penetration through walls of handholes, pullboxes, and building walls below grade shall be watertight.

O. Where an underground conduit enters a structure through a concrete roof or a membrane waterproofed wall or floor, provide a **Link-Seal**, or equal sealing device**.** The sealing device shall be utilized with rigid steel conduit**.**

P. Do not backfill until inspected by OWNER'S REPRESENTATIVE**.**

Q. **Spare Raceways:**

1. Spare raceways shall have a 1/8-inch polypropylene pull cord installed throughout the entire length of the raceway.

2. Provide with permanent, removable cap over each end.

3. Provide PVC plug with pull tab for underground raceways with end bells**.**

4. Identify as specified in Paragraph Identification Devices.

R. **Identification Devices:**

1. Raceway Tags: Identify origin and destination using waterproof tags at each end and at each intermediate pull point. Provide nylon strap for attachment**.**

2. Warning Tape: Continuous lengths of underground warning tapes shall be installed 12-inches above and parallel to duct banks, aligned with centerline of run. Tape shall be 6-inches wide polyethylene film imprinted "CAUTION – ELECTRIC UTILITIES BELOW."

- END OF SECTION -

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SECTION 26 05 83 - WIRE & CABLE

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide wire and cable, complete and operable, in accordance with the Contract Documents.

1.2 REFERENCE STANDARDS

A. The following is a list of standards which may be referenced in this section:

ASTM International

B3	Standard Specification for Soft or Annealed Copper Wire
B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
B496	Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors

National Electrical Manufacturers Association (NEMA)

WC 70	Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy

Underwriters Laboratories, Inc. (UL)

44	Standard for Thermoset-Insulated Wires and Cables
83	Standard for Thermoplastic-Insulated Wires and Cables
486A-486B	Standard for Safety for Wire Connectors
486C	Standard for Safety for Splicing Wire Connectors
510	Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
854	Standard for Safety for Service-Entrance Cables
1277	Standard for Electrical Power and Control Tray Cables

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Sections 01 33 00 - Contractor Submittals, and 26 00 00 – Basic Electrical Requirements.

B. **Product Data:**

1. Each type of wire and cable used for the WORK.

2. Outer diameter and cross-sectional area of overall wire or cable.

3. Insulation type of each wire, including those contained in cables.

4. Jacket type of each cable.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Conductors, including grounding conductors, shall be copper in accordance with ASTM B3.

B. Conductor sizes smaller than #8 AWG shall be stranded per ASTM B8. Conductor sizes #8 AWG and larger shall be stranded per ASTM B496.

C. Aluminum conductor wire and cable will not be permitted, unless specifically indicated otherwise.

D. Insulation shall bear UL label, the manufacturer's trademark, and identify the type, voltage, and conductor size.

E. All conductors, except conductors that form an integral part of equipment such as motors and controllers, shall conform to the requirements of Article 310 of NFPA 70, National Electrical Code (NEC) for current carrying capacity.

2.2 LOW VOLTAGE WIRE AND CABLE

A. **Power and Lighting Wire:**

1. Wire shall be UL listed and conform to requirements of NEMA WC 70 and shall have VW-1 flame rating.

2. THHN/THWN-2 insulation shall meet or exceed UL 83.

3. XHHW-2 insulation shall meet or exceed UL 44.

4. Wire shall be rated for 600 volts in duct or conduit for power and lighting circuits and shall be type THHN/THWN-2 insulation for sizes #8 AWG and smaller, and type XHHW-2 insulation for sizes #6 AWG and larger.

5. Power Conductor Sizes:

a. #12 AWG minimum.

b. Lighting and Receptacle Circuits: #12 AWG, unless noted otherwise.

6. Provide stranded conductors for all circuits.

7. Equivalent parallel sets of conductors are only acceptable when specifically approved by OWNER'S REPRESENTATIVE.

8. CONTRACTOR shall upsize branch conductors to prevent voltage drop from exceeding 3 percent at the farthest connected load or combination of such loads and

where the maximum total voltage drops on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.

9. Manufacturer, or Equal:

    a. **Southwire**.

    b. **Okonite**.

    c. **General Cable**.

B. **Control Wire:**

1. Control wire in duct or conduit shall be the same type as power and lighting wire indicated above.

2. Control wiring shall be minimum #14 AWG, unless noted otherwise.

3. Control wires at panels and cabinets shall be machine tool grade type MTW, UL approved, and rated for 90 degrees C at dry locations.

C. **Control Cable:**

1. Multiconductor cable rated 600V, consisting of overall jacket and ASTM B3/B8 stranded copper conductors, for use in conduits, ducts, troughs, trays, and direct burial.

2. Cable shall be UL listed to UL 1277, UL 1685, and UL 1581, and conform to requirements of NEMA WC 70.

3. Individual conductors shall be #14 AWG and have THHN/THWN insulation. Conductors shall meet or exceed UL 83.

4. Color coding shall be in accordance with ICEA S-58-679 Method 1, Table 2.

5. Overall jacket shall be PVC.

6. Conductor group shall be bound with binder tape inside jacket.

7. Manufacturer, or Equal:

    a. **Southwire**.

    b. **Okonite**.

D. **Instrumentation Cable:**

1. Conductors shall be stranded per ASTM B8.

2. Instrumentation cable shall be rated 600 volts and for use in cable tray and shall conform to UL 1277.

3. Individual conductors shall be #16 AWG stranded, tinned copper. Insulation shall be color coded PVC: black-red for each pair or black-white-red for each triad, with each pair or triad numbered uniquely.

4. Twisted, shielded pair cable (TSP) shall be composed of two twisted conductors, an aluminum polyester foil overall shield, a #18 AWG stranded, tinned copper drain wire, and a PVC outer jacket.

5. Twisted, shielded triad cable (TST) shall be composed of three twisted conductors, an aluminum polyester foil overall shield, a #18 AWG stranded, tinned copper drain wire, and a PVC outer jacket.

6. Utilize only single-pair or single-triad cable, unless otherwise approved by OWNER'S REPRESENTATIVE.

7. Nominal Outer Diameter:

   a. TSP: 0.29 inches.

   b. TST: 0.31 inches.

8. Manufacturer, or Equal: **Okonite; Okoseal-N Type P-OS**.

E. **Ethernet/IP (Category 6) Data Cable:**

1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568 C Category 6 requirements.

2. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.

3. Provide four each individually twisted pair, #23 AWG conductors, with FEP insulation and blue PVC jacket.

4. NFPA 70 Plenum (CMP) rated; comply with flammability plenum requirements of NFPA 70 and NFPA 262.

5. Cable shall withstand a bend radius of 1 inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.

6. Manufacturer, or Equal: **Belden; 7852A**.

F. **Modbus RTU Serial Data Cable:**

1. Modbus RTU cable shall be UL listed and rated at 300 volts for use in cable tray (power-limited tray cable).

2. Conductors: Single triad or two pairs of PE-insulated, #24 AWG conductors. Each conductor shall be 7-strand tinned copper. Third conductor shall be connected as a ground reference wire.

3. Terminations:

    a. RS485 connectors, unless indicated otherwise. Provide mating connectors as required to land cable at equipment-specific port or terminal block.

    b. Provide terminating resistors as required for a complete Modbus RTU serial installation.

4. Shield: Overall aluminum/synthetic shield, overlapped to provide 100 percent coverage.

5. Drain: Tinned copper braid and #24 AWG drain wire, braid overlapped to provide at least 65% coverage.

6. Outer Jacket: Sunlight- and oil-resistant PVC.

7. Characteristic Impedance: 120 Ohms.

8. Nominal Outer Diameter: 0.34 inches.

9. Manufacturer, or Equal: **Belden; 9842**, or triad equivalent.

2.3 SPLICES AND TERMINATIONS

A. Connectors shall be listed to UL 486A-486B.

B. Splices shall be listed to UL 486C.

C. Insulating tape shall be listed to UL 510.

D. Compression connectors shall be straight, single- or double-hole, tin-plated copper lugs.

E. Threaded connectors shall be split-bolt type of high-strength copper alloy.

F. Crimp-on connectors shall be pre-insulated fork or ring type terminations.

G. Pressure type, twist-on connectors will not be acceptable.

H. Splices shall be heat-shrinkable butt-splice type.

I. Splices and Terminations Manufacturers, or Equal:

    1. **Burndy**.

    2. **Thomas & Betts**.

J. General purpose insulating tape shall be **Scotch No. 33**, **Plymouth Slip-knot**, or equal. High temperature tape shall be polyvinyl as manufactured by **Plymouth**, **3M**, or equal.

K. Conductor and cable identification devices shall be printed heat-shrink plastic tubing.

PART 3 -- EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall provide and terminate power, control, and instrumentation conductors, unless indicated otherwise.

B. The CONTRACTOR shall, as a minimum, provide the number of wires listed on the Contract Drawings. Excess wires shall be treated as spares.

3.2 INSTALLATION

A. Conductors shall not be pulled into raceway until raceway has been cleared of moisture and debris.

B. Pulling tensions on raceway cables shall be within the limits recommended by the cable manufacturer. Wire pulling lubricant, where needed, shall be UL approved.

C. Wire in panels, cabinets, and wireways shall be neatly grouped using nylon tie straps and shall be fanned out to terminals.

3.3 COMBINING RACEWAYS

A. In general, only raceways containing the same type (control, signal, and the like) and voltage of conductors/cables, or dedicated conduits from one source to one device/equipment shall be combined, in accordance with the NEC.

B. Instrumentation cable shall not be permitted to be combined in the same raceway with power and control wiring.

C. Wire or cable with insulation rated for 600V shall not be permitted to be combined in the same raceway with wire or cable with insulation rated for 300V or less (power-limited circuits).

D. Raceways other than those containing instrumentation and power-limited circuits may be combined in strict accordance with the NEC and with prior written permission from the OWNER'S REPRESENTATIVE. Permission from the OWNER'S REPRESENTATIVE does not relieve the CONTRACTOR of responsibility to meet national, state, and local code requirements. Raceways combined as such shall be upsized for conduit fill in accordance with the NEC, which shall not be justification for extra compensation.

3.4 SPLICES AND TERMINATIONS

A. Wire taps and splices shall be properly taped and insulated according to their respective classes.

B. Cable splices in underground handholes or pull boxes will not be permitted.

C. Stranded conductors shall be terminated directly on equipment box lugs making sure that conductor strands are confined within lug. Use forked-tongue lugs where equipment box lugs have not been provided.

D. Excess control and instrumentation wires shall be long enough to terminate at any terminal block in the enclosure, be properly taped, be identified with origin, and be neatly coiled.

E. **Power Wire and Cable:**

1. Branch circuit conductors may be spliced in suitable fittings at locations determined by the CONTRACTOR.

2. Splices to motor leads in motor terminal boxes shall be wrapped with mastic material to form a mold and then shall be taped with a minimum of 2 layers of varnished cambric tape over taped with a minimum of 2 layers of high temperature tape.

F. **Control Wire and Cable:**

1. Control conductors shall be spliced or terminated only at the locations indicated and only on terminal strips or terminal lugs of vendor furnished equipment.

2. In junction boxes and control panels, control wire and spare wire shall be terminated to terminal strips.

G. **Instrumentation Wire and Cable:**

1. Shielded instrumentation and data cables shall be grounded at one end only. Bond shields to ground at the cabinet, enclosure, or control panel that contains the system programmable logic controller (PLC) or hard-wire logic relaying.

2. Pair and triad shielded cables installed in conduit runs which exceed available standard cable lengths may be spliced in pull boxes. Such cable runs shall have only one splice per conductor. Shields shall be terminated at unique, ungrounded terminal blocks for such splices so as to keep the shield continuous from equipment end to termination at PLC cabinet or enclosure.

3.5 CABLE IDENTIFICATION

A. Wire and cable shall be identified for proper control of circuits and equipment and to reduce maintenance effort.

B. **Unique Designations:** Identify instrumentation and control cables and conductors with the designations indicated in the circuit schedule on the Contract Drawings. The CONTRACTOR shall assign to each control and instrumentation wire and cable not in the circuit schedule a unique designation. Unique designations shall be assigned to conductors having common terminals and shall be shown on the Record Drawings. Designations shall appear within 3 inches of conductor terminals. "Control Conductor" shall be defined as any conductor used for alarm, annunciator, or signal purposes.

1. Multiconductor Cable:

a. Identification labels shall be attached to the cable at intermediate pull boxes and at stub-up locations beneath free-standing equipment.

b. Cable designations shall form a part of each individual wire designation.

2. Individual control conductors and instrumentation cable shall be identified at intermediate pull boxes and at stub-up locations beneath free-standing equipment. The instrumentation cable designations shall incorporate the loop numbers assigned in the Contract Documents.

3. Power Conductors:

   a. All feeder cables and branch circuit conductors shall match industry-standard color-coding practices.

   b. Insulated ground wire shall be green, and neutral wire shall be white or gray.

   c. Color coding tape shall be used where colored insulation is not available.

   d. Color coding and phasing shall be consistent throughout the facility.

   e. Any phase changes necessary for proper rotation shall be made at the driven equipment and not in the local disconnect.

4. General purpose control wire shall be a color distinct from the conductor colors used for power conductors.

5. Spare cable shall be identified with a unique number as well as with destination.

6. Terminal strips shall be identified by computer printable, cloth, self-sticking marker strips attached under the terminal strip.

3.6 TESTING

A. **Field Tests:** In accordance with Section 26 01 26 – Electrical Testing.

- END OF SECTION -

SECTION 26 24 16 - PANELBOARDS & DRY TYPE TRANSFORMERS

PART 1 -- GENERAL

1.1 SUMMARY

A. Integrated transformer and panelboard assemblies shall meet the requirements for both transformers and panelboards in this section.

B. **Single Manufacturer:** Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

C. Panelboard Schedules are located on the drawings.

1.2 REFERENCE STANDARDS

A. The following is a list of standards which may be referenced in this section:

Code of Federal Regulations (CFR)

10 CFR	Part 431, DOE 2016 Efficiency

Institute of Electrical and Electronic Engineers (IEEE)

C57.96	Guide for Loading Dry Type Transformers

National Electrical Contractors Association (NECA)

407	Recommended Practice for Installing and Maintaining Panelboards

National Electrical Manufacturers Association (NEMA)

289	Application Guide for Ground Fault Circuit Interrupters
AB 1	Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
KS 1	Enclosed Switches
PB 1	Panelboards
PB 1.1	General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less
ST 20	Dry-Type Transformers for General Applications

Underwriters Laboratories, Inc. (UL)

67	Standard for Panelboards
98	Standard for Enclosed and Dead-Front Switches
486E	Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors

489	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
870	Wireways, Auxiliary Gutters and Associated Fittings
943	Ground-Fault Circuit Interrupters
1449	Standard for Surge Protective Devices
1561	Standard for Dry-Type, General Purpose, and Power Transformers

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Sections 01 33 00 – Contractor Submittals, and 26 00 00 – Basic Electrical Requirements.

B. **Product Data:**

1. Transformers:

a. Dimensional drawings and weight.

b. Descriptive information.

c. Conduit entry locations.

d. Transformer nameplate data, including:

1) Voltages.

2) Voltage taps.

3) Winding configuration.

4) Full load kVA.

5) Efficiency.

6) Impedance.

e. Enclosure rating and type.

f. Schematic and connection diagrams.

g. Seismic certification and equipment anchorage details as required by Section 43 00 00 – Equipment General Provisions.

2. Panelboards:

a. Descriptive information on each type of panelboard, breaker, and accessory provided.

b. Shop drawings for panelboards.

c. Conduit entry locations.

d. Tabulation of Panelboard Features:

1) Circuit Breakers: Type, rating, number of poles, and accessories provided.

2) Provisions for future devices.

3) Component list.

4) Voltage, frequency, phase, and number of incoming wires.

5) Full load current rating.

6) Enclosure type.

7) Bus and terminal bar configurations and ratings.

8) Cable lug sizes.

9) Short circuit current rating of assembled panelboard at system nominal voltage.

10) Auxiliary components, such as surge protective devices.

11) Special features, if indicated.

e. Installation information.

f. Seismic certification and equipment anchorage details as required by Section 43 00 00 – Equipment General Provisions.

C. **O&M Data:**

1. In accordance with Section 01 33 00 – Contractor Submittals.

2. Manufacturer's recommended installation instructions.

3. Seismic anchorage and bracing calculations as required by Section 43 00 00 – Equipment General Provisions.

1.4 QUALITY ASSURANCE

A. Provide products that are listed and labeled as defined in NFPA 70.

PART 2 -- PRODUCTS

2.1 TRANSFORMERS

A. Low-voltage power transformers submitted under this section shall be dry-type, self-cooled, two-winding, unless indicated otherwise.

B. Transformers shall be designed, manufactured, and tested in accordance with UL 1561 and NEMA ST 20.

C. Transformers shall be UL-listed and bear the UL label.

D. Transformers shall be suitable for use with 75 degrees C wire at ampacities shown in NFPA 70.

E. Transformers shall meet Department of Energy (DOE) 2016 efficiency requirements at a minimum. Transformers 15 kVA and larger shall comply with California-specific product and usage requirements in Title 20 and Title 24.

F. **Ratings:**

1. Power and voltage ratings, and individual transformer configurations shall be as indicated on the Drawings.

2. Transformers shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in IEEE C57.96.

3. Overload capability shall be in accordance with IEEE C57.96.

4. Impedance: Manufacturer's standard.

5. Transformer sound levels shall not exceed the following NEMA levels for self-cooled ratings:

Up to 9 kVA	40 dB
10 to 50 kVA	45 dB
51 to 150 kVA	50 dB

G. **Construction:**

1. Core and Coil:

a. Encapsulated type for single-phase units up to 25 kVA and three-phase units up to 15 kVA.

b. Varnish-impregnated type for single-phase units above 25 kVA and three-phase units above 15 kVA.

2. Aluminum windings.

3. Insulation Systems: Manufacturer's standard design.

4. Transformers shall have four 2-1/2 percent taps, 2 above and 2 below rated primary voltage.

5. Wall Brackets: Provide where indicated as wall-mount on Drawings, for units up to 30 kVA.

6. Vibration Isolators:

   a. Rated for transformer's weight.

   b. Less than 30 kVA: Isolate entire unit from structure with external vibration isolators.

   c. 30 kVA and Higher: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.

7. Enclosure: Suitable for service conditions in which transformer is being installed, and in accordance with Section 26 00 00 – Basic Electrical Requirements.

H. Manufacturer, or Equal:

1. **Eaton/Cutler Hammer**.

2. **Square D**.

3. **General Electric**.

2.2 PANELBOARDS

A. Panelboards shall be dead-front and factory-assembled.

B. Panelboards shall comply with NEMA PB 1, as well as the provisions of UL 67, and shall be UL listed.

C. Panelboards indicated on Drawings as service equipment shall be UL labeled for such use.

D. Panelboards shall be rated at nominal voltages shown for number of wires and phases shown on Drawings.

E. The manufacturer of the panelboard shall be the manufacturer of the major components within the assembly, including circuit breakers.

F. Panelboards shall be suitable for use with 75 degrees C wire at ampacities shown in NFPA 70, and in accordance with UL 486E.

G. Lugs for termination of conductors shall comply with Section 26 05 83 – Wire & Cable.

H. Provide space, mountings, and bus connections for future circuit breaker provisions where indicated as "SPACE" on Panelboard Schedules such that like devices may be installed without additional hardware or modification of main bussing.

I. **Ratings:**

1. Unless indicated otherwise, load current ratings for panelboard assemblies, buses, and circuit breakers are non-continuous as defined by NFPA 70. Provide 100% (continuous) rated equipment only where specifically indicated.

2. Panelboards rated 240 volts ac or less shall have short circuit current ratings not less than 22 kA rms symmetrical.

3. Panelboards rated 480/277 volts ac shall have short circuit current ratings not less than 35 kA rms symmetrical.

4. Panelboards shall be labeled with a UL short circuit current rating. Series ratings are not acceptable.

J. **Construction:**

1. Provide enclosure type in accordance with Section 26 00 00 – Basic Electrical Requirements.

2. Panelboard finish shall be rust-inhibitor prime with ANSI 61 gray, baked enamel coat.

3. Panelboards shall have tin-plated copper phase bussing and terminal bars, full size throughout length of panelboard. Machine, drill, and tap for mounting of current and future devices along entire bus.

4. Panelboards shall have tin-plated copper neutral bussing and terminal bars, full size throughout length of panelboard, where neutral is required. Neutral terminal bus shall be isolated from enclosure, phase, and equipment ground bussing, unless specifically indicated otherwise. Provide number of termination points to match quantity of breaker pole positions.

5. Panelboards shall have tin-plated copper equipment ground bussing and terminal bars, full size throughout length of panelboard. Ground terminal bus shall be bonded to enclosure. Provide number of termination points to match quantity of breaker pole positions.

6. Equip panelboard with all provisions required to install future devices to completely fill the panelboard.

7. Panelboards shall have hinged doors with combination catch and latch.

8. Front panels shall be so arranged that when the plates are removed, the gutters, terminals, and wiring will be exposed and accessible.

9. Doors shall have inner doors within the plates to have only the breaker operating mechanisms exposed when they are opened. Live conductors and terminals shall be concealed behind the plates.

10. Secure panelboards with keyed, door-handle locks, catch- and tumbler-type. All supplied panelboards shall be keyed alike and two milled keys shall be supplied with each panelboard.

11. Panelboards shall have the necessary barriers, supports, and wiring gutters.

12. Trim screws shall be stainless steel.

13. Provide a metal frame with transparent plastic face to insert typewritten circuit directory inside the inner door on each panelboard.

K. **Circuit Breakers:**

1. Provide in accordance with NEMA KS 1, UL 98, and UL 489.

2. Protective devices shall be adapted to panelboard installation.

3. Circuit breakers shall be thermal-magnetic, quick-make, quick-break type, unless indicated otherwise.

4. Provide small-frame molded-case circuit breakers in panelboards rated 480 volts ac.

5. Provide “miniature” circuit breakers in panelboards rated 240 volts or less, except for main circuit breakers, which shall be small-frame molded-case circuit breakers.

6. Circuit breakers shall be interchangeable and capable of being operated in any position as well as being removable from the front of the panelboard without disturbing adjacent units.

7. Provide bolt-on circuit breakers in all panelboards.

8. Breakers shall indicate ON/OFF and TRIPPED positions clearly on or near handle.

9. Interrupt Rating: Not less than 10 kA rms symmetrical for breakers rated 240 volts ac or less, and not less than 14 kA rms symmetrical for breakers rated 480/277 volts ac.

10. Trip Mechanism:

    a. Thermal and magnetic trip elements in each pole.

    b. Two- and three-pole breakers shall be common trip.

    c. Mechanism opens all poles when overcurrent occurs on any single pole.

    d. Test button on cover.

    e. Do not substitute single-pole breakers with handle ties for multi-pole breakers.

    f. Calibrated for 40 degrees C ambient.

11. Do not use tandem or dual circuit breakers in normal single-pole spaces.

12. Furnish provisions for handle padlocking for circuit breakers where indicated.

13. Provide nameplates for each circuit and blank nameplates for spares.

L. **Surge Protection Devices:**

1. Surge protection devices, where indicated, shall be designed to provide transient voltage protection for panelboards. Surge suppressors shall comply with UL 1449 and shall be UL labeled for such use.

2. Provide surge protection devices of types indicated on Drawings, and as defined in UL 1449.

3. Surge protection devices shall be resettable. Surge protection devices with sacrificial element shall not be acceptable.

4. Panelboard surge protection devices shall be **Eaton SPD Series** or equal.

M. Manufacturer, or Equal:

1. **Eaton/Cutler Hammer**.

2. **Square D**.

3. **General Electric**.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Install in accordance with NECA and manufacturer's instructions.

B. **Transformers:**

1. Load external vibration isolator for transformers such that no direct transformer metal is in direct contact with mounting surface.

2. Provide liquid-tight, flexible metal conduit for electrical connections.

3. Connect voltage taps to modulate actual output voltage under normal system conditions to be as close to rated output voltage as possible.

C. **Panelboards:**

1. Install in accordance with NEMA PB 1.1.

2. Install securely, plumb, in-line, and square with walls.

3. Install top of panelboard 78 inches above floor, unless otherwise shown.

4. Install ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289.

5. Install filler plates in unused spaces.

6. Route conductors neatly in groups; bundle and wrap with nylon wire ties.

7. Provide typewritten circuit directory for each panelboard.

8. Provide acrylic nameplate indicating load served for each branch or feeder circuit breaker and affix next to breaker.

3.2 TESTS

A. Perform in accordance with Section 26 01 26 – Electrical Testing.

- END OF SECTION -

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SECTION 26 32 16 – OWNER-FURNISHED PROPANE ENGINE STANDBY GENERATORS

PART 1 -- GENERAL

1.1 RELATED SECTIONS

A. Refer to the following sections for other requirements related to this section:

1. Section 26 36 23 – Transfer Switches.

1.2 REFERENCE STANDARDS

A. The following is a list of standards which may be referenced in this section:

Institute of Electrical and Electronics Engineers (IEEE)

C37.102	Guide for AC Generator Protection

National Electrical Contractors Association (NECA)

404	Recommended Practices for Installing Generator Sets

National Electrical Manufacturers Association (NEMA)

MG 1	Motors and Generators

National Fire Protection Agency (NFPA)

30	Flammable and Combustible Liquids Code
37	Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
58	Liquefied Petroleum Gas Code
110	Standard for Emergency and Standby Power Systems

1.3 REUSE OF EXISTING EQUIPMENT

A. The following existing equipment from the Iron Gate Dam shall be reused as shown for this facility:

1. 100 kW/125 kVA, 240V, 3-phase, 4-wire Liquid Propane Standby Generator, and associated accessories. Included in the Work is reprogramming and rewiring this generator for 480V, 3-phase power.

2. Pad-mount Propane Tank, including pressure gauges, relief valves, isolation valves, and pressure regulators.

B. Salvage to OWNER the existing line circuit breaker for the standby generator. Details for the new line circuit breaker are provided herein.

C. Contractor shall verify that existing equipment is suitable for use prior to installation. Inform OWNER if existing equipment is defective or otherwise unsuitable.

PART 2 -- PRODUCTS

2.1 LINE CIRCUIT BREAKER

A. A new line circuit breaker shall be supplied to protect the existing standby generator and conductors at 480V, 3-phase. Contractor shall coordinate with local generator supplier to choose an appropriately rated breaker. Rating shown on drawings is anticipated based on conductor sizing.

B. The circuit breaker shall be installed on the generator skid below the control panel.

C. The circuit breaker shall be 100% rated and equipped with an adjustable electronic 'LSI' trip sensor unit with the following functions:

1. Adjustable long-time current pickup.

2. Adjustable long-time delay.

3. Adjustable short-time current pickup.

4. Adjustable short-time delay.

5. Adjustable instantaneous trip.

D. The frame rating of the circuit breaker shall be manufacturer's standard for the generator set supplied.

E. **Interrupt Rating:** Manufacturer's standard at 480V.

2.2 ELECTRICAL CONNECTIONS

A. Power connections to standby generator set auxiliary devices shall be made at the devices by the installing contractor at the time of installation, with required protection provided by plant distribution panels.

2.3 PIPING

A. CONTRACTOR is responsible for routing piping in-kind between relocated tank and standby generator. Any new piping connections shall be 1 ½" diameter Sch 40 steel pipe, epoxy coated.

2.4 CONTROL PANEL

A. Automatic run controls shall be suitable for remote interface and control by transfer switch. Engine generator set shall start and run upon closure of a remote dry contact provided by transfer switch specified in Section 26 36 23 – Transfer Switches.

B. **Communications:**

1. Provide accessory from manufacturer for existing control panel to allow use of Ethernet/IP protocol.

C. The following I/O shall be associated with the standby generator:

#	Description	Type	Connected Device
1	Generator Start	Discrete input	Automatic Transfer Switch
	Remote Generator Emergency Stop	E-stop circuit	Facility SCADA
2	Alarms & Status:		
	(a) Running	Ethernet/IP	Facility SCADA
	(b) Trouble	Discrete output	Facility SCADA
	(c) Fault	Discrete output	Facility SCADA
	(d) Low fuel level	Ethernet/IP	Facility SCADA
	(e) Low oil pressure	Ethernet/IP	Facility SCADA
	(f) High oil temperature	Ethernet/IP	Facility SCADA
	(g) Low oil level	Ethernet/IP	Facility SCADA
	(h) High coolant temperature	Ethernet/IP	Facility SCADA
	(i) Low coolant level	Ethernet/IP	Facility SCADA
	(j) High bearing temperature	Ethernet/IP	Facility SCADA
	(l) Over speed	Ethernet/IP	Facility SCADA
	(m) Over cranking	Ethernet/IP	Facility SCADA
	(n) Battery failure	Ethernet/IP	Facility SCADA
	(o) Charger failure	Ethernet/IP	Facility SCADA

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Level and securely mount engine generator set in accordance with manufacturer's recommendations.

B. Install in accordance with NECA 404.

3.2 PROPANE STORAGE SYSTEM

A. Installation shall be in accordance with NFPA 37 and manufacturer's instructions for fuel line connection.

3.3 FIELD FINISHING

A. Touch up damaged coating with paint system compatible with existing.

3.4 FUNCTIONAL AND PERFORMANCE TESTING

A. In accordance with Section 26 01 26 – Electrical Testing.

B. Submit functional test plan to OWNER for approval prior to performing tests.

- END OF SECTION -

SECTION 26 36 23 - TRANSFER SWITCHES

PART 1 -- GENERAL

1.1 REFERENCE STANDARDS

A. The following is a list of standards which may be referenced in this section:

Institute of Electrical and Electronics Engineers (IEEE)

C37.90.1	Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

National Electrical Manufacturers Association (NEMA)

ICS 1	Industrial Control and Systems: General Requirements
ICS 2	Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts

Underwriters Laboratories Inc. (UL)

1008	Transfer Switch Equipment

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Sections 01 33 00 - Contractor Submittals, and 26 00 00 – Basic Electrical Requirements.

B. **Product Data:**

1. Descriptive product information.
2. Dimensional drawings.
3. Control diagrams, indicating interconnection terminal blocks.
4. Conduit entrance locations.
5. Equipment ratings.
6. Seismic anchorage and bracing drawings and cutsheets.

C. **Technical Manuals:** O&M data shall include the following:

1. Copies of the product data above.
2. Seismic anchorage and bracing calculations.
3. Factory test reports.

PART 2 -- PRODUCTS

2.1 MANUFACTURERS

A. Kohler.

B. ASCO.

2.2 GENERAL

A. Provide new transfer switch to be installed for transfer to existing standby generator power. Refer to Section 26 32 16 – Propane Engine Standby Generators for requirements on reuse of the existing generator.

B. Transfer switches shall be manufactured in accordance with NEMA ICS 1, NEMA ICS 2, IEEE C37.90.1, and UL 1008.

C. Transfer switch consisting of inherently double-throw power switch unit with interconnected control module.

D. Rated as shown for total system transfer of motor, heating, lighting, and other loads.

E. Suitable for 480 volts, three-phase, three-wire, electrical service having an available short circuit current at line terminals of 14 kA rms symmetrical.

F. **Switch Rating:** As shown on Drawings.

G. Provide nonautomatic (manual) transfer switch as indicated on Drawings.

H. Suitable for use with 75 degrees C wire.

I. **Enclosure:**

1. NEMA type 12 steel construction, with enclosure grounding terminal.

2. Dead front, front accessible wall-mounted cabinet.

3. Continuously hinged single door, with handle and lock cylinder.

4. Finish: Baked enamel applied over rust-inhibiting, phosphated base coating. Provide gray finish.

J. **Operating Conditions:** Transfer switches to be fully rated at maximum ambient temperature of 104 degrees F.

K. **Nameplates:** Provide nameplate in accordance with Section 26 00 00 – Basic Electrical Requirements.

2.3 TRANSFER SWITCH

A. Electrically operated, mechanically held, double-throw.

B. Momentarily energized, single-electrically operated mechanism energized from target transfer source.

C. Locking mechanism to maintain constant contact pressure.

D. Mechanical interlock switch to ensure sources are not paralleled.

E. Main and arcing contacts visible for inspection with cabinet door and barrier covers removed.

F. Silver alloy main contacts protected by arcing contacts.

G. Internal operating handle and external control panel to manually transfer in either direction under either loaded or unloaded conditions.

H. **Power Terminals:** Suitable for number and size of conductors shown on Drawings for each source and load.

2.4 CONTROL MODULE

A. Integral to transfer switch unit with keypad and display flush- or semi-flush-mounted to door.

B. Microprocessor for sensing and logic control with inherent communications capability.

C. Backlit LCD display and keypad for viewing and programming transfer switch parameters.

D. LED indicators for SOURCE AVAILABLE (either direction), NORMAL POSITION, EMERGENCY POSITION, and TRANSFER SWITCH FAULT.

E. **Programmable functions:**

1. Voltage and frequency pickup and dropout.

2. Time delays.

3. Generator exerciser.

4. Two discrete inputs and two discrete outputs.

F. **Adjustable Voltage Sensor Ranges:**

1. Pickup: 85 to 100% nominal.

2. Dropout: 75 to 98% of pickup setting.

G. **Adjustable Frequency Sensor Ranges:**

1. Pickup: 90 to 100% nominal.

2. Dropout: 87 to 89% of pickup setting.

H. **Adjustable Time Delays:**

1. Engine Starting Contact Actuation: 0 to 5 minute delay.

2. Load Transfer to Emergency: 0 to 5 minute delay.

3. Retransfer to Normal: 0 to 30 minute delay.

4. Unload Running Time: 0 to 30 minute delay.

5. Controller shall allow bypass of any time delay, for testing and maintenance purposes.

I. **Engine Start Control:** Form C dry contacts, rated 10A at 24 volts dc and wired to easily accessible terminal blocks.

J. **Auxiliary Position Indicating Contacts:**

1. Normally open, dry contacts rated 10A at 120 volts ac.

2. 8 for normal position, 8 for standby position.

K. **Engine Exerciser:**

1. 30-day clock, adjustable to 15-minute increments.

2. Allows for automatic exercising of generator without load transfer.

3. Controller shall allow disabling of automatic exercising, and allow manual start of exerciser sequence.

L. **Communications:**

1. Control panel shall be equipped with Ethernet/IP protocol. Modbus TCP protocol without Ethernet/IP support will not be acceptable.

2.5 FACTORY TESTS

A. Dielectric strength test in accordance with NEMA ICS 1.

B. Test operation of individual components, sequence of operation, correct transfer times, correct voltage and frequency, and time delay settings.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Secure enclosure to wall surface using structural steel channels and anchor bolts of sufficient size and number adequate for site seismic conditions.

3.2 FIELD TESTING

A. In accordance with Section 26 01 26 – Electrical Testing.

- END OF SECTION -

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SECTION 26 50 00 - LIGHTING

PART 1 -- GENERAL

1.1 REFERENCE STANDARDS

A. The following is a list of standards which may be referenced in this section:

California Code of Regulations (CCOR)

Title 24 – California Building Standards Code

Illuminating Engineering Society of North America (IESNA)

LM-79	IES Electrical and Photometric Measurements of Solid-State Lighting Products
LM-80	IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources
TM-21	Projecting Long Term Lumen Maintenance of LED Light Sources

National Electrical Manufacturers Association (NEMA)

ICS 6	Industrial Control and Systems: Enclosures

Underwriters Laboratories Inc. (UL)

1598	Luminaires
2108	Low Voltage Lighting Systems
8750	Light Emitting Diode (LED) Equipment for Use in Lighting Products

U.S. Environmental Protection Agency and U.S. Department of Energy

Energy Star

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Sections 01 33 00 - Contractor Submittals, and 26 00 00 – Basic Electrical Requirements.

B. **Product Data:**

1. Exterior luminaires:

   a. Catalog data sheets and pictures.

   b. Luminaire finish and metal gauge.

   c. Lens material, pattern, and thickness.

   d. Color temperature.

e. Voltages.

f. Approximate life (in hours).

g. Lumen output chart.

h. Color Rendering Index (CRI).

i. IES lighting classification and isolux diagram.

j. Fastening details to wall or pole

k. For light poles, submit wind loading, complete dimensions, and finish

2. Light Emitting Diode (LED) fixtures:

a. Rated life.

b. Operating temperature range.

c. Warranty on light engine and driver.

d. Power factor.

e. IESNA LM-80 test reports.

f. IESNA TM-21 ratings.

PART 2 -- PRODUCTS

2.1 LUMINAIRES

A. Specific requirements relative to execution of WORK of this section are located on the Drawings.

B. Provide luminaires that are labeled by UL or another approved testing agency.

C. Provide products that have been in satisfactory industrial use for at least 2 years.

D. Feed-through type or separate junction box.

E. **Wire Leads**: Minimum 18 AWG.

F. **Component Access**: Accessible and replaceable without removing luminaire from ceiling.

G. **Exterior Installations:**

1. UL Labeled: SUITABLE FOR WET LOCATIONS.

2. When factory-installed photocells are provided, entire assembly shall have UL label.

2.2 LED FIXTURES

A. Provide materials and equipment of manufacturers regularly engaged in the production of LED fixtures.

B. Provide Energy Star compliance for solid state luminaires.

C. Provide RoHS compliant LED light sources and drivers.

D. **Warranty:** 5 years minimum.

E. **Light Engine:**

1. All components on a single plate with quick-disconnect plugs.

2. Provide thermal protection and heat sink.

3. Provide a surge protection device in accordance with IEEE C62.41.2.

4. Light Engine Rating: 100,000 hours at 25 degrees C, L70.

5. Color Temperature:

a. Indoor: 4000K.

b. Outdoor: 5000K.

6. CRI: Minimum of 70.

F. **Drivers:**

1. Expected life of 100,000 hours at 25 degrees C.

2. Operating Voltage Range: 120V to 277V, 60 Hz, unless noted otherwise, with sustained variations of plus or minus 10 percent without damaging the driver.

3. Power Factor: 90% or greater.

2.3 POLES

A. **Wind Rating (with Luminaire):** 100 mph steady winds, without incurred damage.

B. **Material:** As specified on Drawings.

C. **Type:**

1. As specified on Drawings.

2. Hinged type for structure-mount and rail-mount poles. Hinged at mid-point by use of a stainless steel hinge pin.

D. Hardware and pole-mounting kits included with poles.

E. Provide mounting kits for luminaires that are compatible with the luminaire mounting type.

PART 3 -- EXECUTION

3.1 LUMINAIRES

A. Install in accordance with manufacturer's recommendations.

B. Coordinate mounting, fastening, and environmental conditions with Section 26 00 00 – Basic Electrical Requirements.

C. Install plumb and level.

D. **Supports for Hinge-Type Poles:** Provide hardware for mounting to railing and/or concrete structure.

E. Locate poles to avoid conflict with other systems and blockage of luminaire light output.

3.2 CLEANING FOLLOWING CONSTRUCTION

A. Remove labels and other markings, except UL listing mark.

B. Wipe luminaires inside and out to remove construction dust.

C. Clean luminaire plastic lenses with antistatic cleaners only.

D. Touch up painted surfaces of luminaires and poles with matching paint ordered from manufacturer.

- END OF SECTION -

SECTION 31 00 00 - EARTHWORK

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall perform earthwork as indicated and required for construction of the WORK, complete and in place, in accordance with the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

A. The CONTRACTOR shall submit samples of materials proposed for the WORK in conformance with the requirements of Section 01 33 00 – Contractor Submittals. Sample sizes shall be as determined by the testing laboratory

B. CONTRACTOR's Detailed Excavation Plan

1. The CONTRACTOR, prior to beginning any trench or structure excavation 5 feet deep or deeper, shall submit to the OWNER and shall be in receipt of the OWNER's written acceptance of the CONTRACTOR's detailed plan showing the design of shoring, bracing, sloping of the sides of excavation, or other provisions for worker protection against the hazard of caving ground during the excavation of such trenches or structure excavation.

2. The CONTRACTOR’s plan shall be prepared and signed and sealed by a Professional Engineer experienced in the field of geotechnical engineering and licensed in the State where the WORK is being performed.

3. The OWNER’s acceptance of said plan will be for verification of submittal of the plan according to this requirement.

4. If such plan varies from the shoring system standards established in the Construction Safety Orders of the State of California, such alternative systems plans shall be prepared by a civil or structural engineer licensed in the State of California.

C. The CONTRACTOR shall submit certification to the ENGINEER that the chloride concentration in imported materials within the pipe zone does not exceed 100 ppm, when tested in accordance with the requirements of AASHTO T291-94 – Standard Method of Test for determining Water-Soluble Chloride Ion Content in Soil.

D. The CONTRACTOR shall obtain required permits and landowner and agency approvals for disposal of excess excavated material on-Site or off-Site and shall submit copies of related documents to the ENGINEER for information prior to disposal.

PART 2 -- PRODUCTS

2.1 FILL AND BACKFILL MATERIAL REQUIREMENTS

A. **General**

1. Fill, backfill, and embankment materials shall be selected or shall be processed and clean fine earth, rock, gravel, or sand, free from grass, roots, brush, other vegetation and organic matter.

2. Fill and backfill materials that are to be placed within 6 inches of any structure or pipe shall be free of rocks or unbroken masses of earth materials having a maximum dimension larger than 3 inches.

B. **Suitable Materials**

1. Materials not defined below as unsuitable will be considered as suitable materials and may be used in fills, backfilling, and embankment construction, subject to the indicated requirements.

2. If acceptable to the ENGINEER, some of the material listed as unsuitable may be used when thoroughly mixed with suitable material to form a stable composite.

3. Mixing or blending of materials to obtain a suitable composite is the CONTRACTOR's option but is subject to the approval of the ENGINEER.

4. Suitable materials may be obtained from on-Site excavations, may be processed on-Site materials, or may be imported.

5. If imported materials are required by this Section or are required in order to meet the quantity requirements of the WORK, the CONTRACTOR shall provide the imported materials as part of the WORK.

C. **Types of Suitable Materials**. The following types of suitable materials are defined:

Type AS (Aggregate Subbase): Crushed rock aggregate subbase material that can be compacted readily by watering and rolling to form a firm stable base. This material is often specified and required underneath the base course of asphaltic or concrete pavement. At the option of the CONTRACTOR, the grading for either the 3-inch maximum size or 2-inch maximum size gradation shall be used, unless specifically indicated. The sand equivalent value shall be greater than 20. Crushed rock aggregate subbase material shall meet one of the following gradation requirements, as shown on the Drawings or approved by the OWNER:

Sieve Size	Percentage Passing (3-inch Max)	Percentage Passing (2-inch Max)
3-inch	100	100
2.0 inch	90 - 100	100
1.5 inch	-	95 - 100
No. 4	30 - 65	30 - 65
No. 16	15 - 40	15 - 40

No. 200	0 - 20	0 - 20

As an alternative to the above gradation, the CONTRACTOR may use the approved State of California Department of Transportation's **CalTrans** – Class 1 aggregate subbase material.

Type C (Civil Fill) (Not for use beneath concrete foundations): Civil Fill may consist of imported materials or natural on-site materials. Civil Fill may be a combination of Type AS material, Type GF, or Type SF material, or any mixture thereof, except as shown. Some mixing, removal of oversized particles (greater than 4-inch diameter) and/or removal of other unsuitable material may be required. As identified in the GDR, on site sources of this material may consist of existing road base and channel alluvium. The colluvium deposits, consisting of cobbles and boulders within a fat clay matrix, shall not be considered acceptable sources of civil fill material.

Type CLSM (Controlled Low Strength Material): Controlled low strength material (CLSM) shall be in accordance with Section 31 23 00 - Controlled Low Strength Material.

Type DRC (Drain-rock Coarse): Crushed rock or gravel meeting the following gradation requirements.

Sieve Size	Percentage Passing
2-inch	100
1.5-inch	90 - 100
1-inch	20 - 55
3/4-inch	1 - 15
No. 200	0 - 3

As an alternative to the above gradation, the CONTRACTOR may use the approved State of California Department of Transportation's **CalTrans** - Class-1B Permeable material.

Type DRG (Drain-rock Graded): Drain-rock shall be crushed rock or gravel, durable and free from slaking or decomposition under the action of alternate wetting or drying. The drain-rock shall have a sand equivalent value greater than 75. The finish graded surface of the drain-rock immediately beneath hydraulic structures shall be stabilized to provide a firm, smooth surface upon which to construct reinforced concrete floor slabs. The material shall be uniformly graded and shall meet the following gradation requirements:

Sieve Size	Percentage Passing

1-inch	100
0.75-inch	90 – 100
0.375-inch	40 – 100
No. 4	25 – 40
No. 8	18 – 33
No. 30	5 – 15
No. 50	0 – 7
No. 200	0 – 3

As an alternative to the above gradation, the CONTRACTOR may use the approved State of California Department of Transportation's **CalTrans** - Class-2 Permeable material.

The finish graded surface of the drain-rock immediately beneath hydraulic structures shall be stabilized to provide a firm, smooth surface upon which to construct reinforced concrete floor slabs.

Type EF (Embankment Fills from on-site materials): Embankment Fill for the intake grading portion of the project may be obtained from on-Site excavations, may be processed on-Site materials, or may be imported materials comprised of mixtures of Type AS, Type DRG, Type GF, or Type SF material. If on-site material is used for embankments, it may require moisture conditioning to facilitate compaction. Drying of the embankment fill material may not be practical during cold or wet periods of the year. Acceptable embankment material shall meet or exceed the compaction density of 95 percent as determined by ASTM D-1557.

Type GF (Granular Fill 0.75-inch minus): Angular crushed rock, stone or gravel, and sand conforming to the requirements listed below. Do not use pea gravel as granular backfill. The material shall have a maximum liquid limit of 35 and a maximum plasticity index of 10. The material shall have a sand equivalent value greater than 75. (This material is also known as Class I crushed stone.)

Sieve Size	**Percentage Passing**
0.75-inch	100
No. 4	30 - 50
No. 200	0 - 6

As an alternative to the above gradation, the CONTRACTOR may use the approved State of California Department of Transportation's **CalTrans**- Class-2 ¾" max. aggregate base material, provided the liquid limit and plasticity index requirements above are met.

Type SF (Structural Fill / Foundation Base): Crushed rock structural fill material of such nature that it can be compacted readily by watering and rolling to form a firm, stable base for fill material required beneath concrete foundations. This material is often specified and required directly underneath the finish course of asphaltic or concrete pavement. At the option of the CONTRACTOR, the grading for either the 1.5-inch maximum size or 0.75-inch maximum size gradation may be used for material beneath concrete foundations, unless specifically indicated. The sand equivalent value shall be greater than 22. The material shall meet the following gradation requirements:

	Percentage Passing	
Sieve Size	**1.5-inch Max Gradation**	**0.75-inch Max Gradation**
2-inch	100	-
1.5-inch	90 - 100	-
1-inch	-	100
0.75-inch	81 - 91	90 – 100
No. 4	43 - 53	55 – 67
No. 16	23 - 29	28 – 38
No. 200	4 - 10	4 – 10

As an alternative to the above gradation, the CONTRACTOR may use the approved State of California Department of Transportation's **CalTrans**- Class-2 aggregate base material, either the 1.5-inch maximum size gradation or the 0.75-inch maximum size gradation, unless specifically indicated.

Type SNF (Sand Fill): Sand material shall meet the following gradation requirements:

Sieve Size	**Percentage Passing**
0.375-inch	100
No. 4	90 - 100
No. 16	50 - 80
No. 50	5 - 25

No. 200	0 - 5

Type T (Topsoil): Stockpiled topsoil material which has been obtained at the Site by removing soil to a depth not exceeding 2 feet. Removal of the topsoil shall be done after the area has been stripped of vegetation and debris.

Schedule: Earth materials shall be as indicated in the Contract Drawings. Where clear definition in the drawings is not defined, the following schedule may be used to define acceptable fill materials.

Civil Work Area	Material Type
Embankment Fills – (Intake grading and other Embankments)	EF
Pipe Zone (unless indicated as Trench Zone or Bedding)	
Pipe Bedding	SNF
Uncoated DIP	GF
Small PVC (< 6-inch dia.), HDPE (ADS) Drainpipe, & other pipes < 3-inch dia.	GF, SNF
Other PVC, VCP, HDPE Pipe	GF
Trench zone backfill except as identified below	C, EF or an approved mixture thereof.
Final backfill for areas outside of gravel roadways	T
Trench zone and final backfill under structures	Same as pipe zone except where concrete encasement is required
Replace pipeline trench over-excavation	DRC with non-woven filter fabric, or same as pipe zone backfill if trench is above water table.
Gravel Road base materials	GF
Gravel Road subbase materials	AS
Backfill around structures (including berms)	C, EF, or an approved mixture
Under hydraulic or water retaining structures with underdrains	DRG

Civil Work Area	Material Type
Under structures where ground water is removed to allow placement of concrete	DRC, underlain by non-woven filter fabric
Under all other structures	SF
Top 6-inches of embankment fills or backfills around structures	T

D. **Unsuitable Materials**

1. Soils which, when classified under ASTM D 2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System), fall in the classifications of PT, OH, CH, MH, or OL shall be classified as unsuitable materials.

2. In addition to the materials identified as unsuitable in the description above, a material shall be classified as unsuitable if one of the following conditions is present;

   a. Soils which cannot be compacted sufficiently to achieve the density specified for the intended use.

   b. Materials that contain hazardous or designated waste materials including petroleum hydrocarbons, pesticides, heavy metals, and any material which may be classified as hazardous or toxic according to applicable regulations.

2.2 MATERIALS TESTING

A. **Samples**

1. Soils testing of samples submitted by the CONTRACTOR will be performed by a testing laboratory of the OWNER's choice and at the CONTRACTOR's expense.

2. The ENGINEER may direct the CONTRACTOR to supply samples for testing of any material used in the WORK.

B. **Particle Size Analysis**. Particle size analysis of soils and aggregates will be performed using ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils.

C. **Sand Equivalent Value**. Determination of sand equivalent value will be performed using ASTM D 2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.

D. **Unified Soil Classification System**

1. References in this Section to soil classification types and standards shall have the meanings and definitions indicated in ASTM D 2487.

2. The CONTRACTOR shall be bound by applicable provisions of ASTM D 2487 in the interpretation of soil classifications.

E. Testing for sulfate, resistivity, and pH shall be performed in accordance with California Test Methods 532 and 643 of the California Department of Transportation.

F. Testing for chloride shall be performed in accordance with AASHTO T291-94 – Standard Method of Test for determining Water-Soluble Chloride Ion Content in Soil.

2.3 IDENTIFICATION TAPE

A. Unless otherwise indicated, identification tape shall be placed above buried pipelines that are not comprised of magnetic components at least in part.

B. Identification tape shall be 6-inches wide, blue in color, composed of polyethylene, and provided with an integral metallic wire.

C. Tape shall be labeled with CAUTION – WATER LINE BELOW or similar, as approved by the ENGINEER.

2.4 SOIL STERILANT

A. Soil sterilant or chemical weed control agent shall be a commercial product manufactured specifically to sterilize the subgrade soil against the growth of weeds, plants, or any type of vegetation.

PART 3 -- EXECUTION

3.1 EXCAVATION AND BACKFILLING - GENERAL

A. General

1. Except when specifically provided to the contrary, excavation shall include the removal of materials, including obstructions that would interfere with the proper execution and completion of the WORK.

2. The removal of such materials shall conform to the lines and grades indicated or ordered.

3. Unless otherwise indicated, the entire Site shall be stripped of vegetation and debris and shall be grubbed, and such material shall be removed from the Site prior to performing any excavation or placing any fill.

4. The CONTRACTOR shall furnish, place, and maintain supports and shoring that may be required for the sides of excavations.

5. Excavations shall be sloped or otherwise supported in a safe manner in accordance with applicable state safety requirements and the requirements of OSHA Safety and Health Standards for Construction (29CFR1926).

6. The CONTRACTOR shall provide quantity surveys where so required to verify quantities for Unit Price Contracts.

7. Surveys shall be performed prior to beginning WORK and upon completion by a surveyor licensed in the state of California.

B. Removal and Exclusion of Water

1. The CONTRACTOR shall remove and exclude water, including stormwater, groundwater, irrigation water, and wastewater, from excavations.

2. Dewatering wells, wellpoints, sump pumps, or other means shall be used to remove water and continuously maintain groundwater at a level at least 2 feet below the bottom of excavations before the excavation WORK begins at each location.

3. Water shall be removed and excluded until backfilling is complete and field soils testing has been completed.

3.2 OVER-EXCAVATION

A. **Indicated**

1. Where areas are indicated to be over-excavated, excavation shall be to the depth indicated, and backfill shall be installed to the grade indicated.

B. **Not Indicated**

1. When ordered to over-excavate areas deeper and/or wider than required by the Contract Documents, the CONTRACTOR shall over-excavate to the dimensions ordered and backfill to the indicated grade.

C. **Neither Indicated nor Ordered**

1. Any over-excavation carried below the grade that is neither ordered or nor indicated shall be backfilled and compacted to the required grade with the indicated material as part of the WORK

3.3 EXCAVATION IN VICINITY OF TREES

A. All trees within the footprint of grading operations and/or concrete construction as indicated shall be removed. Elsewhere trees shall be protected from injury during construction operations.

B. Protected trees shall be supported during excavation by any means previously reviewed and accepted by the ENGINEER.

3.4 ROCK EXCAVATION

A. **Normal Excavation**. Nearly all excavation, except where indicated in the Contract Drawings shall be considered normal excavation, and may be accomplished using conventional equipment as follows:

1. For general excavation, a D-9R Caterpillar tractor with a single shank ripper, or equivalent equipment, is considered conventional equipment, if it can rip at a production rate of at least 300 bank cubic yards per hour.

2. For trench excavation, a 235C Caterpillar excavator with a medium stick and a rock ripping bucket, or equivalent equipment, is considered conventional equipment, if it can excavate at a production rate of at least 30 bank cubic yards per hour.

3. If material is encountered which the CONTRACTOR believes cannot be excavated by conventional equipment, the ENGINEER shall be notified immediately. The CONTRACTOR shall provide performance tests of the specified conventional or equivalent equipment. If the ENGINEER confirms in writing that the conventional equipment cannot perform at the production rates indicated, the excavation will be considered rock excavation.

B. **Rock Excavation**. Rock excavation shall include removal and disposal of the following items:

1. Boulders measuring 1/3 of a cubic yard or more in volume;

2. Rock material in ledges, bedding deposits, and un-stratified masses that cannot be removed using conventional equipment as defined herein and which require systematic drilling and blasting for removal;

3. Concrete or masonry structures that have been abandoned; and,

4. Conglomerate deposits that are so firmly cemented that they possess the characteristics of solid rock and cannot be removed using conventional equipment as herein defined and require systematic drilling and blasting for removal.

C. **Scope and Payment for Rock Excavation**

1. Rock excavation shall be performed by the CONTRACTOR, provided that if the quantity of rock excavation is affected by any change in the scope of the WORK an appropriate adjustment of the Contract Price will be made. Payment for rock excavation shall be as set forth in the Bid form as a unit price item. If a unit price item for rock excavation is not provided in the Bid form, the extra cost for excavation of rock will be treated as a change.

2. Otherwise, payment will be made in accordance with a negotiated price.

D. **Explosives and Blasting**. Blasting will be permitted on the project site, but will not be permitted within 100 feet of the existing dams or intake structures at the site.

3.5 DISPOSAL OF EXCESS EXCAVATED MATERIAL

A. Unless otherwise indicated, excess excavated material shall be the property of the CONTRACTOR.

B. The CONTRACTOR shall be responsible for the removal and disposal of excess excavated material.

C. The CONTRACTOR shall remove and dispose of excess excavated material at a location selected by the CONTRACTOR and as approved by the ENGINEER or at an off-Site location selected and arranged for by the CONTRACTOR.

D. The CONTRACTOR shall obtain required permits and landowner and agency approvals for disposal of excess excavated material on-Site or off-Site and shall submit copies of related documents to the ENGINEER for information prior to disposal. CONTRACTOR shall pay costs associated with the removal and disposal.

3.6 BACKFILL

A. **General**

1. Backfill shall not be dropped directly upon any structure or pipe.

2. Backfill shall not be placed around or upon any structure until the concrete has attained sufficient strength to withstand the loads imposed.

3. Backfill around water-retaining structures shall not be placed until the structures have been tested, and the structures shall be full of water while backfill is being placed.

B. **Pre-Placement Conditions**

1. Except for drain rock materials being placed in over-excavated areas or trenches, backfill shall not be placed until water is removed from the excavation and the trench sidewalls and bottom have been dried to a moisture content suitable for compaction

2. Immediately prior to placement of backfill materials, the bottoms and sidewalls of trenches and structure excavations shall have any loose, sloughing, or caving soil and rock materials removed.

3. Trench sidewalls shall consist of excavated surfaces that are in a relatively undisturbed condition before placement of backfill materials.

C. **Layering**

1. Backfill materials shall be placed and spread evenly in layers. During spreading, each layer shall be thoroughly mixed as necessary in order to promote uniformity of material in each layer.

2. When compaction is achieved using mechanical equipment, the layers shall be evenly spread such that when compacted each layer shall not exceed 6 inches in thickness.

D. **Moisture Content**

1. Where the backfill material moisture content is below the optimum moisture content, water shall be added before or during spreading until the proper moisture content is achieved.

2. Where the backfill material moisture content is too high to permit the indicated degree of compaction, the material shall be dried until the moisture content is satisfactory.

3.7 STRUCTURE, ROADWAY, AND EMBANKMENT EXCAVATION AND BACKFILL

A. Excavation Beneath Structures and Embankments

1. Except where indicated otherwise for a particular structure or where ordered by the ENGINEER, excavation shall be carried to an elevation 18 inches below the bottom of the footing or 6 inches below the bottom of the slab and brought back to grade with compacted materials acceptable for placement beneath structures.

2. The area where a fill or embankment is to be constructed shall be cleared of vegetation, roots, and foreign material.

3. Where indicated or ordered, areas beneath structures or fills shall be over-excavated.

4. The subgrade areas beneath embankments shall be excavated to remove not less than the top 6 inches of native material and where such subgrade is sloped, the native material shall be benched.

5. When such over-excavation is indicated, both the over-excavation and the subsequent backfill to the required grade shall be performed by the CONTRACTOR.

6. After the required excavation or over-excavation for fills and embankments has been completed, the exposed surface shall be scarified to a depth of 6 inches, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density as per these specifications.

B. Excavation Beneath Concrete Reservoirs

1. Excavation under reservoirs shall extend to the bottom of the drain rock layer.

2. After such excavation has been completed, the exposed surface shall be rolled with heavy compaction equipment to 95 percent of maximum density and then graded to provide a reasonably smooth surface for placement of the drain rock.

3. Areas under the reservoir upon which fill, not drain rock, is to be placed, shall be scarified to a depth of 6 inches, brought to optimum moisture content, and compacted to obtain 95 percent of maximum density.

C. Excavation Beneath Gravel Roadway Areas

1. Excavation under gravel roadway areas shall extend to the bottom of the aggregate subbase.

2. After the required excavation has been completed, the top 12 inches of exposed surface shall be scarified, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density.

3. The finished subgrade shall be even, self-draining, and in conformance with the slope of the finished roadway surfacing.

4. Areas that could accumulate standing water shall be regraded to provide a self-draining subgrade.

D. **Notification of ENGINEER**

1. The CONTRACTOR shall notify the ENGINEER at least 3 Days in advance of completion of any structure or roadway excavation and shall allow the ENGINEER a review period of at least one day before the exposed foundation is scarified and compacted or is covered with backfill or with any construction materials.

E. **Compaction of Fill, Backfill, and Embankment Materials**

1. Each layer of backfill materials as defined herein, where the material is graded such that 10 percent or more passes a No. 4 sieve, shall be mechanically compacted to the indicated percentage of density.

2. Equipment that is consistently capable of achieving the required degree of compaction shall be used, and each layer shall be compacted over its entire area while the material is at the required moisture content.

3. Each layer of coarse granular backfill materials with less than 10 percent passing the No. 4 sieve shall be compacted by means of at least 2 passes from a vibratory compactor that is capable of obtaining the required density in 2 passes.

F. **Heavy Equipme**nt

1. Equipment weighing more than 10,000 pounds shall not be used closer to walls than a horizontal distance equal to the vertical depth of the fill above undisturbed soil at that time.

2. Hand-operated power compaction equipment shall be used where the use of heavier equipment is impractical or restricted due to weight limitations.

G. **Layering**

1. Embankment and fill material shall be placed and spread evenly in approximately horizontal layers.

2. Each layer shall be moistened and aerated as necessary.

3. Unless otherwise approved by the ENGINEER, no layer shall exceed 6 inches of compacted thickness.

4. The embankment and fill shall be compacted in conformance with Paragraph I, below.

H. **Embankments and Fills on Slopes**

1. When an embankment or fill is to be constructed and compacted against hillsides or fill slopes steeper than 4:1, the slopes of the hillsides or fills shall be horizontally benched in order to key the embankment or fill to the underlying ground.

2. A minimum of 12 inches perpendicular to the slope of the hillside or fill shall be removed and re-compacted as the embankment or fill is brought up in layers.

3. Material thus cut shall be re-compacted along with the new material.

4. Hillside or fill slopes 4:1 or flatter shall be prepared in accordance with Paragraph A, above.

I. **Compaction Requirements**

1. The following compaction requirements shall be in accordance with ASTM D 1557 - Test Method for Laboratory Compaction Characteristics of Soils Using Modified Effort (56,000 ft - lbf/ft^3) (2,700 kN-m/m^3) where the material is graded such that 10 percent or more passes a No. 4 sieve and in accordance with ASTM D 4253 - Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table, and D 4254 - Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density, where the material is coarse granular backfill materials with less than 10 percent passing the No. 4 sieve:

Location or Use of Fill or Backfill	Percentage of Maximum Dry Density	Percentage of Relative Density
Embankments and fills not identified otherwise	90	55
Embankments and fills beneath roadway areas or structures	95	70
Backfill beneath structures and hydraulic structures	95	70
Topsoil	80	NA
Aggregate base or subbase	95	NA

3.8 PIPELINE AND UTILITY TRENCH EXCAVATION AND BACKFILL

A. **General**

1. Unless otherwise indicated or ordered, excavation for pipelines and utilities shall be open-cut trenches with minimum widths as indicated.

B. **Trench Bottom**

1. Except where pipe bedding is required, the bottom of the trench shall be excavated uniformly to the grade of the bottom of the pipe.

2. Excavations for pipe bells and welding shall be made as required.

3. Where pipe bedding is required, the bottom of the trench shall be excavated uniformly to the grade of the bottom of the pipe bedding.

C. **Open Trenches**

1. The maximum amount of open trench permitted in any one location shall be 500 feet or the length necessary to accommodate the amount of pipe installed in a single Day, whichever is greater.

2. Trenches shall be fully backfilled at the end of each Day or, in lieu thereof, shall be covered by heavy steel plates adequately braced and capable of supporting vehicular traffic in those locations where it is impractical to backfill at the end of each Day.

3. These requirements for backfilling or use of steel plate will be waived in cases where the trench is located further than 100 feet from any traveled roadway or occupied structure; in such cases, however, barricades and warning lights meeting appropriate safety requirements shall be provided and maintained.

D. **Embankments, Fills and Structural Backfills**

1. Where pipelines are to be installed in embankments, fills, or structure backfills, the fill shall be constructed to a level at least one foot above the top of the pipe before the trench is excavated.

2. Upon completion of the embankment or structural backfill, a trench conforming to the appropriate detail may be excavated and the pipe may be installed.

E. **Trench Shield**

1. If a moveable trench shield is used during excavation operations, the trench width shall be wider than the shield such that the shield is free to be lifted and then moved horizontally without binding against the trench sidewalls and causing sloughing or caving of the trench walls.

2. If the trench walls cave or slough, the trench shall be excavated as an open excavation with sloped sidewalls or with trench shoring, as indicated and as required by the pipe structural design.

3. If a moveable trench shield is used during excavation, pipe installation, and backfill operations, the shield shall be moved by lifting the shield free of the trench bottom or backfill and then moving the shield horizontally.

4. The CONTRACTOR shall not drag trench shields along the trench causing damage or displacement to the trench sidewalls, the pipe, or the bedding and backfill.

F. **Placing and Spreading of Backfill Materials**

1. Each layer of coarse granular backfill materials with less than 10 percent passing the No. 4 sieve shall be compacted by means of at least 2 passes from a vibratory

compactor that is capable of achieving the required density in 2 passes and that is acceptable to the ENGINEER.

2. Where such materials are used for pipe zone backfill, vibratory compaction shall be used at vertical intervals of the lesser of one-half the diameter of the pipe; or 24 inches, measured in the uncompacted state.

3. In addition, these materials shall be subjected to vibratory compaction at the springline of the pipe and the top of the pipe zone backfill, regardless of whether that dimension is less than 24 inches or not.

4. Each layer of backfill material with greater than 10 percent passing the No. 4 sieve shall be compacted using mechanical compactors suitable for the WORK.

5. The material shall be placed and compacted under the haunch of the pipe and up each side evenly so as not to move the pipe during the placement of the backfill.

6. The material shall be placed in lifts that will not exceed 6 inches when compacted to the required density.

G. **Mechanical Compaction**

1. Backfill around and over pipelines that is mechanically compacted shall be compacted using light, hand-operated vibratory compactors and rollers that do not damage the pipe.

2. After completion of at least 2 feet of compacted backfill over the top of pipeline, compaction equipment weighing no more than 8,000 pounds may be used to complete the trench backfill.

H. **Pipe And Utility Trench Backfill**

1. Definitions

a. **Bedding**. The bedding is defined as that portion of pipe zone backfill material between the trench subgrade and the bottom of the pipe.

b. **Pipe Zone**. The pipe zone is defined as that portion of the vertical trench cross-section lying between a plane below the bottom surface of the pipe and a plane at a point above the top surface of the pipe as indicated.

c. **Trench Zone**. The trench zone (located above the pipe zone) is defined as that portion of the vertical trench cross-section lying as indicated between a plane above the top surface of the pipe and a plane at a point 18 inches below the finished surface grade, or if the trench is under pavement, 18 inches below the roadway subgrade.

d. **Final Backfill**. Final backfill is defined as backfill in the trench cross-sectional area within 18 inches of finished grade, or if the trench is under a roadway, backfill within 18 inches of the roadway subgrade.

2. Pipe Zone Backfill

    a. Final Trim

        1) After compacting the bedding, the CONTRACTOR shall perform a final trim using a stringline for establishing grade, such that each pipe section when first laid will be continually in contact with the bedding along the extreme bottom of the pipe.

        2) Excavation for pipe bells and welding shall be made as required.

    b. The pipe zone shall be backfilled with the indicated backfill material.

    c. Pipe zone backfill materials shall be manually spread evenly around the pipe, maintaining the same height on both sides of the pipe such that when compacted the pipe zone backfill will provide uniform bearing and side support.

    d. The CONTRACTOR shall exercise care in order to prevent damage to the pipeline coating, cathodic bonds, and the pipe itself during the installation and backfill operations.

3. Trench Zone Backfill

    a. After the pipe zone backfill has been placed, backfilling of the trench zone may proceed.

4. Final Backfill

    a. Where pipe trench is located under roadway areas, final backfill shall be placed and compacted according to Paragraph K, below, and sloped according to the final grade of the road base material.

    b. Where pipe trench is located in yard areas, outside of the road surfacing, final backfill shall be placed to within 6 inches of the final grade and topped with topsoil. Topsoil shall be reseeded with native grasses in accordance with the Contract Drawings and Specification 31 35 30.

I. **Identification Tape**

1. Install identification tape as indicated.

2. Terminate the tape in a precast concrete box either adjacent to or part of the valve box, manhole, vault, or other structure into which the non-metallic pipe enters or at the end of the non-metallic pipeline.

3. The termination box shall be covered with a cast iron lid.

4. The box shall be located at grade in road surfacing areas or 6 inches above grade in yard areas.

J. **Trench Shield**

1. If a moveable trench shield is used during backfill operations, the shield shall be lifted to a location above each layer of backfill material prior to compaction of the layer.

2. The CONTRACTOR shall not displace the pipe or backfill while the shield is being moved.

K. **Compaction Requirements**

1. The following compaction test requirements shall be in accordance with ASTM D 1557 - Test Method for Laboratory Compaction Characteristics of Soils Using Modified Effort (56,000 ft - lbf/ft^3) (2,700 kN-m/m^3) where the material is graded such that 10 percent or more passes a No. 4 sieve, and in accordance with ASTM D 4253 - Standard Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table, and D 4254 - Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density where the material is coarse granular backfill materials with less than 10 percent passing the No. 4 sieve.

Location or Use of Fill or Backfill	Percentage of Maximum Dry Density	Percentage of Relative Density
Pipe embedment backfill for flexible pipe.	90	70
Pipe bedding and over-excavated zones under bedding for flexible pipe, including trench plugs.	90	70
Pipe zone backfill portion above embedment for flexible pipe	90	70
Final backfill, beneath paved areas or structures.	95	70
Final backfill, not beneath paved areas or structures.	90	40
Final backfill, beneath landscape areas	85	40
Trench zone backfill, beneath road surfacing areas, including trench plugs.	90	70
Trench zone backfill, beneath structures, including trench plugs.	95	70
Trench zone backfill, not beneath road surfacing areas or structures,	90	40

including trench plugs.		

3.9 FIELD TESTING

A. **General**:

1. Field soils testing will be performed by a testing laboratory of the OWNER's choice at the OWNER's expense, except as indicated below.

B. **Density**

1. Where soil material is required to be compacted to a percentage of maximum density, the maximum density at optimum moisture content will be determined in accordance with Method C of ASTM D 1557.

2. Where cohesionless, free draining soil material is required to be compacted to a percentage of relative density, the calculation of relative density will be determined in accordance with ASTM D 4253 and D 4254.

3. Field density in-place tests will be performed in accordance with ASTM D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method, ASTM D 2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place By Nuclear Methods (Shallow Depth), or by such other means acceptable to the ENGINEER.

C. **Remediation**

1. In case the test of the fill or backfill shows non-compliance with the required density, the CONTRACTOR shall accomplish such remedy as may be required to ensure compliance.

2. Subsequent testing to show compliance shall be by a testing laboratory selected by the OWNER and paid by the CONTRACTOR.

D. **CONTRACTOR's Responsibilities**

1. The CONTRACTOR shall provide test trenches and excavations, including excavation, trench support and groundwater removal for the OWNER's field soils testing operations.

2. The trenches and excavations shall be provided at the locations and to the depths as required by the OWNER.

3. Lawn areas destroyed by test trenching and excavation shall be regraded and reseeded with natural grass mix in accordance with Section 31 35 30.

- END OF SECTION -

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